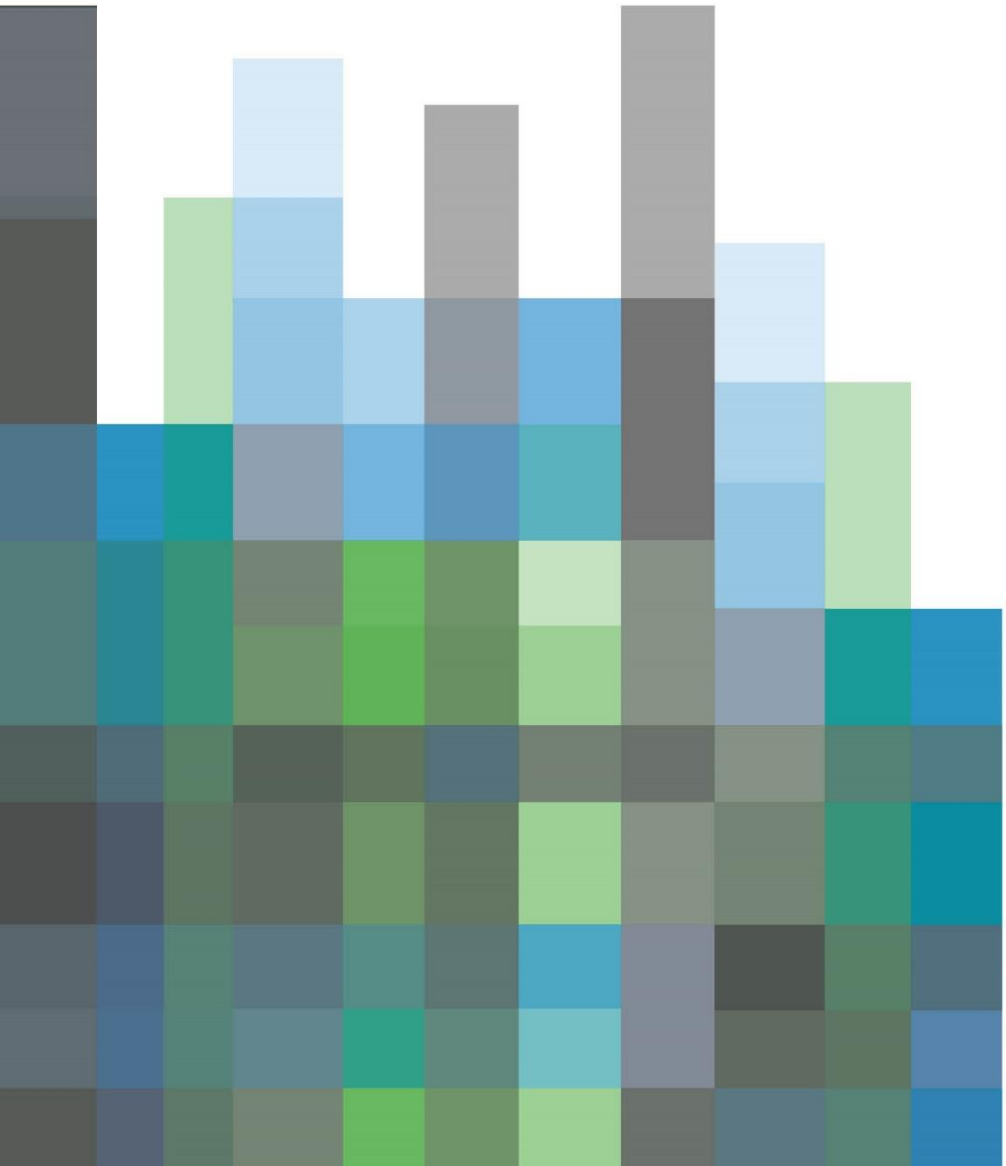
March 2022

Risk Based Cost Estimating and Management Guide

ILLINOIS STATE TOLL HIGHWAY AUTHORITY



Illinois Tollway

INTRODUCTION

Risk Based Cost Estimating and Management Guide

The Illinois Tollway's vision is to review, track and mitigate project risks throughout the entire design process. This document is intended to provide guidance on how to alleviate and diminish risks associated with the Illinois Tollway's projects. This is not intended to be a list of rigid regulations or a manual to completely nullify all potential risks. All projects contain a possibility for risks and the Illinois Tollway wishes to minimize that possibility, not completely eradicate them, as it is impractical. This guide is to provide a basis of guidelines to the Design Section Engineer (DSE) for conducting a thorough assessment and reduction of the Illinois Tollway's project risks. This document provides a framework and minimum expectations for risk management regarding all of the Illinois Tollway's projects.

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SECTION 1.0 INTRODUCTION

1.1 Purpose and Use of the Risk Based Cost Estimating and Management Guide

It shall be understood that this Risk Based Cost Estimating and Management Guide shall be contractually a part of and directly pursuant to the Proposal and Agreement for Design Section Engineering Services. Each Design Section Engineer (DSE) shall furnish services assigned to him/her per Agreement with the Illinois Tollway and in accordance with this Guide and the Design Section Engineer's Manual. Such services shall be performed under the direct administration of the Illinois Tollway.

This guide, in conjunction with the Design Section Engineer's Manual, provides the DSE with the basic framework and guidelines for conducting a thorough review as well as tracking and mitigation of the Tollway Project risks throughout the design process. The Guide provides a framework and minimum expectations for risk management but does not limit the extent to which the DSE may deploy risk management within the project.

1.2 Terms and Definitions

This Article contains definitions of frequently used terms as well as definitions with special or specific meanings as it applies to Illinois Tollway work. Other Articles define infrequently used or technical terms particular to that Article. Whenever in this Guide the following proper nouns are used, their intent and meaning, both the singular and plural thereof, shall be as follows:

3-D Engineered Model: A digital representation of any three-dimensional engineered object.

Addendum: Written interpretation or modification of any of the Contract Documents which shall be delivered to prospective Bidders prior to the opening of bids.

Agreement: The legal written instrument or negotiated Contract defining the obligations and considerations of the signatory parties including, but not limited to the performance of the Services, furnishing of labor and materials and basis of payment. The term "Agreement" includes all Supplemental Agreements.

Base Sheets and Guide Special Provisions: A document provided to the DSE by the Illinois Tollway that contains pertinent information for facilities, materials and/or systems that the DSE may incorporate into the design. Guide documents may be used as base documents when allowed by the Illinois Tollway. Base Sheets shall be modified and completed by the DSE to be specific for the Contract.

Chief Engineering Officer: The Chief Engineering Officer of the Illinois Tollway.

Conceptual Design: An initial stage of design work, which develops the nature of the required improvement(s), demonstrates the intent of the proposed design and verifies compliance with established parameters and design criteria. The Conceptual Design shall include description of alternatives considered in reaching the reported conclusions.

Constructability Review: An independent structured review of current project design

documentation with the objective of ensuring that the number of potential change orders is minimized, and the probability of delays and disputes is reduced. The review also addresses sequencing, utility relocations, coordination of owner furnished items, staging, access and impact on adjacent neighborhood issues, schedule and funding, coordination with other projects, impact on traffic and toll operations, which directly or indirectly impact the design documents under review. The reviewer should have construction or construction management experience and be independent of the individuals participating in the design.

Construction Section: Any one of the numerous divisions into which construction of the roadway, facilities and appurtenances of the Toll Highway may be divided for the purpose of awarding Contracts.

Construction Manager (CM): The Engineer or firm of engineers and their duly authorized employees, agents and representatives retained by the Illinois Tollway to observe The Work to determine whether it is being performed and constructed in compliance with the Contract.

Consultant Quality Program (CQP): A program developed and proposed by the Design Section Engineer (DSE) and approved by the Chief Engineering Officer that describes the process by which the DSE shall endeavor to ensure that only quality work is submitted to the Illinois Tollway during the course of the project. The program is to be written following the Illinois Tollway's GUIDELINES FOR DESIGN SECTION ENGINEER'S QUALITY PROGRAM available on the WBPM system.

Consulting Engineer: The Engineer or firm of Engineers retained by the Illinois Tollway for the purpose of carrying out the duties imposed on the Consulting Engineer pursuant to the terms and conditions of the contract between the Consulting Engineer and the Illinois Tollway and any Trust Indenture and any additional requirements, entered into, by, or on behalf of the Illinois Tollway. Also referred to as the General Engineering Consultant (GEC).

Contract: The written agreement executed between the Illinois Tollway and the successful Bidder and any supplemental agreements duly executed, establishing the terms and conditions for the performance and construction of The Work and the furnishing of labor, materials and equipment by which the Contractor is bound to perform The Work and to furnish labor, equipment and materials and by which the Illinois Tollway is obligated to compensate the Contractor therefore at the established rate or price. The Contract includes the Advertisement to Bidders, Instructions to Bidders, the Proposal, Bonds, the Standard Specifications, the Illinois Tollway Supplemental Specifications, the Contract Plans, the Special Provisions and all Addenda and any Extra Work Order, Change Order or Supplemental Agreements after execution of the Agreement.

Contractor: The individual, partnership, firm or corporation, or any combination thereof, who has entered into the Construction Contract.

Contract Documents: All the documents mentioned under the definition of "Contract."

Contract Plans: The term commonly used to designate the "drawings" incorporated into the Contract Documents. They are the design drawings, special provisions and contract requirements, which have had all addendum items incorporated.

Corridor Construction Manager (CCM): The Engineer or firm of Engineers contracted by the Illinois Tollway to act as the duly authorized agent of the Chief Engineering Officer to manage

other Construction Managers (CMs) in accordance with the scope of their particular duties delegated to them by the terms of their Agreement.

Deputy Chief of Engineering for Planning: The individual responsible for the Planning and Programming Division of the Illinois Tollway under supervision of the Chief Engineering Officer.

Deputy Chief of Program Control/System Integrity: The individual engineer responsible for the Design Division of the Illinois Tollway under supervision of the Chief Engineering Officer.

Deputy Chief of Program Implementation: The individual engineers responsible for Implementation of final design and construction programs under supervision of the Chief Engineering Officer.

Deputy Program Manager: An individual Engineer responsible for a corridor within the Illinois Tollway system under supervision of the Deputy Chief of Program Implementation.

Designer: The person (or consultant team) responsible for performing a design task for an Illinois Tollway project. Although this is typically the Design Section Engineer (DSE), it may also include a person (or consultant team) hired by a Contractor to perform design as part of a Value Engineering Proposal or part of a Performance Based Design.

Design Corridor Manager (DCM): The Engineer or the firm of Engineers contracted by the Illinois Tollway to act as the duly authorized agent of the Chief Engineering Officer to manage other DSEs, in accordance with the scope of the particular duties delegated to them by the terms of their Agreement.

Design Section: Any one of the numerous divisions into which design of the roadway, facilities and appurtenances of the Illinois Tollway may be divided for the purposes of design.

Design Section Engineer (DSE): The Engineer or firm of Engineers and their duly authorized employees, agents and representatives retained by the Illinois Tollway to prepare the Contract Plans for a Design Section.

DSE Project Manager: A member of the DSE's staff responsible for all activities of all design disciplines and who serves as the interface with the Illinois Tollway Project Manager.

Field Check: A review meeting at the proposed Project site for the purpose of performing a comparison of the DSE design with field conditions including topography, utilities, drainage structures, buildings and other items. Representatives may accompany the DSE from the Illinois Tollway and/or the Consulting Engineer.

Final Check: The procedure adopted by the Illinois Tollway by which the final drawings, special provisions, supporting calculations and other documents are inspected and reviewed to determine their acceptability as Contract Documents.

Final Design: Drawings, Special Provisions and supporting calculations which are deemed by the Design Section Engineer to be complete and correct in all respects, including corrections and revisions resulting from the review of Pre-Final Drawings, but which have not been subjected to a Final Check nor accepted by the Illinois Tollway as Contract Documents.

Geotechnical Engineer: The Engineer or firm of Engineers contracted by the Illinois Tollway or

the DSE to perform work in the field of Soil Mechanics and Foundation Engineering for the Design Section.

Illinois Tollway: The Illinois State Toll Highway Authority.

Illinois Tollway Project Manager: The representative of the Illinois Tollway that the Chief Engineering Officer assigned to be the technical and administrative liaison between the Illinois Tollway and its various contractors, DSE and/or CM.

Master Planning: A stage of design development sometimes performed under a separate Agreement, which is reached prior to the start of the Conceptual Design. The Master Planning Design efforts typically include the development and analysis of major alternative designs and the development of concept budget and schedule. Only selected projects include a Master Planning Design submittal.

Pre-Final Design: A complete set of checked plans, accompanied with special provisions and calculations, which includes all anticipated drawings and contains complete design computations and pay item quantity documentation. This design submittal shall be a biddable set of construction documents.

Preliminary Design: Drawings, sketches and work sheets prepared by the DSE, which demonstrates the general intended content of the Contract Plans. The Preliminary Design submittal includes draft special provisions, structural/ mechanical and electrical calculations, preliminary quantity calculations and updated budget and schedule.

Program Manager: The Engineer or firm of Engineers retained by the Illinois Tollway for the purposes of carrying out the duties imposed on the Program Manager, pursuant to the terms and conditions of an authorized Program Management Contract. Also known as the Program Management Office (PMO).

Project: The proposed development that is the subject of the Services stipulated in the Agreement. It may be comprised of one or more Design or Construction Sections.

Project Engineer: A member of the DSE's staff responsible for the design of a singular discipline identified within the Contract Documents.

Project Principal: A member of the DSE's staff responsible for the performance of all services required of the DSE by the Agreement and who has the full authority to obligate the Design Section Engineer in administrative, contractual and legal matters.

Risk Based Cost Estimating and Management: Qualitative and/or Quantitative Risk assessment process utilized to develop mitigation strategies to manage schedule and budget

Web-Based Program Management (WBPM) System: Software database tool used to reduce coordination errors and improve productivity through automation of previously paper-based processes. The database is administered via a website on the Internet, allowing controlled access to the documentation processes. The WBPM system is utilized as a communication, collaboration and coordination tool, as well as a document management solution, for various project activities during planning, design and construction phases. The WBPM system allows Illinois Tollway authorized users with various roles to collaborate on various types of projects. The WBPM system is the official repository of the Project records.

Work: The improvement described in the Construction Contract Documents

NOTE:

This guide follows the traditional definitions for **shall, should** and **may**. **Shall** is used to mean something that is required or mandatory, while **should** is used to mean something that is recommended, but not mandatory and **may** is used to mean something that is optional and carries no requirement or recommendation.

1.3 Introduction to Risk

Risks are defined as uncertain events or conditions that, if they occur, have a positive or negative effect on a project's objectives including the scope, schedule, cost and/or quality. Positive risks are categorized as opportunities. Negative risks are categorized as threats.

It is important to differentiate between risks and issues within a project. Risks are items which may occur in the future. There is uncertainty in both the likelihood of occurrence as well as the magnitude of impact. Issues are risks that have become realities. While there may still remain uncertainty in the magnitude of the impact, the issue has already occurred. This distinction becomes important when evaluating project risk. Only looking at the issues that directly face the project at the time of risk evaluation not only misses a significant portion of the opportunity to mitigate negative outcomes but also misses the opportunity to completely eliminate the occurrence of issues in the first place, which is the best possible mitigation method.

Risks fall into a variety of categories that can be broken out by general characteristics, discipline, magnitude, etc. In general, risks fall into the categories of knowns, known-unknowns, and unknown-unknowns.

- Knowns: These are risks that are highly predictable or are already known will occur in the future. Knowns that have already occurred are issues and do not have any remaining uncertainty in their occurrence.
- Known-Unknowns: These are risks for which we are able to identify the nature of the scope and estimate the uncertainty in occurrence and outcome. Based on the nature of the risk, mitigation strategies may be applied to reduce or eliminate the
- Unknown-Unknowns: These are risks for which no specific estimate of the scope, likelihood and magnitude. These risks are captured as traditional blanket contingency. A

goal of risk management is to, through careful analysis of the project, move as much risk out of this category and mitigate it through the risk management process.

There is, for most things, a degree of uncertainty. While the engineering process attempts, where feasible, to manage the uncertainty of most standard issues to the extent that they can generally be considered certainties, some degree of variability will still exist. Some facts, such as the modulus of stiffness for a specific grade of structural steel, can be quoted as single value. However, when enough testing is performed, it is shown that there is actually a range of values associated with the stiffness. Other values cannot be dealt with in this fashion. These uncertain values are often better expressed by a range or probability distribution that can account for the variability.

When dealing with risk, it is important to account for not only the extremes of the potential outcomes, but the likelihood of given outcomes so that appropriate actions and preventative actions may be developed.

1.4 Abbreviations & Acronyms

- CE Consulting Engineer
- CM Construction Manager
- DCM Design Corridor Manager
- DSE Design Section Engineer
- GEC General Engineering Consultant to the Illinois Tollway
- MOT Maintenance of Traffic
- MPR Master Plan Report
- NTP Notice to Proceed
- PM Project Manager
- PMO Program Management Office
- WBPM Web-Based Program Management

SECTION 2.0 RISK BASED COST ESTIMATING AND MANAGEMENT

2.1 Introduction

This section provides background on the objectives and principles of Risk Based Cost Estimating and Management for Illinois Tollway design projects.

2.2 Risk Based Cost Estimating and Management

Accurate cost estimates are the foundation of delivering successful and accountable programs. Under traditional estimating and management practices, a generalized contingency factor is applied based on the complexity of the project and design milestone at the time of estimation. This blanket-contingency number is determined in advance based on past experience with typical projects and generally get lower as the project progresses towards advertisement. It does not, however, provide a means of using best practices and proactive management to reduce contingency based on contract specifics and does not provide detailed information to the project team on ways to improve the project by removing uncertainty and addressing potential issues that will affect the success of the design and the final construction project.

A more proactive and detail-oriented means of determining the appropriate contingency at any given point within a project is to use risk-based cost estimating and management, or, risk management. In this process, care is taken to identify and quantify potential issues and uncertainties that may affect the cost or schedule of the project. By estimating the likelihood of occurrence and spectrum of likely impact magnitudes, the project manager is able to calculate justifiable predicted outcomes in the estimation of cost and schedule. More importantly, the project is able to use process to identify potential issues before they become certainties and find ways to prevent their occurrence and/or limit their impacts.

The figure below demonstrates the basic concept of managed risk through the life of a major design project. The areas for Allowances and Identified Risks can be seen to diminish as the project proceeds towards the award of construction and then to zero as the final construction cost is determined. Under a method with a risk-based approach, the allowances and risks would be lumped together. By managing the risk properly reductions in not only the allowance and risk budget are reduced, but the overall cost of the contract is reduced. Both outcomes are of significant value to the Tollway.

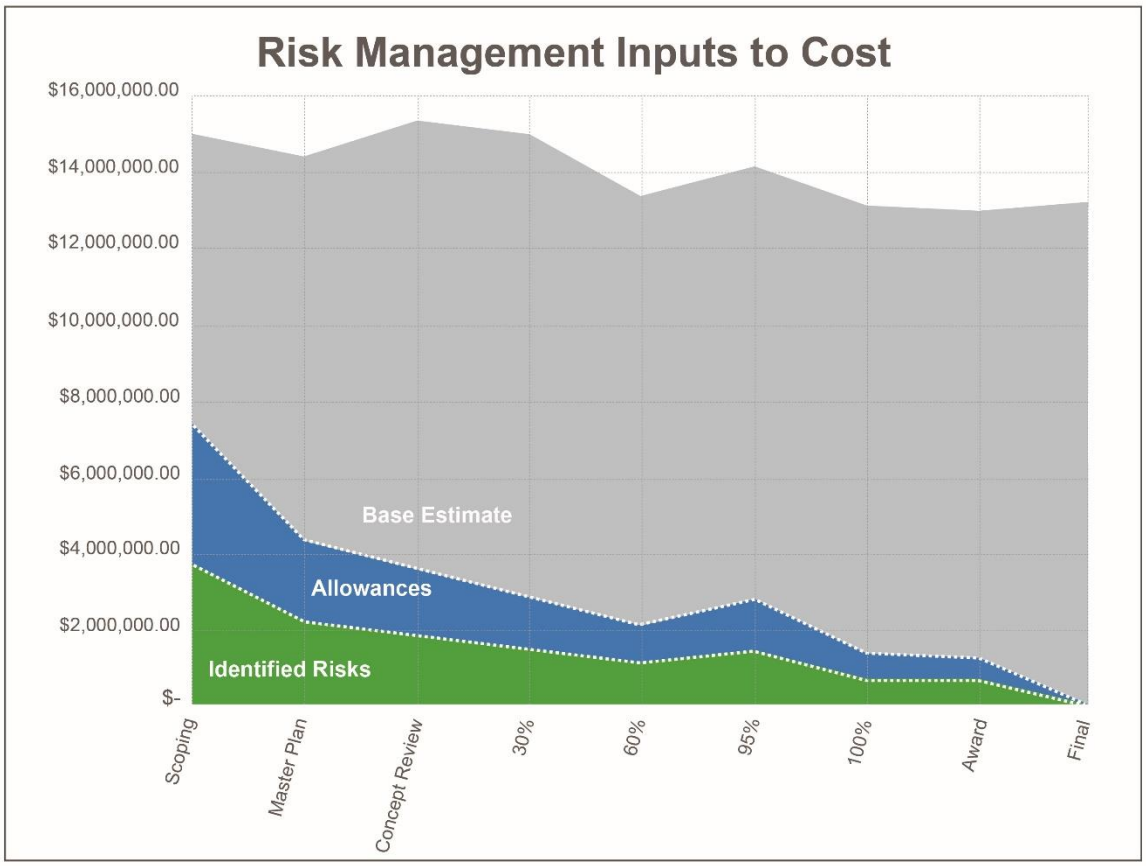

Figure 1: Principle of Risk Management of Cost

Risks with Illinois Tollway transportation projects are factors which pose a hazard to the successful completion not only of the design scope laid out for the DSE, but also those factors which pose a hazard to the completion of the construction of the work itself. The potential for risk is measured both in terms of schedule delay and cost. A systematic approach is necessary to successfully quantify appropriate project risks and impacts early in the project development phase enough to successfully mitigate those risks or baseline the project costs more accurately.

These risks shall be identified at the earliest possible time in the design so that appropriate steps may be taken to reduce or eliminate the impacts. These steps are referred to as mitigation strategies.

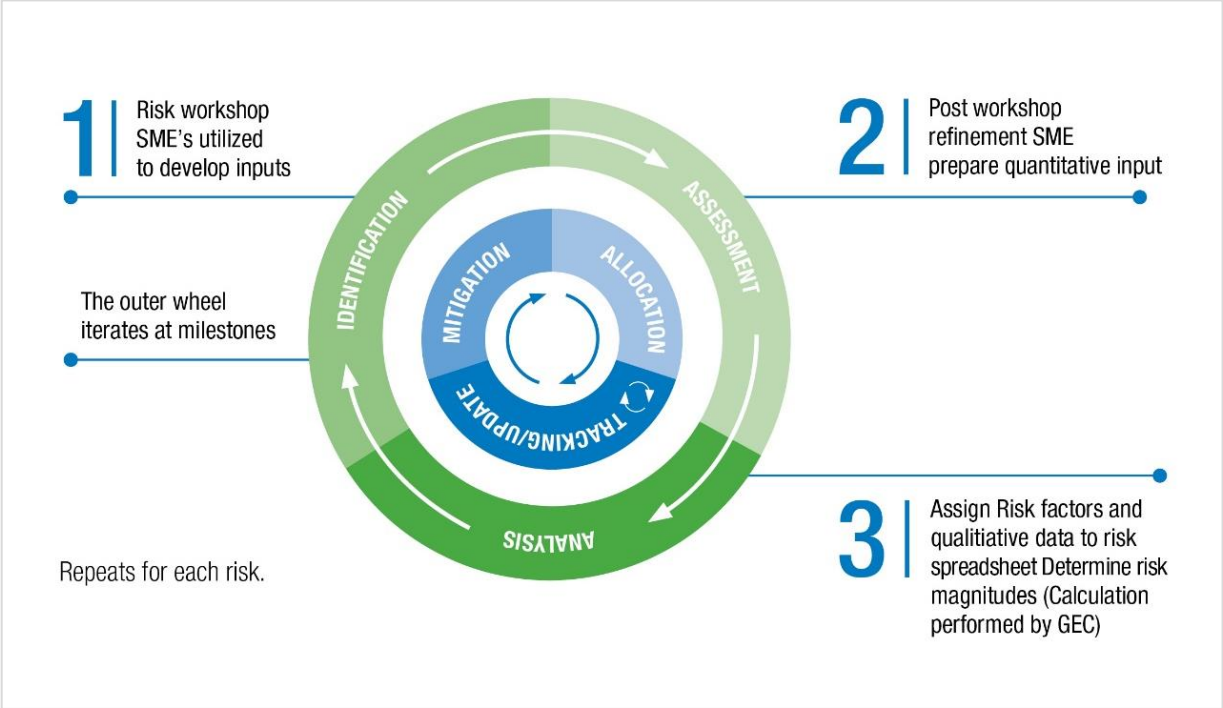

Figure 2: Risk Management Work Flow

While there are several levels on which the risk management review process iterates, it should be noted that the level of effort diminishes as the project progresses towards completion. When new risks are injected into the registers, they can be stepped through process quickly without a complete workshop process and without the effort required when a large number of risks are considered simultaneously.

Active management of the risks, mitigations, and actions happens continuously. As risks are closed, the volume of work reduces. By filtering the register for open risks, an uncluttered view of the work ahead can be presented.

The primary components of the risk management workflow are detailed below.

2.2.1 Identification

Identification of risks is the first step in the risk management process. During this step, both a broad and a deep review of the project is required to develop a listing of the risks and opportunities that are present within the project. Consideration of the project goals as well as the predefined scope items should be made to ensure that the scope of the project is executable and will address the core concerns of the Tollway in a cost-efficient manner.

This is where the Risk Register begins to take shape. A preliminary Risk Register will be generated. This Risk Register may be distributed to the project team for review in advance of a Risk Workshop. The Risk Workshop allows the project team and selected subject matter experts (SMEs) to provide inputs to the workshop and feed upon the team's collaborative efforts to round out the full risk register. The goal of the risk workshop is to capture as much of the basis for risk and opportunity within the project. Gathering consensus information for inputs which are not well

defined will aide in later stages, but the focus should be given towards developing the basic definition of risks for later assessment and analysis. The Risk Workshop will be conducted in coordination with the Tollway PM and the GEC Risk Manager.

The centralized repository for storing and tracking risks and mitigation strategies is a Risk Register. The DSE shall be responsible for developing and maintaining an up-to-date risk register throughout the project. The Risk Register is to be updated to reflect the most current actions taken throughout the process to ensure that individual and total risk has been minimized. At the completion of the project, the final Risk Register will serve as tool for the future Construction Manager (CM) to use to identify potential risks in the construction phase as well as what steps have already been taken.

It must be noted that the development and maintenance of an active risk register is only the start of risk management and a tool to guide and document work. The actual benefits of risk management come from the proactive implementation of mitigation strategies to avoid or mitigate risk to the project. Much of this work is inherent to the process of successfully designing the work. Risk Management is a proactive process of quantifying potential issues on a project early enough to deliver a reasonable and defensible engineering estimate while minimizing change management in Phase III.

2.2.2 Assessment

The Assessment phase of risk management focuses on providing fine detail on the risks and opportunities identified within the identification phase. This includes defining, to the extent possible, the likelihood of occurrence and the likely magnitude of the outcomes or consequence of the event. SMEs and other members of the project team determine or verify the items in the risk register. Where necessary outside input can be garnered.

The inputs from this phase will be used in the analysis phase to determine the individual and cumulative impacts to the project and to determine the appropriate risk contingency to carry based on the remaining exposure. Care must be taken to use objective and reasonable values for likelihoods and magnitudes of impacts to avoid biasing the assessment of risks.

2.2.3 Analysis

Analysis is the process of using the risk register inputs of likelihood and impact magnitude to develop and operate a risk model that can determine the reasonable risk values that should be used for the project in general and for specific risks individually. This is typically performed using Monte Carlo or other iterative mathematical method to simulate a large number of data points that reveal the overall risk distribution functions. These are then reduced to statically justifiable metrics which can be more useful than an average, such a 90^{th} Percentile value.

2.2.4 Mitigation

Mitigation is the process of proactively addressing risks prior to their occurrence. For opportunities, this is the process of working to ensure that opportunities may be capitalized upon. For each risk, it is necessary to identify one or more mitigation strategies which will reduce or eliminate the likelihood of occurrence and/or reduce the likely magnitude of consequences for the risk.

It is often necessary or desirable to develop multiple mitigation strategies. Implementation of multiple strategies may be required to reduce a risk to an acceptable level. Where multiple strategies exist, cost-benefit analysis may allow for selection of the best mitigation strategy.

2.2.5 Allocation

Allocation is the process of determining the appropriate place to hold risk that cannot be eliminated. For risks that have been determined to be truly likely to happen, it may be necessary to assume the risk into the baseline cost of the project. For risks which still carry significant uncertainty and/or have a chance to be mitigated, then they may be carried as part of the risk-based contingency based on the calculated likely impact base on the risk analysis.

2.2.6 Tracking/Update

Tracking and updating is the operation and management of the risk register, associated action items, and translation of current status back into the risk register. As mitigation strategies are applied to a risk, the status of the risk (open/closed) and the inputs for likelihood of occurrence and magnitude of outcome will change. When significant changes have been made to the quantitative analysis fields have been made, it may be necessary to re-analyze the risk register. Comment fields, next step fields, dues dates, and other managerial data points will need to be updated.

2.2.7 Iteration and Periodic Risk Injection

This process is iterative. Risk values for cost and schedule will decrease over the life of the project. As new risks are identified whether during periodic repeat of the identification phase at a milestone, or through other means of discovery, the risk should be walked through the process of identification, assessment, analysis, mitigation and allocation so that it may be tracked and updated with the balance of the risks. As risks are closed through mitigation or assumption, the level of effort required to manage the risk register will generally decrease.

2.3 DSE Risk Management Responsibilities

The DSE shall work in conjunction with the Illinois Tollway to develop and maintain an active risk register throughout the life of the design project. The DSE shall be responsible for ensuring that risk and opportunities are clearly identified, communicated to the Tollway PM, and addressed through specific actions in a timely manner. This will require tracking and reporting of actions as well as updating the risk register as needed to reflect the current status of the project and the best estimate of current risk.

The DSE will be responsible for providing input from subject matter experts within the DSE team in the required project disciplines sufficient to identify and estimate the scope, likelihood and magnitude of the risks contained within the project. The DSE will also be required to obtain and incorporate feedback from the Tollway subject matter experts and the Tollway PM.

The GEC Risk Manager will provide risk modeling within the risk register using Monte Carlo simulation tools and provide the DSE with updated metrics at intervals and upon request. The GEC will also be available as a resource to both the Tollway PM and the DSE to evaluate the specifics of risk and help develop consistency in reporting.

While the Risk Register does represent a deliverable to the Illinois Tollway, it is intended to serve as working process in the project to aid the designer in identifying problems and opportunities so that the work may be delivered at the highest quality and value to the Tollway.

This Guide identifies key deliverable points to the Illinois Tollway and the GEC, but the DSE should keep the Risk Register current and valid at all times.

2.3.1 Preliminary Risk Register

Once the scope of the work has been approved by the Tollway PM, the DSE should develop a preliminary risk register. This register can identify broad categorical risks where unknowns in the scope or the specifics of the work exist. Where specific risks are identified, they may also be populated. Primary focus in the development of the initial register is to identify as many significant risks as possible. Specific risk impact criteria may be added as identified. Risk mitigation strategies may also be added as available. The DSE shall utilize its project team and internal subject matter experts to develop a well-considered partial risk register. Individual risks do not need to be fully developed (all inputs estimated) in order to be included. It is expected that the risk register will be further developed during the risk workshop, but it must be noted that each item within the risk register will help spur further consideration from workshop participants and as such, careful consideration of the preliminary register is key to the success of the workshop.

Upon completion of the draft preliminary risk register, the DSE will schedule a preliminary risk workshop with the Tollway PM and the GEC Risk Manager. The preliminary risk register will be transmitted via email at least 48 hours in advance to allow for review prior to the workshop. The goal of the preliminary risk workshop is to ensure that the Risk Register template is in good order and that initial approach to risk identification is in line with Tollway expectations. The preliminary risk workshop will provide the DSE with additional inputs and feedback for the Risk Register.

Attendees will include:

- DSE PM
- Tollway PM
- DSE Subject Matter Experts
    - Key disciplines (structures, drainage, geometrics, materials, etc.)
    - Experience project managers.
- Tollway GEC Risk Manager
- Tollway GEC SMEs (optional)

2.3.2 Active Risk Register

Once the preliminary risk register has been submitted to the Tollway PM and GEC Risk Manager via email and the preliminary risk register workshop has been completed, it is the responsibility of the DSE to keep the risk register up to date throughout the life of the project. This is an interactive process. The goal of the Tollway Risk Management process is not to force DSE firms into specific

risk management software packages. For this reason, the Tollway GEC will provide the required calculations.

The Risk Register is required to be submitted to the Illinois Tollway and the GEC Risk Manager as a formal deliverable and stored in the Tollway WBPMS at the following points with typical projects.

- Master Plan (Executive Summary)
- 30% Concept Design Milestone Review Submittal
- 60% Preliminary Design Milestone Review Submittal
    - 60% DMR Risk Workshop
- 95% Pre-Final Design Milestone Review Submittal
    - 95% DMR Risk Workshop
- Advertisement
- Award
- Close-out

2.3.3 Risk Workshops

Risk workshops provide the opportunity for informed peer review of the risk register. For large scale or long duration projects is may be desirable to perform second full-scale risk workshop at or near the 60% DMR when more of the design is developed. Active risk management that incorporates risks as they are uncovered will limit the need for this.

SECTION 3.0 RISK CRITERIA

3.1 Standardized Criteria

The Tollway and the GEC will review and analyze the DSE risk register using quantitative analysis tools. To aide in the keeping the analysis compatible with both the DSE and the Tollway's analysis packages, the basic framework for a Tollway risk register shall conform to the criteria below. The GEC Risk Manager will perform quantitative analysis and simulation using the risk register.

3.1.1 Risk ID

The DSE shall maintain a unique ID for risks as they are identified to ensure that risks can be readily referenced throughout the project. The DSE may designate this numbering system in such a way that is consistent with their work practices and other internal documentation.

3.1.2 Risk Status

Each risk will be either open or closed. Open risks are active and mitigation strategies may still be pursued. Closed risks have either had sufficient mitigation strategies applied to eliminate the risk, or the calculated risk has been absorbed into the project budget and schedule.

3.1.3 Risk Description

A brief description of the risk should contain the critical component of the risk as it pertains to the work and differentiate it from other, similar risks. Brevity is desirable in order to allow the register to condensed to smaller formats. An extended risk description is available where additional detail is required.

3.1.4 Risk Description (Extended)

The extended risk description is provided so that more detail regarding the risk can be provided. This field will typically be hidden in condensed versions of the risk register to make analytics and tracking of risks simpler.

3.1.5 Risk Category

Each risk should be categorized as to the primary area that it affects. Multiple categories may be assigned to an individual risk. The categories may be assigned by the DSE based on the specifics of the scope, but typical categories include:

- Land Acquisition/ROW
- Drainage
- Safety
- Permitting
- Intergovernmental Agreement
- Trigger Points
- Railroad
- Utility
- Lead Time
- Unforeseen Conditions
- Design Deviation

3.1.6 Risk Owner(s)

Each risk should have a specific owner. This is the group or specific person who has been assigned to ensure that the risk will be mitigated or absorbed. It must be clear that the Risk Owner is *not* the cause of the risk. Rather than assign this role by default to the project manager or other standardized person, this role should be assigned specifically to the person with responsibility for the risk.

3.1.7 Ball-In-Court

Ball-In-Court is used to identify the group or specific person currently tasked with next steps to work on the risk or the mitigation strategies. This value may change as work proceeds.

3.1.8 Due Date

This field is used to track the due date for the next significant action required to address the risk or close it out. The Due Date may be updated as actions are taken and required next steps are adjusted.

3.1.9 Likelihood of Occurrence

For Tollway analysis, a single value for likelihood of occurrence will be used. Where data exists to support the use of a more complex distribution for likelihood of occurrence, contact the GEC Risk Manager for guidance on modifying the Risk Register to allow for the use of a multi-parameter distribution for occurrence.

3.1.10 Risk Impacts – Cost

These cells within the risk register define the impacts that the specific identified risk will have upon the work. When performing quantitative risk analysis on the risk register, it is necessary to use a distribution, rather than a discreet cost for the risk impact to account for the variability that exits within the risk.

3.1.10.1 Impact Distribution Type – Cost

Where there is not specific evidence or historical data for a different distribution, it is acceptable to use a standard triangular distribution. In this case, the value for this cell will be “TRIANGLE.”

Triangular distributions are defined using three key values, which are the lowest cost, most likely cost and high cost. Where alternate distributions are desired to be used, consult the GEC Risk Manager to alter the Risk Register to allow for other distributions and document their defining parameters.

3.1.10.2 Impact – Cost – Low

The low impact cost is the lowest likely cost that will be incurred in the event the risk occurs.

3.1.10.3 Impact – Cost – Most Likely

The most likely cost is the cost with the highest probability of occurrence. It does not necessarily represent the average of the low and high costs. Skewing the most likely cost towards the low or the high-cost impact values is representative of risks which have costs not centered around the average.

3.1.10.4 Impact – Cost – High

The high impact cost represents the maximum realistic cost that will be incurred if the risk event occurs. Care should be taken to ensure this value is realistic. It is not necessary to account for highly unlikely catastrophic type consequences within a typical risk. The risk impact range should represent the outcomes which are likely to occur. Where very low probability high impact risks need to be addressed, they can be handled within a separate risk to avoid skewing the impacts of more traditional risks.

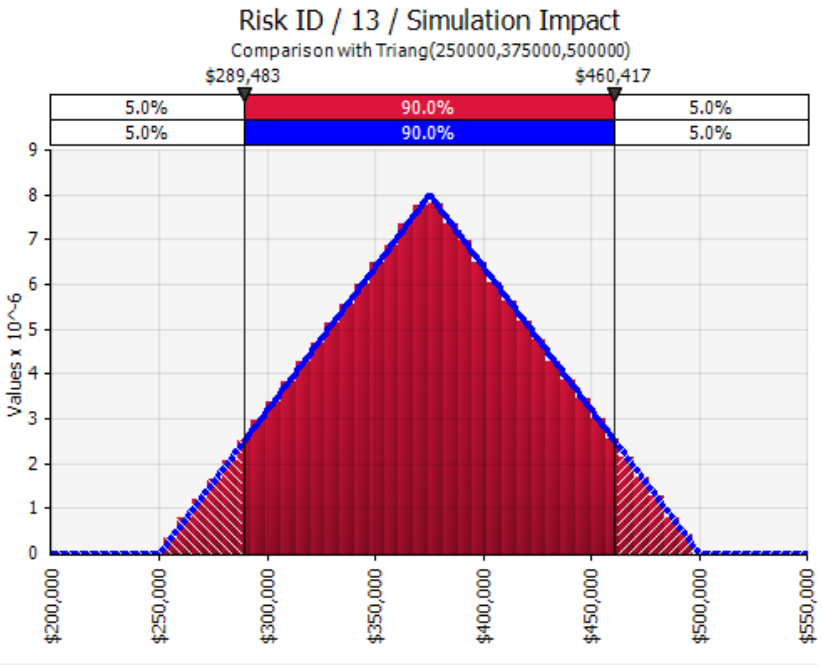

Figure 3: Typical Triangular Cost Distribution (Low=$250k, Most Likely=$375K, High =$500k)

The figure above shows a generalized triangular distribution. The Low, Most Likely, and High-cost impacts are shown. The darker section shows that 90% of the outcomes will fall between $289K and $460K. The risk model uses this model to determine the impact of the risk for every iteration within the simulation.

3.1.11 Risk Impacts – Schedule

Schedule impacts are generally addressed in terms of either weeks or months, depending on the magnitude of the work and desired granularity. The units used should be clearly stated. The risk description should clearly identify whether the risk impact is measuring risk to the completion of the design schedule or risk to the likely construction schedule.

3.1.11.1 Impact Distribution Type – Schedule

Where there is not specific evidence or historical data for a different distribution, it is acceptable to use a standard triangular distribution. In this case, the value for this cell will be “TRIANGLE.”

Triangular distributions are defined using three key values, which are the lowest cost, most likely cost and high cost. Where alternate distributions are desired to be used, consult the GEC Risk

Manager to alter the Risk Register to allow for other distributions and document their defining parameters.

3.1.11.2 Impact – Schedule – Low

The low schedule impact is the lowest likely cost that will be incurred in the event the risk occurs.

3.1.11.3 Impact – Schedule – Most Likely

The most likely schedule impact is the delay with the highest probability of occurrence. It does not necessarily represent the average of the low and high delay. Skewing the most likely schedule impact towards the low or the high delay values is representative of risks which have schedule impacts not centered around the average.

3.1.11.4 Impact – Schedule – High

The high schedule impact represents the maximum realistic delay that will be incurred if the risk event occurs. Care should be taken to ensure this value is realistic. The risk impact range should represent the outcomes which are likely to occur. Where very low probability high impact risks need to be addressed, they can be handled within a separate risk to avoid skewing the impacts of more traditional risks.

3.1.12 Mitigation Strategies

Multiple mitigation strategies can, and in many cases, should be assigned to an individual risk. In this event, each of the associated parameters should be populated for

3.1.12.1 Mitigation ID

The DSE shall maintain a unique ID for risks as they are identified to ensure that mitigation strategies can be readily referenced throughout the project. The DSE may designate this numbering system in such a way that is consistent with their work practices and other internal documentation. Generally, the Mitigation ID will be a subset of the Risk ID (i.e., 1-1 to indicate Mitigation Strategy 1 for Risk 1)

3.1.12.2 Mitigation Description

Sufficient detail should be provided to document the nature of the mitigation strategy. It is not necessary for all details of the mitigation strategy to be spelled out within the risk register, but the key points, particularly as they relate to the specific risk. This will allow the risk register to be reviewed at intervals without requiring reference to detailed correspondence.

3.1.12.3 Mitigation Cost

An estimate of the cost associated with the mitigation strategy should be provided. This will allow for cost-benefit analysis in the event that competing resources require prioritization of mitigation.

3.1.12.4 Mitigation Impact to Risk – Schedule

This field identifies what portion of the schedule risk will be eliminated if the strategy is implemented.

3.1.12.5 Mitigation Impact to Risk – Cost

This field identifies what portion of the cost risk will be eliminated if the strategy is implemented.

3.1.12.6 Mitigation Strategy – Comments

Details about next steps, additional data or assistance needed can be documented in this field.

3.1.13 Mitigation Tracking

3.1.13.1 Next Steps

A brief description of the next steps required to forward the Mitigation Strategy is required to document actions that will be taken to reduce risk. More detailed write-up can be contained in a separate action item list when more detail is required.

3.1.13.2 Next Steps Due Date

Inclusion of a specific date when the next steps will be complete allows for interim deadline tracking.

3.1.13.3 Mitigation Due Date

The specific date when the Mitigation Strategy will be complete allows tracking of overall mitigation status.

3.1.13.4 Mitigation Status

Mitigation strategies may be tracked as in-progress, on-hold, completed, or cancelled.

3.1.13.5 Mitigation Comments

The mitigation comments field allows for general comments that do not fit best in next steps. Summary of actions taken will be provided in Post-Mitigation section.

3.1.14 Post-Mitigation Risk Impacts & Simulation

Once mitigation strategies have been implemented, their impacts to total risk should be applied to the initial risks. This will be represented by providing post-mitigation risk separate from initial risk. These inputs represent the modifications to the initial risk as modified by the mitigation strategy that was applied. The post-mitigation risk simulation provides a means of determining and documenting the reduction in risk that results from each mitigation strategy.

The criteria for risk impact and likelihood will be modified and used as post-mitigation risk to document the remaining risk. These values may be updated as work proceeds to identify current risk exposure. The Archive Actions Taken field may be used to document the realized reduction in overall risk for schedule and cost. The individual fields in the risk register are detailed below.

3.1.14.1 Likelihood of Occurrence

See 3.1.9. The value of Likelihood of Occurrence should be reassessed after the mitigation strategy has been applied to reflect the new probability of occurrence. For risks which have been eliminated, this value will be 0%

3.1.14.2 Impact Distribution Type – Cost

See 3.1.10.1.

3.1.14.3 Impact Cost – Low

See 3.1.10.2. The revised value for post-mitigation analysis should be reassessed to reflect the outcomes of mitigation. The value may be zero if the risk is fully mitigated.

3.1.14.4 Impact Cost – Most Likely

See 3.1.10.3. The revised value for post-mitigation analysis should be reassessed to reflect the outcomes of mitigation. The value may be zero if the risk is fully mitigated.

3.1.14.5 Impact Cost – High

See 3.1.10.3. The revised value for post-mitigation analysis should be reassessed to reflect the outcomes of mitigation. The value may be zero if the risk is fully mitigated.

3.1.14.6 Impact Distribution Type – Schedule

See 3.1.11.1.

3.1.14.7 Impact – Schedule – Low

See 3.1.11.2. The revised value for post-mitigation analysis should be reassessed to reflect the outcomes of mitigation. The value may be zero if the risk is fully mitigated.

3.1.14.8 Impact – Schedule – Most Likely

See 3.1.11.3. The revised value for post-mitigation analysis should be reassessed to reflect the outcomes of mitigation. The value may be zero if the risk is fully mitigated.

3.1.14.9 Impact – Schedule - High

See 3.1.11.3. The revised value for post-mitigation analysis should be reassessed to reflect the outcomes of mitigation. The value may be zero if the risk is fully mitigated.

3.1.15 Risk Actions Taken to Mitigate - Summary

As work proceeds, comments and actions that are no longer current within the commentary fields above can be appended into this field to allow for a running history of actions taken. This field may contain a large amount of text but may be hidden or condensed for typical reporting. The data within the field will be of value when reviewing specific risks. This field should contain a concise summary of actions at the close of the mitigation.

3.2 Risk Simulation Outputs

In order to run simulation within the Risk Register, the GEC Risk Manager will use series of fields that accommodate the quantitative analysis and the simulation outputs. These fields will be locked so that the Risk Register does not become corrupted during the course of standard updates by the DSE and may be hidden to simplify viewing of the register. The GEC will perform the Monte Carlo Simulation on submitted Risk Registers at standard DMR submittals and when requested by the DSE during the course of the work. The standard fields are shown below. These fields will exist for both initial risk and post-mitigation risk as modified by individual mitigation strategies.

3.2.1 Simulation Event Occurrence

This binary value field is used during simulation to indicate whether the risk event has occurred based on the provide likelihood of occurrence. A value of 1 indicates that the risk has occurred in

the iteration. A value of 0 indicates that the risk event has not occurred in the iteration. The value of this field determines whether both Cost and Schedule Impacts will be applied to the iteration.

3.2.2 Simulation Cost Impact

This field represents the cost in dollars within a single iteration that was generated from the cost risk function defined by the parameters defined in Risk Impact – Cost. This value only represents the single iteration displayed and should not be used in wider analysis. This field may generally be hidden when working with the Risk Register.

3.2.3 Simulation Schedule Impact

This field represents the schedule impact within a single iteration that was generated from the schedule risk function defined by the parameters defined in Risk Impact – Schedule. This value only represents the single iteration displayed and should not be used in wider analysis. This field may generally be hidden when working with the Risk Register.

3.2.4 Simulation Cost Output for Summary - Cost

This is a field used by the risk modeling software to store values used on the computation of the overall risk distribution. The field itself will not be used by the DSE. Rather, the summary statistics this field contributes will be used.

3.2.5 Simulation Cost Output for Summary - Schedule

This is a field used by the risk modeling software to store values used on the computation of the overall risk distribution. The field itself will not be used by the DSE. Rather, the summary statistics this field contributes will be used.

3.2.6 Modeled 80th Percentile Cost Impact

As an output from the complete Monte Carlo simulation, the 80th Percentile value for the Cost Impact of the risk will be reported. This value is generated through iteration of the model (generally at 5,000 to 10,000 iterations) and aggregating a complete model of the cost impact risk profile. The 80th Percentile value provide a solid basis to manage against factoring in the likelihood of risk occurrence and then variable nature of the risk impact.

3.2.7 Modeled 80th Percentile Schedule Impact

As an output from the complete Monte Carlo simulation, the 80th Percentile value for the Schedule Impact of the risk will be reported. This value is generated through iteration of the model (generally at 5,000 to 10,000 iterations) and aggregating a complete model of the cost impact risk profile. The 80th Percentile value provides a solid basis to manage against factoring in the likelihood of risk occurrence and then variable nature of the risk impact.

3.3 Additional Risk Reporting Tools

3.3.1 Project Risk Tornado Chart

The project risk tornado chart provides a visual cue to the relative impact that each risk poses to the total risk for the project. It is intended to allow the project team to be able to quickly gauge the relative magnitude of schedule and cost impacts for risks. It should not be used as the only measure of risk importance.

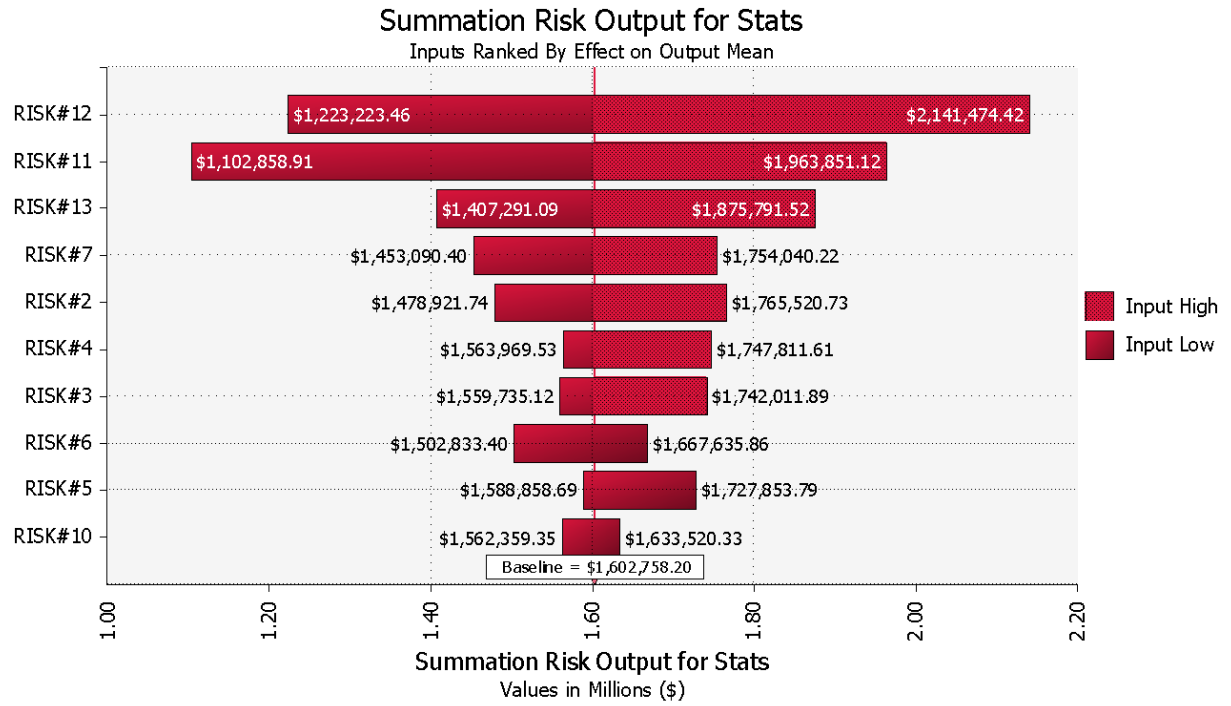

Figure 4: Typical Summary Output - Tornedo Chart

3.3.2 Individual Risk Profiles

Additional detail regarding the calculated risk outcomes for each risk will be provided by the GEC Risk Manager. While these reports are not critical to the overall management of risk at the project level, they can provide detail on specific nature of the costs and schedule impacts associated for a given risk.

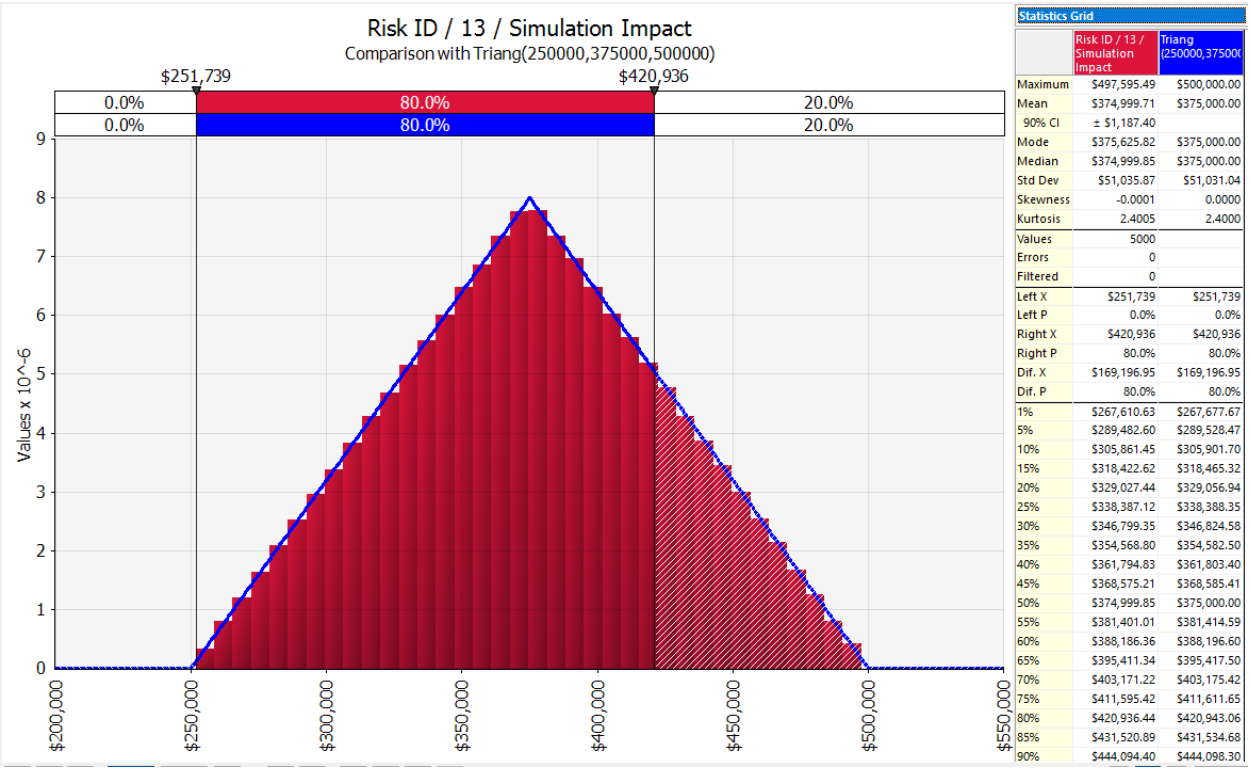

Figure 5: Sample detailed risk profile showing 80th percentile range and detailed risk statistics.

3.4 Operation of the Risk Register Spreadsheet

3.4.1 Editing Inputs

Throughout the life of the risk management process, the inputs to the risk register will need to be updated as additional details are determined, as mitigation strategies are applied, and as risks are closed to ensure that the risk register accurately reflects the current status of the project risk. The DSE may update inputs based on their judgement as needed. Any changes to the numerical inputs should be based on sound reasoning and be defensible. Risk check-ins during the regularly scheduled Book Meetings will provide the Tollway PM with a basis for input changes.

It should be noted that adjusting the inputs will not have a direct impact on the risk outcomes until the register is recalculated. It is not necessary to recalculate the register each time an input is updated, but when major changes are made, the DSE may request updated calculations from the GEC Risk Manager.

Timely update of status tracking and comment fields to provide make the Risk Register current is critical to active tracking of risks. The DSE should update the Risk Register regularly so that it may be relayed to the Tollway PM.

3.4.2 Adding Mitigation Strategies

There is not a one-to-one relationship between risks and mitigations. Often, multiple strategies will need to be considered to effectively resolve a significant risk. In many cases, multiple strategies will also need to be enacted. The DSE may add rows within the spreadsheet to

accommodate as many mitigation strategies as needed. The Mitigation ID field should use a numbering scheme which includes the Risk ID (i.e., 1-1 or 1.1 for Risk 1, Mitigation 1).

3.4.3 Closing Risks

Risks are closed when they have either been fully mitigated or been realized as project costs and absorbed into the baseline. At this point, there is no longer a need for active management of the risk. The risk should remain on the register, but its status should be moved to closed along with noting its closure status. Review of all recently (since last check-in) closed risks should be performed at the Book Meeting.

3.4.4 Requesting Updates

The DSE may request updates of the risk calculations or modifications to the risk register spreadsheet from the GEC Risk Manager as needed. Modifications to the sheet to accommodate additional columns to facilitate project specific needs and recalculation based on changes to risk inputs and the addition or closure of risks are a few examples.

3.4.5 Linking to Action Items

The DSE is responsible for ensuring that a tracking sheet of action items that are associated with each risk and mitigation strategy. The outcomes of these actions are critical to the implementation of the mitigation strategies which will reduce the overall risk for the project. The DSE will develop their own spreadsheet or database to track these action items. The format should be such that it may be reported to the Tollway PM on a regular basis and available for review at Book Meetings. Each action item should have at a minimum an assigned owner, an action summary, a current status, a due date, and an outcome summary.

SECTION 4.0 RISK REGISTER TEMPLATE

The referenced risk register template is provided for use by the DSE in the risk management process by the GEC. The template may be modified to meet the needs of the DSE with respect to the specific project. The GEC risk manager will lock down the columns required for quantitative risk simulation. The required fields laid out in Section 3 should be maintained and will be referenced with in the spreadsheet. Additional field to hold other data as desired by the DSE may be added as necessary and will not hinder the ability of the GEC Risk Manager to review the work or perform the Monte Carlo simulations.

If the DSE requires assistance in the initial setup or maintenance of the risk register, they should contact the GEC Risk Manager to schedule a meeting.

SECTION 5.0 RISK EXAMPLES

This section will walk-through the phases of workflow for a specific risk. The sample risk is for a roadway reconstruction project. The identification step for this risk yields the risk register inputs shown below.

Identification

Risk Description							
Risk ID	Risk Status	Risk Description	Risk Description (Extended)	Risk Category/Discipline	Risk Owner	Ball-In-Court	Next Due Date
1	Open	Lack of geotechnical boring data - Roadway.	There is insufficient soil boring data in the existing alignment to determine the support conditions that exist beneath the existing pavement structure. Potential for underdesign or large quantity of cut and fill to provide pavement support in long term.	Pavement/Geotech	D. Manning	J.Jackson	1/15/2020

The sufficient information is given to demonstrate the specific nature of the risk, who is responsible for the risk as a whole, who is working on the risk at the time, and when the next action is required. As much information should be filled in on the register as possible when the risk is identified. It may be updated or modified at a later time as information gathered.

Assessment

During the assessment step, the analytical inputs for the risk are developed. For the sample risk it can be seen that there is a 60% chance that there will be a negative consequence to not having sufficient geotechnical borings for the project. The cost is expected to range from $50,000 to $1,000,000, with a most likely cost of $500,000. The schedule delay is expected to range from 1 week to 15 weeks with a most likely delay of 5 weeks. These values can be estimated from historical data, gathered from subject matter experts and/or develop through experienced input in a risk workshop environment.

Risk Description			**Risk Likelihood - Input**	**Risk Impacts - Cost - Inputs**				**Risk Impacts - Schedule - Inputs**			
Risk ID	Risk Status	Risk Description	Likelihood of Occurrence (%)	Impact Distribution Type - Cost	Impact - Cost - Low	Impact - Cost - Most Likely	Impact - Cost - High	Impact Distribution Type - Schedule	Impact - Cost - Schedule (Weeks)	Impact - Schedule- Most Likely (Weeks)	Impact - Schedule - High (Weeks)
1	Open	Lack of geotechnical boring data - Roadway.	60%	Triangle	$ 50,000	$ 500,000	$ 1,000,000	Triangle	1	5	15

Analysis

Once the inputs have been established in the assessment step, the risk simulation, or analysis step may be completed. This work is done through Monte Carlo or other interactive simulation method. The shaded cells below, which are typically hidden when working with the risk register at the daily management level, are where the formulas as held to allow the simulation. The output of the simulation, the 80th percentile (P80) Cost Impact for this risk was calculated at $200,000. The P80 Impact to schedule was calculated to be 4 weeks.

Risk Description			Risk Likelihood - Input	Risk Impacts - Cost - Inputs				Simulation Workspace - Hidden			Risk Impacts - Schedule - Cost	Risk Impacts - Schedule - Inputs				Simulation Workspace - Hidden		Risk Impacts - Schedule - Output
Risk ID	Risk Status	Risk Description	Likelihood of Occurrence (%)	Impact Distribution Type - Cost	Impact - Cost - Low	Impact - Cost - Most Likely	Impact - Cost - High	Simulation Event Occurrence (Cost & Schedule)	Simulation Cost Impact	Simulation Cost Output for Summary Cost	P80 Impact - Cost	Impact Distribution Type - Schedule	Impact - Cost - Schedule (Weeks)	Impact - Schedule- Most Likely (Weeks)	Impact - Schedule - High (Weeks)	Simulation Schedule Impact	Simulation Cost Output for Summary Schedule	P80 Impact - Schedule (Weeks)
1	Open	Lack of geotechnical boring data - Roadway.	60%	Triangle	$ 50,000	$ 500,000	$ 1,000,000				$ 200,000	Triangle	1	5	15			4

Mitigation

The mitigation for the risk was determined to have two likely paths forward, both of which could be pursued. Additional borings could be provided within the design contract to supplement the existing information. Further, the Tollway is be queried for additional soil boring or geotechnical data from past design and construction projects that could provide additional information about areas which will require more than standard subgrade stabilization practices. For both of these mitigation strategies, John Jackson has been assigned to take ownership of the mitigation method. Both strategies, if implemented will reduce the range of risk inputs. It figure below shows the mitigation strategy and does not represent completed work to mitigate the risk.

Risk Description			**Mitigation Strategy - Inputs**					
Risk ID	Risk Status	Risk Description	Mitigation ID	Mitigation Description	Estimated Cost of Mitigation	Mitigation Impact - Cost	Mitigation Impact - Schedule	Mitigation Owner
1	Open	Lack of geotechnical boring data - Roadway.	1-1	Commission additional borings as close as possible to final alignment to ensure good data exists for design.	$ 100,000	Will reduce all three inputs for risk of additional undercut.	Will reduce low, most likely and high impacts to schedule.	J. Jackson
			1-2	Request review of previous contracts in project limits to see if an recent projects have produced meaningful soil boring data that can be used.	$ -	Will reduce all three inputs for risk of additional undercut.	Will reduce low, most likely and high impacts to schedule.	J. Jackson

Allocation

Because this risk is open and remains uncertain, it is carried within the risk contingency. The value of the risk as shown above is $200,000 and 4 weeks of schedule. As the risk is addressed within the register, portions of that risk will be allocated to contingency or removed from contingency as the realized costs are assumed into the base cost estimate.

Tracking/Update

The process of mitigating the risk is the series of actions that are executed within each mitigation strategy. These are monitored in the Tracking/Update step. This is the process performed by the DSE to ensure that the specific actions required to perform the mitigation strategies are performed with the timetable that is laid out in the risk register. As these actions are taken (or not), the register is updated with revised statuses.

Risk Description			Mitigation Strategy - Inputs						Mitigation Tracking				
Risk ID	Risk Status	Risk Description	Mitigation ID	Mitigation Description	Estimated Cost of Mitigation	Mitigation Impact - Cost	Mitigation Impact - Schedule	Mitigation Owner	Next Steps	Next Steps Due Date	Mitigation Due Date	Mitigation Status	Mitigation Comments
1	Open	Lack of geotechnical boring data - Roadway.	1-1	Commission additional borings as close as possible to final alignment to ensure good data exists for design.	$ 100,000	Will reduce all three inputs for risk of additional undercut.	Will reduce low, most likely and high impacts to schedule.	J. Jackson	Determine desired layout of borings and assign to geotechnical subconsultant. Monitor progress.	1/15/2020	2/28/2020	In Progress	Borings at 2000' spacings in areas of larger concern. 4000' spacing elsewhere. Review results as they are generated to modify plan as needed.
			1-2	Request review of previous contracts in project limits to see if an recent projects have produced meaningful soil boring data that can be used.	$ -	Will reduce all three inputs for risk of additional undercut.	Will reduce low, most likely and high impacts to schedule.	J. Jackson	Contact PMO, GEC and Tollway PM to request any additional data.	2/1/2020	2/1/2020	In Progress	Request for info included a 2 week deadline. Follow-up on 2/1/2020

As mitigations are complete for a risk, the post-mitigation values are assessed and analyzed to determine the remaining unmitigated risk. The GEC may update the values in the risk register at milestones or upon request from the DSE. The examples below show the roadway geotechnical risk post-mitigation.

		Mitigation Strategy - Inputs		Post-Mitigation Risk Impacts - Cost - Input								Post-Mitigation Cost - Output
Risk Status	Risk Description	Mitigation ID	Mitigation Description	Likelihood of Occurrence (%)	Impact Distribution Type - Cost	Impact - Cost - Low	Impact - Cost - Most Likely	Impact - Cost - High	Simulation Event Occurrence (Cost & Schedule)	Simulation Cost Impact - Single Risk	Simulation Cost Output for Summary	PBO Impact - Cost
Open	Lack of geotechnical boring data - Roadway.	1-1	Commission additional borings as close as possible to final alignment to ensure good data exists for design.	25%	Triangle	$ -	$ 50,000.00	$ 150,000.00				$ 22,000.00
		1-2	Request review of previous contracts in project limits to see if an recent projects have produced meaningful soil boring data that can be used.									

Post-Mitigation Risk Impacts - Schedule - Input						Post-Mitigation Schedule - Output	
Impact Distribution Type - Schedule	Impact -Schedule- Low	Impact - Schedule- Most Likely	Impact - Schedule - High	Simulation Schedule Impact for Single Risk	Simulation Schedule Output for Summary	PBO Impact - Schedule	Risk - Actions Taken to Mitigate- Summary
Triangle	0	2	6			1.1	Additional borings identified areas that will require additional stabilization. Those costs are added to the baseline. Relative uniformity of remaining areas justifies reducing risk inputs. Some risk remains due to historical knowns and inherent variability (minimal).

In this example, the remaining uncertainty or risk associated with the borings may be represented by the by a P80 cost of $22,000 and a P80 delay of 1.1 weeks. The costs associated with the required soil remediation will be built into the project baseline so that they may be planned for properly.

As new information is uncovered in this process, the analytical inputs from the assessment phase or the mitigation phase may be updated. Using these revised inputs, the register may be taken through the Assessment step to update the risk simulation values for the risk and for the post-mitigation risk.