RISK MANAGEMENT AND RISK-BASED COST ESTIMATION GUIDELINES


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NEVADA DEPARTMENT OF TRANSPORTATION RISK MANAGEMENT AND RISK-BASED COST ESTIMATION GUIDELINES

The goal of this manual is to provide guidance to NDOT personnel and consultants in best practice methods of risk management and risk-based cost estimation. It is recognized that guidelines cannot provide entirely complete and practical guidance applicable to all situations and cannot replace experience and sound judgment. As such, deviations from these guidelines may, in some cases, be unavoidable or otherwise justifiable.

Procedure for Guideline Revisions

The guideline will be periodically revised or updated. For edits or updates, contact the Project Management Division at (775) 888-7321. All updates will be available on the Project Management Division SharePoint Portal which should be visited regularly for updated information.

Responsibility:

The Project Management Division is responsible for edits and updates to this document.

Temporary Revisions:

Temporary revisions will be issued by the Project Management Division to reflect updated/revised procedures. These will be reflected on dated errata sheet(s) posted on the Project Management Division SharePoint Portal.

Scheduled Revisions:

As deemed necessary by the Project Management Chief, the Project Management Chief will assemble a Review Team for reviewing the guidelines and errata sheets to determine if a revised edition of the guidelines is required. The Project Management Division Chief will evaluate and approve the recommendations of the team for revisions to the guidelines.

Foreword

These guidelines address the first step in NDOT project management's vision of achieving statewide uniformity and consistency of project cost estimates and department-wide priority on estimating, managing, and controlling costs. Risk-based cost estimation and risk management involves the use of resources, including personnel that have the necessary knowledge, skills, and abilities to accurately and consistently predict costs.

The future is uncertain, but what is certain is there are two questions that will be asked about our transportation projects: "How much will it cost?" and "How long will it take?"

Risk-based estimates of project cost and schedule provide an alternative to traditional deterministic estimates which typically contain lump sum contingencies based on overall costs. Risk-based estimates establish project-specific contingency amounts that are based on specific risk drivers. In addition, risk-based estimates allow the project team to communicate the degree of uncertainty associated with the estimates to decision makers and stakeholders. The risk-based estimates are developed by establishing base estimates founded on clear assumptions without contingencies for unknowns, quantifying and estimating uncertainties, and quantifying specific risks (threats and opportunities). The resulting probability distributions and sensitivity analyses can be used as tools to understand, communicate, and manage risk to improve project development and delivery.

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Definitions of Selected Terms

Base Cost Estimate – The base cost estimate represents the project cost that can reasonably be expected if the project materializes as planned and there is no occurrence of risk. The base cost estimate is unbiased and neutral - it is neither optimistic nor conservative. The base cost includes the known and quantified items and the known but not yet quantified (miscellaneous item allowance). The base cost estimate does not include any risks, unknown/unknowns or contingencies.

NOTE: base cost estimates are to be prepared in current year dollars and will exclude future cost escalation.

During the life of a NDOT project an estimate has many names:

a) Planning Level Estimate (Project Scoping and NEPA)
b) Engineer's Estimate – initial design estimate version
c) Intermediate Review Estimate – for intermediate design review meeting, and reflects 60% plan sets
d) QA Estimate – checking phase of plan set
e) Final Engineer's Estimate – for final design review meeting, and reflects 100% plan sets
f) Preliminary Estimate – reflects small sets, ready to send to EBS for advertising
g) Agreement Estimate – award of contract

Planning level estimates utilize macro-level estimating tools including NDOT Wizard which estimates concepts based on overall area or length of projects such as cost per lane-mile and square footage of elements including bridge structures and retaining walls. In addition, non-developed items including but not limited to MOT, ITS, lighting, signing, and striping are based on a lump sum percentage value for each element.

As the project transitions from a planning level estimate to engineer's estimate, macro-level quantification and unit pricing will develop in NDOT bid item specific items, quantities, and costs. As bid items are developed, pricing will be developed utilizing NDOT's Masterworks software which considers project location (District) and efficiencies or inefficiencies based on quantity amount.

The final Agreement Estimate is based on the accepted bid amount submitted by the contractor and awarded by the Department. This estimate will become part of the contractor's final contract with the Department.

The **base cost estimate** can be developed utilizing several different methods as defined in this section. The following provides a brief comparison amongst the different definitions, as defined in these guidelines.

- **Cost Estimate** - A prediction of the project costs based on readily available information including incorporation of risks and uncertainties. See **Cost Estimate**.
- **Base Cost Estimate** – Cost estimate without risk or contingencies.
- **Cost-Based Estimation** – Also referred to as a production-based estimate. Utilizes production rates, labor, equipment, and material costs. Typical method a contractor uses to develop a bid price. See **Cost-Based Estimation**. Method commonly used to develop an independent cost estimate during the construction manager at-risk (CMAR) delivery method.

- **Historical Bid -Based Estimate** – Utilizes historical bid prices received on past projects based on similar quantities, constraints, and project location. See **Historical Bid-Based Estimation**. Method typically used by the Department.
- **Risk-Based Cost Estimation** – Estimate utilizing a probable risks and associated cost impacts in combination with a base cost estimate. Method required for FHWA Major Projects and typically used by the Department on projects over $25 million. See **Risk-Based Cost Estimation.**

For the purposes of this document NDOT project estimate will most often be referred as the base cost estimate .

Construction (CN) – The cost of the construction contract. For the purpose of this document CN is the cost of the Contractor awarded construction cost only and does not include construction engineering.

Construction Contingency – A markup applied to the base cost estimate to account for minor risk events related to quantities, work elements, field changes, or other project requirements during construction. For design-related contingencies see the definition of **Miscellaneous Item Allowance.**

Construction Engineering (CE) – The total construction management effort (cost) of administering a construction contract through project closeout.

Cost-Based Estimation - A method to estimate the bid cost for items of work based on estimating the cost of each component (labor, materials, equipment, including contractor and sub-contractor markups) to complete the work and then adding a reasonable amount for addressing a contractor's overhead and profit. Sometimes referred to as Production-Based Estimation.

Cost Estimate - A prediction of quantities, cost, and/or price of resources required by the scope of an asset investment option, activity, or project. As a prediction, an estimate must address risks and uncertainties. Estimates are used primarily as inputs for budgeting, cost or value analysis, decision making in business, asset and project planning, or for project cost and schedule control processes. Cost estimates are determined using experience and calculating and forecasting the future cost of resources, methods, and management within a scheduled time frame. (Source: Copyright 2007, AACE International, Inc., AACE International Recommended Practices, Number 10S-90)

CY – Current Year

Escalation - changes in the cost or price of specific items or work over a period of time.

Historical Bid-Based Estimation – This type of estimation tends to be a straightforward count or measure of units of items multiplied by unit costs. These unit costs are developed from historical NDOT project bids (Bid Tabs) and may be modified to reflect project specific conditions. This is the most common type of estimating at NDOT.

Impact – Consequences of a risk event occurrence, such as added cost or time to a defined project. Risk impacts can also include factors such as loss of goodwill, or trust, reduced public safety, etc.

Major Project - Based on the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), signed into law on August 10, 2005, a Major Project is defined as "a project with a total estimated cost of $500 million or more that is receiving Federal financial assistance."

Miscellaneous Item Allowance - Sometimes referred to as “minor items” or “design allowance”, miscellaneous item allowance is typically meant to cover a variety of expected cost items not yet specifically identified or quantified. It is also used to account for a lack of project definition during the preparation of planning and environmental phase base cost estimates. Often percentages are used as individual “placeholders” for items that have not yet been estimated. This item can also be used for right of way and utility relocation prior to establishment of right-of-way needs or utility prior rights investigation.

Mobilization – Calculated as a percentage of the total of the construction cost estimate, mobilization is included in a project estimate to cover a contractor’s preconstruction expenses and the cost of preparatory work and operations (such as moving equipment on site and staging).

Opportunity – A risk event that can result in a savings of cost or time relative to the base estimate.

Parametric Estimation – A method to estimate the cost of a project or a part of a project based on one or more project parameters. Historical bid data is used to define the cost of a typical transportation facility segment, such as cost per lane mile, cost per interchange or cost per square foot. Historical percentages can be used to estimate project segments based on major project parameters. These methods are often used in early estimating, such as planning and scoping estimates and carry higher uncertainties than more detailed estimates.

Planning Costs – The costs associated with a project prior to officially beginning the NEPA process. This would include initial long-term planning, corridor planning, feasibility study, and scoping efforts.

Preliminary Engineering (PE) – The preconstruction effort of taking a project through the, Environmental, Final Design, and R/W. The terms “Design” or “” are sometimes used interchangeably with PE.

Preliminary Estimate – The Preliminary Estimate is typically the final estimate prior to letting and should reflect the complete project scope and current assumptions. Revising a Preliminary Estimate during the letting period would be the exception, not the rule. However, bid period addenda changing the scope or cost of the work may require a revised Preliminary Estimate or reconciliation of the changed value to serve as part of the justification for award.

Probability - The likelihood or chance that something is the case or will happen. The theory is used to draw conclusions about the likelihood of potential events and the underlying mechanics of complex systems.

Project – A project is defined by the limits described in the appropriate scoping or environmental document.

Project Budget – The base cost estimate plus the risk reserve.

Total Project Cost – The total project cost reflects all costs assigned to the project. As defined by FHWA, the project cost is subdivided into the following categories: PE + R/W + (CN+CE) While FHWA includes CN and CE as a single cost, for the purposes of this document CN and CE will be separated.

Percentile – A percentile represents the probability of non-exceedance of a particular value in a probabilistic estimate. For example, a 70th percentile value indicates that there is a 7 in 10 likelihood that the corresponding value will not be exceeded.

Project Cost Range – Uncertainty in estimated costs is communicated in the form of a Project Cost Range. If a quantitative risk analysis has been performed the range is reported as 10th percentile for the low estimate and 90th percentile the high estimate. For qualitative risk assessments the range is reported as the base cost for the low estimate and the (base cost + (base cost * risk allowance)) for the high estimate.

Right of Way Cost (R/W) – The cost to acquire the right of way needed for the project. Utility relocation cost are part of the R/W cost of the project except for easements and fee acquisitions required to replace any utility prior rights. See the definition of **Utility Relocations**.

Risk – The combination of the probability of an uncertain event and its consequences. A positive consequence presents an opportunity; a negative consequence poses a threat.

Risk-Based Cost Estimation – Involves simple or complex modeling based on inferred and probabilistic relationships among cost, schedule, and events related to the project. Risk elements (opportunities or threats) are defined and applied to the base cost estimate with its uncertainties through modeling to provide a probable range for both project cost and schedule.

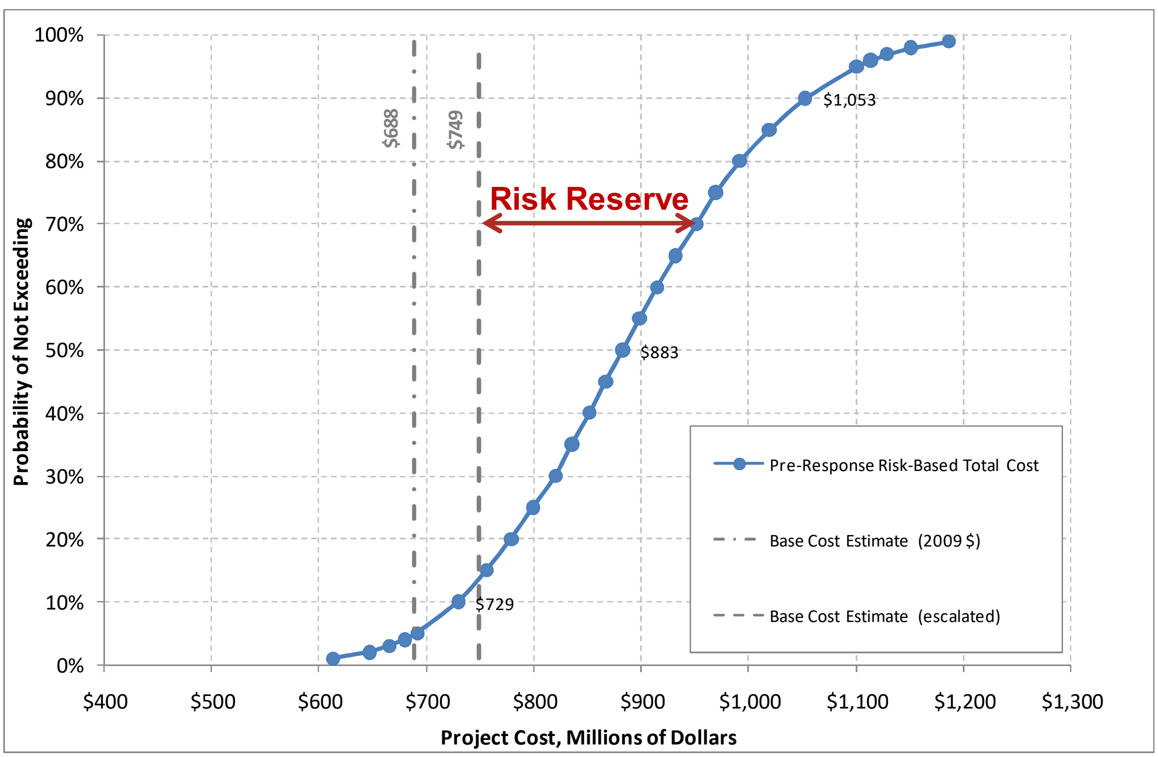

Figure 1 – Example of Risk-Based Probabilistic Cost Results

The risk-based cost estimate is reported using ranges and percentiles. Figure 1 details the probabilistic cost results of an example project. The 80 percent confidence interval, described by the cost range between the 10th percentile and 90th percentile values, indicates that the project cost is expected to fall between $729 million and $1,053 million. There is 70 percent likelihood that construction costs will not exceed $950 million (also referred to as the 70^{th} percentile).

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

RMP – Risk Management Plan

Risk Reserve - An estimate of costs associated with the identified risks.

Risk Statement – A written statement that describes the possible risk event including its consequences, the probability of those consequences occurring, and any assumptions or past occurrences upon which the risk was based.

Scope Changes - Changes in the requirements or specifications on which the design and estimate is based. Examples would include changes to project limits, work types, or capacity factors, such as traffic loads, vehicles per lane, or storm water factors.

Threat – A risk event that can result in increased cost and/or time relative to the base estimate.

Uncertainty - Uncertainty is the lack of knowledge and can be expressed as a range using numbers or percentages around any given value.

Utility Relocation - The cost to relocate utilities within the project limits. This includes easements and fee acquisitions required to replace any utility's prior rights.

YOE – Estimates of future cost that account for escalation are expressed in Year of Expenditure (YOE) terms.

Manual Organization

A brief synopsis of each chapter is provided below.

Chapter 1, **Risk Management** project risk management is a scalable activity and should be commensurate with the size and complexity of the project under consideration. This chapter provides the required risk management process for projects over $100 million and suggestions on projects under $100 million.

Chapter 2, **Cost Estimating Process**, offers background information and the fundamental concepts concerning the estimating process.

Chapter 3, **Base Cost Estimate Methodology**, discusses the specific information that must be gathered in the first step of the process.

Chapter 4, **Base Cost Estimate and Project Development Level**, the estimate for each level of project development has a specific purpose, methodology, and expected level of accuracy.

Chapter 5, **Important Factors Impacting Base Cost Estimation**, many factors influence a project estimate. Several key factors are described in this chapter.

Chapter 6, **Base Cost Estimation Markups**, markups such as mobilization, preliminary engineering (PE), miscellaneous item allowance in design (only for historical bid-based, cost-based, and risk-based methods), and construction engineering (CE) applied to the base cost estimate.

Chapter 7, **Documentation/Basis of Estimate**, documentation is a key element in good estimating practice. The estimate file should be a well-organized, easy to follow history from the first estimate at the beginning of the planning phase through preparation of the final estimate. The basis of estimate document, described in this chapter, contains recommended organization, topics and format.

Chapter 8, **Project Schedule,** provide guidance for the development of Gantt charts and flow charts for use within risk analysis.

Chapter 9, **Independent Estimate/Estimate Review**, every estimate should have some level of review as determined by the Project Manager.

Chapter 10, **Risk Management Planning**, provides guidance for the development of the risk management plan.

Chapter 11, **Risk Identification**, this chapter contains guidance on how to identify and document risks.

Chapter 12, **Qualitative Risk Analysis**, qualitative risk analysis assesses the impact and likelihood of the identified risks and develops prioritized lists of these risks for further analysis or direct mitigation.

Chapter 13, **Quantitative Risk Analysis**, addresses the objectives and guidelines for the risk assessment needed to conduct a quantitative risk assessment. Quantitative risk analysis uses a more detailed approach to evaluating and prioritizing risks by way of numerically estimating the probability a project will meet its cost and time objectives.

Chapter 14, **Risk Response & Value Engineering**, discusses the development of risk response strategies and integrates the value engineering into the process of risk response for the purpose of reducing threats and enhancing opportunities to a project's cost and schedule.

Chapter 15, **Risk Monitoring and Control**, after risk response actions have been implemented, these actions must be tracked and a record of their effectiveness and any changes to the project risk profile.

Chapter 16, **Use and Reporting of Risk-Based Cost Estimation Results**, how the information gained from risk-based cost estimation will be used to assist us in project delivery.

The Purpose of these Guidelines

Accurate estimation of the cost of transportation projects is a fundamental responsibility of the Nevada Department of Transportation (NDOT). In recognition of the fundamental and strategic importance of cost estimating these guidelines provide consistent practices across the agency to enhance methods for meeting this responsibility.

The purpose of the Risk-Based Cost Estimation and Risk Management Guidelines is to assist NDOT in achieving accuracy, accountability, and consistency in risk-based cost estimation and risk management efforts during the planning, environmental, design, and construction phases of project development. It provides guidance to NDOT Project Managers and Teams in their efforts to create accurate and consistent base cost estimates and to better manage the risks affecting project scope, schedule, and cost throughout the project development cycle.

The base cost estimate is a living document. It increases or decreases depending on a variety of factors over the life of the project. During each phase of project development, new information is uncovered and with each discovery, the base cost estimate needs to be adjusted. Each of these revisions will use different estimating inputs, methods, techniques and tools.

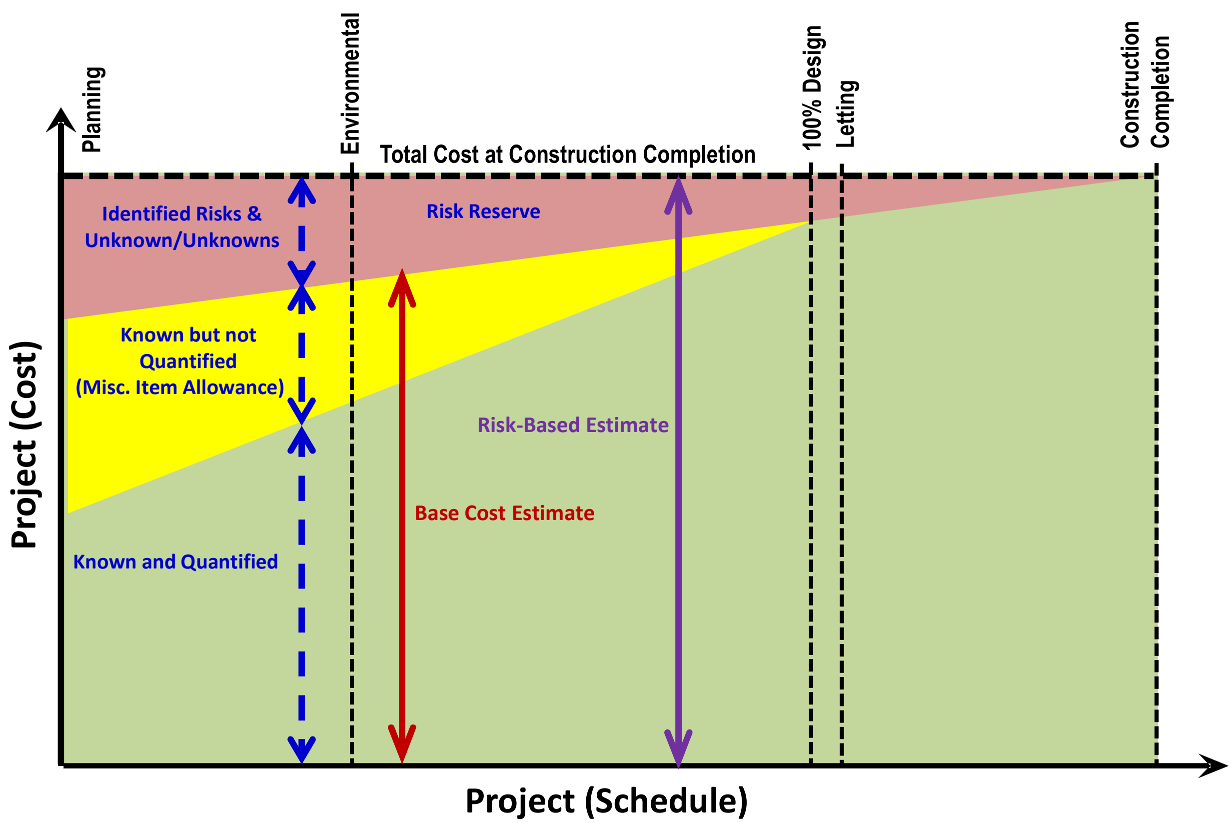

Figure 2 – Assessment of Project Cost

The base cost estimate for any project includes known and quantified items along with the other items needed to construct the project but have yet to be fully identified (miscellaneous item allowance). As depicted in Figure 2, as the project progresses, the number of known and quantified items increases and the items that have yet to be quantified and risks decreases.

A project cost or schedule estimate is more appropriately expressed not as a single number but as a range that reflects the uncertainties and risks specific to that project. Risk-based estimates replace traditional estimating approaches that rely on single-number estimates using lumped contingencies. By using a risk-based estimation process Project Managers and stakeholders develop a more complete understanding of possible project outcomes and their contributing factors. A risk-based estimate addresses each project uncertainty or risk on an individual basis. This will also allow the Project Manager to account and adjust the impacts of the major risks to the project as the project is developed.

The level of project risk management depends on the size and complexity of the project. All projects, regardless of project size and complexity, require some form of risk analysis and risk management planning. The framework of risk analysis remains the same, but the tools and level of effort vary with the project size and needs. Larger more complex projects need to use more robust analysis techniques via Monte-Carlo simulation models; whereas smaller, less complex projects may utilize simpler qualitative analysis. A qualitative analysis as identified in Section 12 could be utilized on smaller projects such as rural 3R's such NDOT's Risk Tracking and Analysis Tool for Small and Medium Size Projects.

These guidelines will help identify procedures to increase the effectiveness in the following ways:

- Provide a consistent approach for determining and updating the base cost estimate for all projects including:
  - quantity estimation
  - unit pricing
  - uncertainty surrounding quantities and pricing
  - estimate(s) reviews
  - estimate(s) documentation
  - estimate(s) communication
  - management of estimate data
- Provide guidance on how to treat the common and recurring challenges encountered in the estimating process.
- Provide methodologies of developing more accurate and consistent ranges for project scheduling and cost estimating to help improve planning and project delivery.
- Increase Project Manager and Project Team member risk awareness.
- Provide a structured methodology and ensure that risks are managed in a consistent manner on all NDOT projects.*****
- Identify data requirements for risk analysis input and for output.
- Provide tools, techniques, and guidance for proactive risk management.

***** The methodology used in development of these guidelines is consistent with the Project Management Institute's (PMI) Project Management Body of Knowledge (PMBOK) process.

The material contained in the following chapters does not provide "how-to" procedures with specific details on cost estimation practice or cost estimation management. However, this manual does provide the necessary knowledge and information for users to create and implement approaches that meet the requirements for managing project-specific cost and risk for NDOT projects.

1. Risk Management

1.1 Accounting for Risk in Project Cost and Schedule

Accounting for risk is critical to developing more accurate project estimates. Identifying risks and determining their potential impact will allow Project Managers to take into account factors that are not yet well defined but may ultimately influence project cost.

Traditional cost estimating methods, whether being done as historical-based estimates or cost-based estimates, are forms of “deterministic” estimating practices that result in single-value estimates with no indication of any optimism/conservatism or uncertainty that may be associated with the estimate value.. The input data relied upon for unit prices, quantities, and allowances typically use average values, probable values, or other statistical representations or estimator judgment.

Project base estimates are established or predicted based on available project knowledge and certain assumptions and contingencies. For example, engineering costs are developed based on anticipated scope, past experience, and assumed delivery method; construction costs are developed based on an anticipated design, allocating markups for known factors (e.g., 7% construction engineering), assumed quantities and unit costs; project schedule is developed based on an anticipated delivery method, probable milestones and past experience. However, as the project is developed, conditions may occur that will impact the base conditions for better (opportunities) or for worse (threats).

The traditional way of dealing with project unknowns is to establish contingency or allowance factors for cost and schedule. In this method, the project adjusted baseline is expressed as “base” plus “contingency”. The contingency value is based on judgment, experience, and set of assumptions with unknown confidence. More often than not this method can under or over estimate the actual scope, duration, and cost. Traditional estimating practices tend to produce “the number” for a project. But this single number masks the critical uncertainty inherent in a particular project. It implies a sense of precision beyond what can be achieved during planning, scoping or early design phases.

As mentioned a project cost or schedule estimate is more appropriately expressed not as a single number but as a range that reflects the uncertainties and risks specific to that project. Risk-based estimates replace traditional estimating approaches which rely on single-number estimates based upon the use of lumped contingencies. To determine an accurate estimate range for both cost and schedule, risk must be identified and quantified.

Project estimates should be comprised of three components:

- Base Cost
- Uncertainty
- Risk

The base cost represents the cost which can reasonably be expected if the project materializes as planned. This base cost may include allowances for known or anticipated miscellaneous or minor items, but it should not include any risks or contingencies.

Base estimate uncertainty can be quantified by applying ranges to cost items to reflect estimating uncertainty or variability in unit bid prices, quantities, and allowances. Uncertainty associated with quantities and allowances typically reduces as the design and estimate are advanced. Price uncertainty generally does not reduce unless the cost item is analyzed in greater detail (e.g., through a production-based estimate) or additional information is obtained. The base estimate uncertainty associated with construction costs to be performed by the contractor reduces to zero once the contract has been awarded and a fixed price established. Any remaining uncertainty associated with the elements of work contained in the contract are addressed as risks.

Once the base cost with its uncertainty has been established, a comprehensive and non-overlapping list of risks is created of both opportunities and threats, called a "risk register." The risk register includes explicitly defined risk events that are quantified based upon the potential consequences of each risk event (relative to the base estimate) and the probability of those consequences occurring. The risks are separate from (and in addition to the base estimate uncertainties).

Risk-based estimation methods utilize a variety of techniques, including historical data, cost-based estimating, and the best judgment of subject matter experts for given types of work, to develop the necessary inputs for risk analysis.

Quantitative techniques, such as Monte Carlo simulation, can provide powerful tools for analysis of project risk and uncertainty. This technique provides probabilistic forecasts of project cost and schedule which include a representation of the uncertainty associated with those forecasts. In this approach the base cost (with uncertainty), base schedule, and risks are combined to develop a risk-based estimate based on a specified percentile or confidence level (e.g., 70% probability of success). A risk reserve is then established as the difference between the baseline and the selected confidence level. It is recommended the 70th percentile as the target percentile for estimating purposes, unless directed otherwise by the Project Manager or Project Management Chief.. For additional details on risk reserve and allowances see **Chapter 16. Use and Reporting of Risk-Based Cost Estimation Results**.

A key by-product from risk-based cost estimation is that the NDOT management may be engaged early in the project development phase to offer guidance on how best to account for sensitivities and risks for the project and to provide direction on the confidence that project cost or schedule will meet specific outcomes. For example, Figure 3 is a graphical representation of a given project cost (horizontal axis) to its likelihood of not being exceeded (vertical axis)

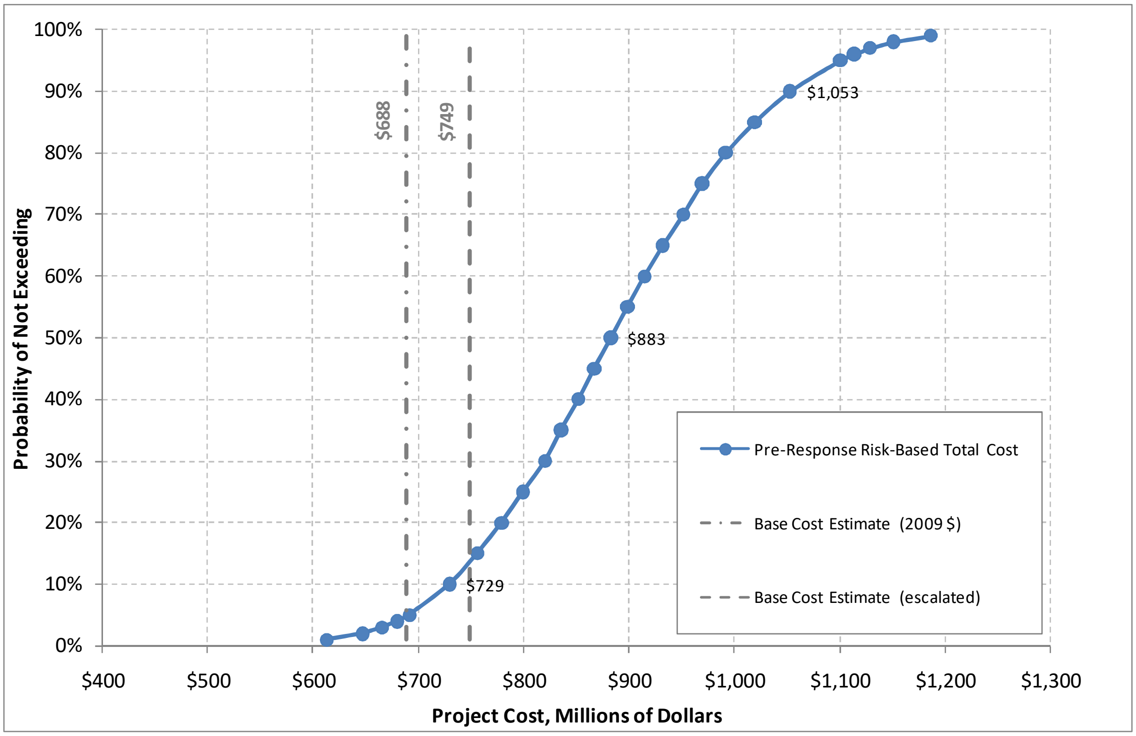

Figure 3 – Project Cost

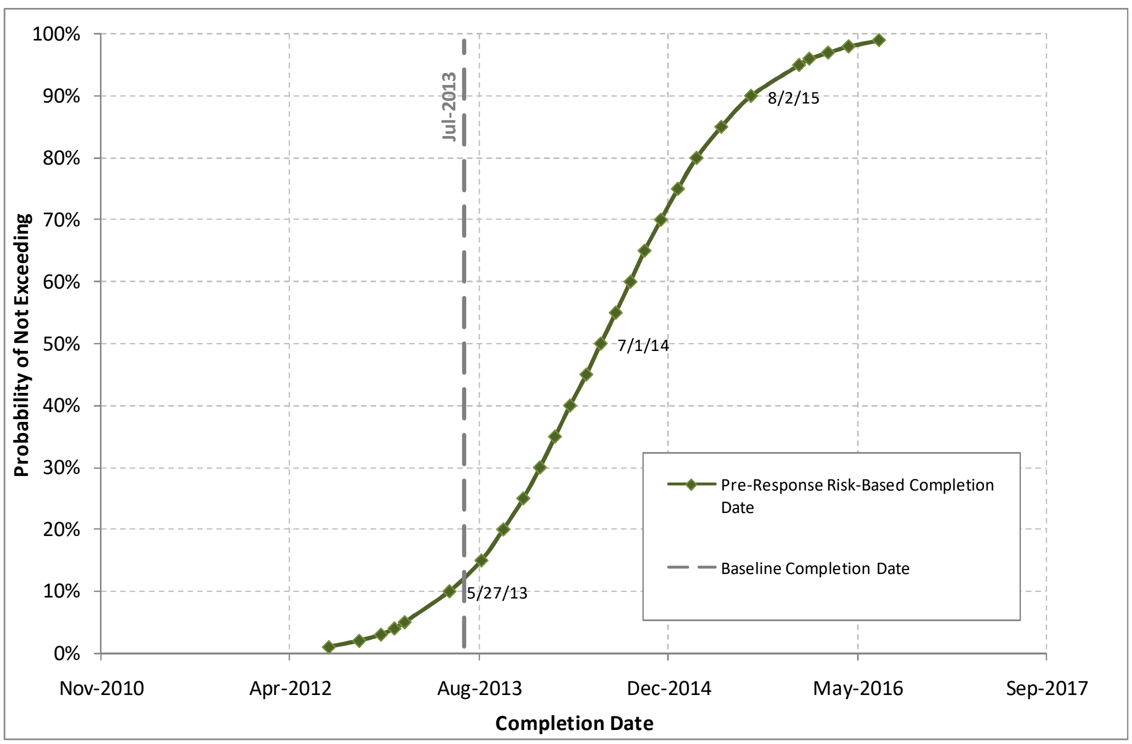

Figure 4 – Project Completion Date

Figure 4 is a graphical representation of a given project completion date (horizontal axis) to its likelihood of not being exceeded (vertical axis).

The use of such graphics, with supporting sensitivity analysis, provides an effective communication tool to help all project stakeholders quickly understand the nature and magnitude of project risks. Such information can be used to ensure that effective decisions are made at the appropriate management level, rather than at lower staff levels where cost and schedule estimates are often performed.

The risk-based cost estimation and associated risk management assists project development by:

- Encouraging pro-activity and early planning
- Building confidence and credibility in the project's plans and estimates
- Provide transparency to the project development process
- Improving communication among project disciplines
- Add credibility to the process so decision makers understand how the project scope, budget and schedule is derived
- Identifying specific threats and opportunities and developing targeted mitigation strategies
-
- Allowing better allocation of risks and identification of project delivery methods
- Allowing transparency, integrity, and accountability throughout the life cycle of the project
- Maximizing the likelihood of meeting on-time, on-budget goals
- Help projects avoid exceeding scope, schedule, and budget,

Project Managers must understand risk tolerance and then must weigh the value of project decisions with the risks associated with the project. It is important that NDOT continues to inform decision-makers of the risks associated with the projects developed.

Lastly, projects over $500 million are designated by the Federal Highway Administration (FHWA) as "major projects," which require that special attention be given to the preparation of the total program cost estimate. NDOT will conduct develop risk based cost estimates on projects over $100 million and it is also recommend on projects over $25 million.

In January 2007, FHWA issued cost estimating guidance for major projects and project ranging from $100 million up to $500 million. The document, titled "Major Project Program Cost Estimating Guidance", calls for rigorous, transparent cost estimating accounting for project risk and uncertainty. The processes and procedures outlined in these guidelines are intended to meet FHWA's requirements for the Cost Estimate Review (CER) process. While performing risk-based estimate and following the CER process is recommended for projects over $25 million, the NDOT Project Manager can elect to follow this process based on project complexity, scope, and schedule on projects between $25-$100 million.

1.2 Project Risk Management and Risk-Based Cost Estimation

Project risk management is a scalable activity, and the level of effort should be commensurate with the size and complexity of the project under consideration. Larger more complex projects need to use robust analysis techniques via Monte Carlo simulation models; whereas smaller, less complex projects may utilize simpler qualitative analysis.

A project is defined by the limits described in the environmental document. Projects are often implemented over a number of years and may involve numerous individual elements and segments. These individual segments may be progressed as individual contracts that collectively comprise the project.

It is NDOT policy to conduct risk-based cost estimating workshops for all projects over $100 Million in total cost. These workshops provide information to Project Managers that can help them control scope, cost, schedule, and manage risks for all projects. This policy reaffirms the requirement that a risk management plan is a component of every project management plan and financial plan.

For projects up to $100 million dollars, the Project Team can use a qualitative risk analysis approach in conjunction with a risk register.

Table 1 provides the risk management process based on project size. Project Managers are encouraged to use the recommended process on projects that have complicated elements or other high-risk items.

Table 1 – Risk Management Process

Project Size ($)	Required Process	Recommended Process
< $10 M	Qualitative Assessment	Qualitative Assessment
$10 M to $25 M	Qualitative Assessment	Informal quantitative workshop using the "NDOT Risk Tracking and Analysis Tool for Small and Medium Size Projects"
$25 M to $100 M	Qualitative Assessment	Cost Risk Assessment (CRA)
> $100 M	Cost Risk Assessment (CRA)	Cost Risk Assessment (CRA)

1.3 FHWA Requirements

FHWA has established requirements for cost estimation and risk analysis, which NDOT intends to meet or exceed for all projects receiving federal funding. FHWA requires the following for major projects (exceeding $500 million in cost) and for projects ranging from $100 million to $500 million:

- Maintain consistency with the current Major Project Financial Plan guidance.
- Maintain consistency with the current FHWA CER guidance.
- Evaluate project cost and schedule uncertainty through a probabilistic risk-based evaluation as described in the FHWA CER guidance.
- For projects with defined scope documented under NEPA and an established phasing plan, YOE cost results must be prepared for the funded phase as well as the total project.
- Include all previously incurred expenses (Pre-NEPA study, NEPA, ROW, or any preliminary engineering costs, etc.) in the total project cost results.

- For projects being procured as a public-private partnership (P3), a separate analysis of the risk allocation with the developer is required.
- FHWA has established the 70th percentile for budget establishment purposes, and NDOT has adopted the same guidance.

2. Cost Estimating Process

2.1 Introduction

All projects benefit from following a thoughtful and deliberate process in developing project cost estimates. The process adopted from the Washington State DOT and presented in Figure 5, describes the way NDOT develops its base cost estimates for projects over $100 million. It is applied to all levels of project delivery, starting with the planning level scoping estimate and ending with the final project plans, specification, and estimate.

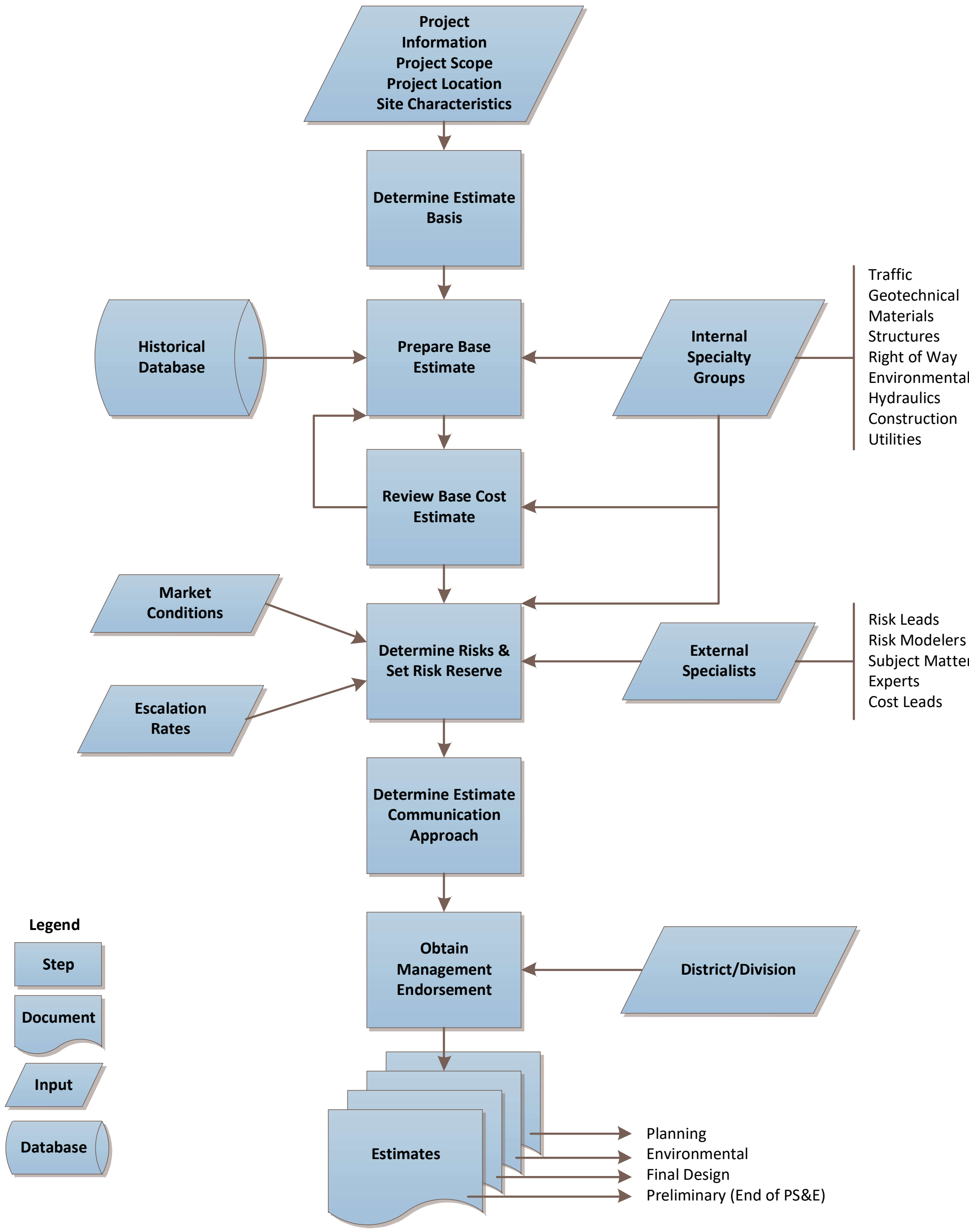

Figure 5 – Cost Estimation Process

Each level of estimate may require different estimating inputs, methods, techniques and tools. Projects over $100 million by nature can take many years to complete the planning, design, and construction process. During this time the estimate needs to be updated according to the timeline set forth in Section **16.4 Frequency of Estimate Updates**.

The task of cost estimating, by its very nature, requires the application of prudent judgment to the completion of the task. A short description of each step in the cost estimating process is presented below.

2.2 Determine Estimate Basis

This activity focuses on obtaining project information, including all previously developed project scope and schedule details and data, from which a project cost estimate can be prepared. The level of scope detail varies depending on the project phase, project type, and project complexity, but would include the design matrix and criteria, all assumptions and pertinent scope details.

The estimate basis should be clearly documented, with the end result being a complete traceable history for each estimate. This documentation is covered in detail in Chapter **7. Documentation/Basis of Estimate**.

2.3 Prepare Base Cost Estimate

This activity covers the development of estimated costs for all components of a project, excluding future escalation. These components may be estimated using different techniques depending on the level of scope definition and the size and complexity of the project. The number and detail of components estimated may vary depending on the project development phase.

For example, in the planning phase the NDOT WIZARD Tool is typically used for estimating. This tool uses parametric estimating techniques along with percentages for contingencies or risk.

As the design progresses into the environmental and final design phases and more details about the project are known, items within the estimate become more exact. Key inputs at this point in the delivery of the project include a more detailed scope, historical databases and other cost databases, knowledge of market conditions, and use of escalation rates. NDOT has internal specialty groups that should be used to provide estimate information when preparing base estimates. This documentation is covered in detail in Chapter **3. Base Cost Estimate Methodology**.

<u>A required component of any estimate is the preparation of a Basis of Estimate document describing the project and including underlying assumptions, cautionary notes, and exclusions.</u> The base cost estimate should also be consistent with, and include as an attachment for reference, the associated schedule for all remaining project activities.

During the planning phase, the project schedule will be cursory and very general in its coverage. However, as a minimum it should include the major milestones NDOT uses to measure performance and progress on projects. The planning phase schedule may only include a few activities, but should begin with the development of the project, and include right-of-way/ utilities, design, and construction.

NOTE: All base cost estimation is done in current year dollars.

2.4 Review Base Cost Estimate

This activity is necessary to ensure:

1) assumptions and basis are appropriate for the project and the project delivery method,
2) the base cost estimate is an accurate reflection of the project's scope of work;
3) any added contingencies or escalations have been removed;
4) scope, schedule and cost items are calculated properly and required components are not missing or double counted; and
5) historical data, the cost-based estimate data, or other data used reasonably reflects project scope and site conditions.

NDOT Specialty Groups and/or subject matter experts (SMEs) must participate in reviewing the base estimate. See Chapter **9. Independent Estimate/Estimate Review**.

2.5 Determine Risks

This activity is part of developing a risk management plan for a project and is an integral component of project management planning process. Risk management is an active and ongoing process of maximizing the probability and consequences of positive risk events (opportunities) and minimizing the probability and consequences of negative risk events (threats) to the project objectives.

In the context of cost estimating, the cost impact of project risks (whether an opportunity or a threat) must be included to derive a total project cost. This is required for all projects over $100 million and suggested for projects under $100 million.

Formal or informal risk assessment techniques are a valuable and valid tool and should be applied to all estimates. This documentation is covered in detail in Chapter **11. Risk Identification**.

2.6 Determine Estimate Communication Approach

Cost estimates are communicated to both internal and external constituencies. The communication approach determines what estimate information should be communicated, who should receive this information, how the information should be communicated, and when the information should be communicated.

Cost estimate information should be included when the communication plan is developed as part of the project management process. Often the words are as important as the numbers. The Basis of Estimate (BOE) document can be used effectively as a communication tool to convey key information about the project to others. See Chapter **7. Documentation/Basis of Estimate**.

2.7 Conduct Independent Review and Obtain Management Endorsement

Base cost estimates are key products of the project management process and are fundamental documents upon which key management decisions are based. Given their importance, all base cost estimates should receive an independent review and then be reconciled and revised as needed to respond to comments that may arise from an independent review. Independent review will consist of experienced individuals that were not involved in the development of the original base estimate. The independent review team should be comprised of staff with equal or greater experience than those that developed the base cost estimate. It is important the independent review team an unbiased approach in validating the base cost estimate. Once independent review comments have been satisfactorily incorporated, estimates should be presented to management staff for approval. See Chapter **9. Independent Estimate/Estimate Review** of this manual.

Management approval, both Division specific and overall project manager/coordinator, of estimates developed for initial budgeting or baseline definition is a necessary step in the overall project management process to provide realistic and dependable estimates. Revised estimates typically developed if project requirements change, or as design is developed, should also be reviewed by management staff, revised as necessary to reflect management comments, and then approved. Each revised estimate shall then be incorporated into project cost baselines through the established project change management process.

3. Base Cost Estimate Methodology

3.1 Introduction

NDOT's vision for risk-based cost estimation and risk management calls for well-documented and complete base cost estimates. To accomplish this, estimates need to have clearly spelled-out assumptions and risks that can be easily communicated. The key to realizing this vision is a universal understanding of all components of a project's base cost estimate.

Estimation methodologies fall into one of four categories: parametric, historical bid-based, cost-based, or risk-based. These categories encompass many individual techniques/tools to aid in preparing cost estimates. It is important to understand that any combination of the methods may be found in any given estimate as shown in Table 2.

Table 2 – Cost Estimation Methodologies

Project Development Phase	Purpose of Estimate	Methodology
Planning	Conceptual Estimating	Similar Projects Parametric Historical % Risk-based NDOT Wizard
	Budget Authorization (Establish baseline cost for project)	Parametric Analogous Projects Historical % Risk-based NDOT Wizard
	Early Design Estimates	Parametric Analogous Projects Historical bid-based Risk-based NDOT Wizard
Environmental	Design Estimates (Project Control of Scope, Schedule, Budget)	Historical bid-based Cost-based Risk-based
Final Design	Final Engineer's Estimate (100% Design) Preliminary Estimate (Ready for Advertisement	Historical bid-based Cost-based Risk-based

As shown in Table 2 risk-based cost estimation can happen at any time during the project development process.

3.2 Base Cost Estimating Techniques

Cost estimating begins when a project enters into the planning level scoping phase of project development. However, estimating occurs throughout the other design phases of project development. Early cost estimating is critical, as this is the time when the baseline project definition, cost, and schedule are determined. Base cost estimating techniques must produce consistent and accurate estimates. However, the use of cost estimating tools will vary depending on the level of project definition, the project type, and complexity of the project.

Computer software such as the NDOT Wizard Tool is often used to facilitate application of these types of estimating techniques especially during the planning (pre-NEPA and NEPA) process. There are a variety of techniques that can be used to support cost estimating, which can be summarized as follows:

Estimation based on Analogous or Similar Projects: This technique relies heavily on one project very similar to the project being estimated. The reference (analogous or similar) project is typically one previously constructed within a recent timeframe, is currently under construction, is bid for construction, or has a completed final design level estimate. Items, quantities, and unit costs from the similar project are used as a basis for estimating the current project. Similar costs from the reference project can be used to estimate other groups, categories, elements, and items of total project cost.

Parametric Estimation: Parametric estimation techniques are primarily used to support development of scoping or early design estimates where very little project definition is available. Major project parameters are identified. Statistical relationships and/or non-statistical ratios between historical data and other parameters (e.g., tons of asphalt, square foot of bridge deck area) are used to calculate the cost of various items of work. The length, width, and depth (LWD) is a type of parametric estimating. Typically, the historical bid prices used to develop the estimate come from previous projects awarded by NDOT.

NOTE: The NDOT Wizard tool uses parametric estimation techniques to assist in creating estimates during the Planning Phase of a project.

Cost-Based Estimates: This technique relies on the estimating approach wherein construction costs, based on a selected productivity, are estimated for labor, material, equipment, contractor overhead, and contractor profit for each major item. This approach typically produces an accurate estimate and is useful in estimating unique items of work where there is insufficient bid history. The application of cost-based estimating during Scoping and Design would be similar to that used during Letting. Estimates of other groups and/or categories of total project cost are estimated from the bottom up. This means that resources associated with certain groups or categories, such as project development and detailed design, are specifically identified for elements and tied to when these resources will be engaged on the project (i.e., a period of time a lead designer will work on a project).

Cost-based estimate methods do not rely on historical NDOT bid data, but rather are based on determining, for an item or set of items, the contractor's cost for labor, equipment, materials and specialty subcontractor effort (if appropriate) needed to complete the work. A reasonable amount for contractor overhead and profit is then added.

This method is preferable on unique projects or where geographical influences, market factors and volatility of material prices can cause the use of historical bid-based methods to be unreliable. Also, since contractors generally utilize a cost-based estimating approach to prepare bids, this method can provide more accurate and defensible costs to support the decision for contract award/rejection and to support any future price negotiations with the contractor after contract award.

Cost-based estimates require significant effort, time, and estimator experience to prepare. They should be limited to those items that comprise the largest dollar value of the project, typically that 20% of items of work that account for 80% of project cost. The cost of the remainder of estimate line items can be determined using historical bid-based estimate methods. This approach provides for a more efficient use of estimating resources and reduces the total time and cost of preparing cost-based estimates. Cost-based estimating is also a good way to check a few large items of work in a historical bid-based estimate to ensure that the historical prices are still valid.

Historical Bid-Based Estimation: The use of historical unit cost bid data from recently bid contracts is the most common estimation approach. Under this approach, bid data are summarized and adjusted for project conditions (e.g., project location, size, quantities, etc.) and the general market conditions. Items are developed for major elements of work so quantities and historical unit prices can be applied to these items. Early on, during the Planning and Environmental Phases, percentages (Miscellaneous Item Allowance) are used to estimate items where little or no definition is available.

Historical bid-based methods are commonly used and are appropriate when design definition has advanced to the point where quantification of units of work is possible. These methods apply historical unit costs to counts or measures of work items to determine a total cost for the item or project.

The unit cost data used is typically received by NDOT in bid documents from prior projects and should be modified or adjusted to reflect current prices (escalate to current time) and project specific conditions such as geographic location, quantity of item needed, and the scheduled timing of project advertisement. See Chapter **5. Important Factors Impacting Base Cost Estimation** later in these guidelines.

Historical cost data sources include:

- Masterworks
- Bid Tabs Pro by Oman Systems
- RS Means, when NDOT specific unit costs are not available (this tool can be used for both historic bid-based and cost-based methods)

NOTE: It is important to remember unit bid cost data from past projects carries with it all of the adjustment from the various factors discussed in Chapter 5 along with any risk associated with that item. Very high and very low unit bid prices should be reviewed prior to acceptance.

Estimation based on Historical Percentages: This technique is used in conjunction with other tools such as historical bid-based estimating. Historical percentages are used to estimate costs for items within an element not typically defined early during the planning and NEPA phase. A percent is developed based on historical cost information from past projects to cover certain items comprising an element. This percentage is based on a relationship between the sum of the selected items and a total cost category such as direct construction. Historical percentages are used to estimate other groups and/or categories of total project cost.

Combined Cost Estimation Approach: As described in the section on total project cost, a project's base cost estimate could include diverse and largely unrelated components, such as the roadway, bridges & structures, haul roads, utilities, and environmental clean-up. Therefore, the methodology employed for estimating costs is likely to be different depending upon the available data and the project phase in which the cost estimate is prepared. The estimate needs to diligently documented and communicated to the Project Team. The basis as well as the methodology used for estimating the costs associated with work elements, and items need to be clearly identified. Integrating the estimated costs for each into the base cost estimate is a significant responsibility that cannot rest on a single person, especially for complex projects.

3.3 Uncertainty

Estimating is not an exact science; a cost estimate is only a projection of the ultimate project costs and is made up of many elements that may not be completely or equally defined at the time the estimate is prepared. As a result, there is variability or uncertainty associated with any estimate. When applied to the project estimate, this uncertainty reflects the range within the base cost is expected to fall at project completion.

A numerical value of uncertainty is, in essence, an estimate of the error or tolerance within the quantity or unit price of an item. For any given project, the level of uncertainty is directly related to its position in the project life cycle, i.e., the earlier in the project development process, the greater the uncertainty; conversely, the closer to completion, the less uncertainty.

Uncertainty can be expressed in terms of a percentage (of the quantity and/or unit cost) lower or higher than the base as shown in Figures 6 through 9, or in absolute unit price or quantity terms.

		Unit Cost				
Item and Description	**Unit**		**Under**	**Base**	**Over**	
SECTION 2: GRADING						
Roadway Excavation Incl Haul	C.Y.	$15.75	-10%	$18	5%	$18.38
Unsuitable Foundation Excavation Incl. Haul	C.Y.	$18.41	-5%	$19	25%	$24.22
Gravel Borrow Incl. Haul	C.Y.	$19.55	-15%	$23	5%	$24.15
Embankment Compaction	C.Y.	$1.90	-5%	$2	5%	$2.10

Figure 6 – Example of Unit Cost Uncertainty Ranges

When estimating a unit price for an item, other projects with similar characteristics are reviewed. These past projects help inform the selection of unit price for use in the current project estimate. When reviewing unit bid prices from the historical database, a range of costs for an item will be identified. This price history, coupled with the estimator's professional judgment, can be used to inform the base unit cost of an item along with the low and high costs or uncertainty range.

Example: Project A had a unit bid price of $15/CY for roadway excavation and Project B had a unit bid price of $19/CY. The amount of material on our project is similar to Project B, but Project A is a more recent contract. The person estimating this material may choose $18/CY as the base unit price figuring the volume of material sways the cost in that direction with an uncertainty range of low of $16/CY (roughly 10%) and a high of $18.5 (roughly 5%).

Item and Description	Quantity				
		Under	Base	Over	
SECTION 2: GRADING					
Roadway Excavation Incl Haul	61,213	-5%	64,435	5%	67,657
Unsuitable Foundation Excavation Incl. Haul	12,246	-5%	12,890	5%	13,535
Gravel Borrow Incl. Haul	62,947	-5%	66,260	5%	69,573
Embankment Compaction	56,821	-5%	59,812	5%	62,803

Figure 7 – Example of Quantity Uncertainty Ranges

As the design progresses on a project we learn more about it. During the Planning and Environmental Phases, we may just have an approximation of the quantities needed for certain items if computer modeling hasn't been completed yet. During Final Design the range of uncertainty around bid items narrows as we get a clearer picture of the amounts needed.

Item and Description	Total Cost		
	Under	Base	Over
SECTION 2: GRADING	-16.3%		12.0%
Roadway Excavation Incl Haul	$964,108.69	$1,127,613	$1,243,192.78
Unsuitable Foundation Excavation Incl. Haul	$225,393.73	$249,744	$327,788.67
Gravel Borrow Incl. Haul	$1,230,613.85	$1,523,980	$1,680,187.95
Embankment Compaction	$107,960.66	$119,624	$131,885.46
Subtotal Grading	**$2,528,077**	**$3,020,960**	**$3,383,055**

Figure 8 – Example of Total Cost Uncertainty Ranges

The price and quantity uncertainty ranges can then be mathematically combined to create the overall uncertainty range for the base cost estimate, considering the assumptions used to establish the range parameters and any correlations (i.e., indirect relationships due to common underlying factors such as raw material pricing, etc.) among individual line items.

Item and Description	Unit	Comments
SECTION 2: GRADING		
Roadway Excavation Incl Haul	C.Y.	large quanity may bring a better unit price
Unsuitable Foundation Excavation Incl. Haul	C.Y.	unsuitable ex is typically 25-50% more expensive than roadway ex
Gravel Borrow Incl. Haul	C.Y.	depending on haul, unit price could be lower
Embankment Compaction	C.Y.	

Figure 9 – Example of Total Cost Uncertainty Comments

When the estimator establishes the uncertainty ranges, consideration should be given to other factors that might affect quantities or bid prices, such as level of design, delivery method, specialty items, project location and accessibility, project terrain, effect of existing traffic on the contractor's operations, source and availability of materials and water, time limits that might require more than ordinary overtime work or double shifting, and season of the year in which the work is to be done.

The uncertainty ranges established by the project estimators should be reviewed and validated by the project team and applicable discipline representatives prior to risk modeling.

See Chapter **5. Important Factors Impacting Base Cost Estimation** of these guidelines for additional information.

Uncertainty associated with quantities and allowances typically reduce as the design and estimate are advanced. Price uncertainty generally does not reduce unless the cost item is analyzed in greater detail (e.g., through a production-based estimate) or additional information is obtained. The base estimate uncertainty associated with construction costs to be performed by the contractor reduces to zero once the contract has been awarded and a fixed price established. Any remaining uncertainty associated with the elements of work contained in the contract should be addressed as risks.

4. Base Cost Estimation and Project Development Level

4.1 Overview

The base cost estimate represents the project cost that can reasonably be expected if the project materializes as planned and there is no risk. The base cost estimate is unbiased and neutral - it is neither optimistic nor conservative. The base cost includes the known and quantified items and the known but not yet quantified items (miscellaneous item allowance). The base cost estimate does not include any risks, unknown/unknowns, escalation, or contingencies.

There are three main project development levels for design-bid-build delivery within NDOT prior to advertisement and construction:

1. Planning
2. Environmental
3. Final Design

The base cost estimate for each level of project development has a specific purpose, methodology, and expected level of accuracy. The following table was revised from "Cost Estimating Manual for WSDOT Projects". It summarizes the relationship existing between the various project development levels, purpose of the estimate, estimating methods, and the estimates expected level of accuracy.

Table 3 – General Cost Estimation Ranges

Project Development Level	Project Maturity (% of design completed)	Purpose of Estimate	Techniques	Expected Level of Accuracy
Planning	0% to 2%	Conceptual Estimating Alternatives Evaluation	Risk-based or Judgment Historical % Similar Projects Parametric NDOT Wizard	-50% to 200%
	1% to 15%	Budget Authorization (Establish baseline cost for project)	Parametric Analogous Projects Historical % Risk-based NDOT Wizard	-40% to 100%
Environmental	15% to 30%	Design Estimates (Project Control of Scope, Schedule, Budget)	Historical bid-based Cost-based Risk-based NDOT Wizard	-10% to 25%
Final Design	30% to 100%	Preliminary Estimate (prior to advertisement)	Historical bid-based Cost-based Risk-based	-5% to 10%

Note the inverse relationship in Table 3 between the project development level of design and the expected accuracy range. Some of the typical causes of project cost accuracy are lack of scope definition, multiple alternatives, and lack of information about factors outside the roadway prism (right of way, community, cultural, and environmental). As the project progresses, more data becomes available and the expected accuracy range narrows.

4.2 Planning Level

In this level the project needs are analyzed and conceptual solutions are developed. Project descriptions, costs, and schedules are broadly defined. The planning level typically addresses such issues as number of lanes, location and length of project, and general interchange and intersection spacing. The intent of this level is to develop reasonable and feasible design alternatives, and to identify the best means to address risk and uncertainties in cost, scope, and schedule.

The Planning Level typically consists of two sub-phases: Systems/Corridor Planning; and Scoping Process.

Systems/Corridor Planning

The Planning Division is the project lead during systems/corridor planning sub-level. They control the scope, budget, and schedule of project activities in this sub-level. As necessary they will form and manage a Project Team to assist them with their activities. The Project Manager, if assigned, acts as an advisor to the planning division. The project participants and the Project Manager assist the planning division to refine the purpose and need of the project and develop a rough base cost estimate of project options, costs, and schedule ranges.

Scoping Process

At the end of the systems/corridor planning level (typically completion of the corridor study and beginning of the Environmental Study Phase), the Systems/Corridor Planning results are forwarded to Project Scoping to begin and lead the scoping process. A Project Manager is assigned as the project lead and is included as a member of the Scoping Team.

In the planning level of project development, there is usually very little information with which to work, and the information known is often incomplete or dated. The Scoping Team takes a detailed look at a project by gathering available data, reviewing this information, conducting field studies, coordinating with major disciplines including stakeholders, developing alternatives, determining the risk and preparing a cost estimate and a schedule for the most likely alternative.

The base cost estimate should reflect costs for all work being contemplated and the Scoping Team should have rough calculations and assumptions to back them up. All items of work should be identified; the associated units of work, quantities and unit costs should be incorporated into the base cost estimate.

Clearly document assumptions and scope definitions in the Basis of Estimate (BOE) document so that all future changes can be accurately compared to this estimate.

4.2.1 Techniques

The NDOT Wizard tool uses parametric estimating techniques and is often used for planning estimates. Per lane mile and per square foot are two types of parametric estimating techniques the Wizard Tool uses. Historical bid prices and historical percentages can also be used to generate costs during the planning level. Analogous project estimating is another approach that can be utilized (see Section **3.2 Base Cost Estimating Techniques**).

Add the appropriate percentage(s) for miscellaneous item allowance(s) (see Section **6.2 Miscellaneous Item Allowance**) within the base cost estimate. For items such as drainage, traffic control, structures, etc. contact the appropriate subject matter expert to determine the amount or percentage to be used based on the type of project and the level of current design.

4.2.2 Potential Challenges

When using analogous project estimating, the chosen historical project must be truly analogous. Finding an appropriate project or projects and determining the similarities and differences between the historical projects and the current project can take significant time and effort. Project data from older projects is less reliable due to variations in prices, standards, construction technology, and work methods. Project location, timeframe, size, quantity differences, delivery method, and contractor are among additional considerations that should be accounted for when selecting an analogous project. The analogous method is best used as a tool to determine broad price ranges for simple, straight forward projects or as a check to verify estimates prepared using another method.

- Due to the lack of scope definition or preliminary design, care should be taken to properly communicate with project stakeholders regarding the range of possible cost and schedule changes as the project becomes more defined.
- Given the large-scale assumptions inherent in parametric estimating methods, all assumptions must be documented clearly.
- Provide an adequate range of costs reflecting the unknowns in the project. This can be accomplished through allowances in the estimate for those items not yet defined or quantified.
- Keep the estimate current as the project waits to move on to preliminary design.

4.3 Environmental Level

Projects requiring federal approval, change of access control on an access-controlled highway, or use federal funding are subject to the National Environmental Policy Act (NEPA) to address potential social, environmental, economic, and political issues. During this level studies are conducted to define existing conditions and identify likely impacts and mitigations resulting in the preferred design alternative being selected from among the various alternatives. In this level the project scope is fully defined, preliminary designs are refined, significant right-of-way issues are identified, project costs and benefits are estimated, and risks are broadly defined.

Finally, a preliminary project schedule is determined. At the conclusion of this level, major projects are divided into smaller construction segments to address the project's social, environmental, economic and political issues as well as funding availability and constructability.

During the Environmental Level the project schedule should be based on the work breakout structure template for the appropriate project type. The schedule should be maintained using historical data from previous projects of similar nature, conversations with major project contributors and the judgment of other experienced Project Managers.

The Project Team should maintain the estimate using various estimating techniques, the best information readily available. The Project Team should always develop its own estimates and not rely on previous attempts.

The requirements and assumptions will become better understood for many items in the scope such as right-of-way needs, likely permit conditions, environmental mitigation, quantities of major items, and outside stakeholders. As scope definition improves, the accuracy of the estimate will likewise improve. The work effort required to prepare, document and review the estimate also increases.

Continue to adjust the uncertainty ranges for unit prices and quantities and update the miscellaneous item allowances within the estimate to reflect the additional understanding. Clearly document each of these updates in relation to the previous estimate. Update the Basis of Estimate document for the project as appropriate (See Chapter **7. Documentation/Basis of Estimate**).

4.3.1 Techniques

For quantifiable items such as asphalt concrete pavement, bridges and roadway excavation, historical bid-based or cost-based estimating methodologies should be used for pricing. Other items not yet quantified may be estimated parametrically or through the use of historical percentages. Adjustments to the amount of uncertainty should be made. As more information is obtained the amount of uncertainty for each bid item should be reduced.

At this point in the life of the base cost estimate the miscellaneous item allowance percentages should be changed to an estimated dollar amount. As the project progresses and items are identified and quantified an equal amount of dollars should be removed from the miscellaneous item allowance.

As design definition advances, engineers are better able to determine project work items and their associated quantities and unit prices. Historical bid-based methodologies are typically used for items of work for which historical data is available. Cost-based estimating methodologies can be used for those items with little or no NDOT bid history, or for major items of work that are project “cost drivers”.

Key resources are suppliers, contractors, and other individuals knowledgeable about current prices for the subject items, typical construction methodology and production rates, and equipment used. The designer should contact these resources to develop basic cost data for materials, labor and equipment. Continue to adjust the amount of uncertainty applied to each bid item

Risks should be identified, and a risk management plan developed to be included in the estimate notebook for future reference.

4.3.2 Potential Challenges

All changes, assumptions, and data origins should be clearly documented by using the Basis of Estimate (See Chapter **7. Documentation/Basis of Estimate**). This is particularly important because any future estimates will be compared with this one to justify changes in the cost of the project.

Individuals estimating quantities or unit costs should guard against false precision; assuming a level of precision not inherent to this level of estimate. Although a properly developed estimate will include well documented assumptions, many of the details impacting project cost are not defined at the time a scoping level estimate is done.

It is important to choose the correct unit costs for major items and then correctly escalate those costs to current dollars. This includes rounding costs (and quantities) to an appropriate significant figure.

Significant project definition continues to be developed until the project is ready for advertisement. Use appropriate item allowances and ranges for estimates.

If cost-based estimation techniques are used, pay special attention to documenting all of the assumptions made in the development of unit prices such as the crew size, crew make up, production rates, equipment mix and type. The costs assumed for contractor overhead and profit as well as for subcontractor work should also be clearly documented. It is important to remember these decisions may not reflect the decisions of the individual contractors bidding the job, thus introducing elements of risk into the estimate.

Use sound risk identification and quantification practices to ensure major risks to the project are identified and documented.

4.4 Final Design Level

During this level, the design and delivery method of the selected alternative identified during the environmental studies phase is finalized. In this level the project scope is finalized, detailed project design schedule and cost estimates are developed, and project benefits are fully determined. The right-of-way requirements are also determined and acquisition is initiated. Additionally, utilities relocation is initiated toward the end of this level. At the end of this level the project design and cost estimate are completed and the project is advertised for construction.

The base cost estimate is prepared for the final contract review in preparation for advertisement and is used to obligate construction funds and to evaluate contractor’s bids.

During Final Design Level the schedule should be based on the actual man hours needed to complete the remaining work and guaranteed delivery dates from major project contributors. Before submitting the project workbook and plans, the designer should ensure quantity calculations have been cross checked. It is preferable another Design Team checks the plans against the base cost estimate. With every revision to the base cost estimate the Basis of Estimate document needs to be updated.

4.4.1 Techniques

The project has matured to a point design engineers are able to specify all items of work required for the project and accurately estimate quantities and unit prices. This level of project estimate has the advantage of detailed understanding of project scope, conditions, and construction phasing. If the person providing information to the estimate is from outside the Project Team, they should take special care to understand the details of the project, including performing a detailed review of the plans and specifications.

All quantities and unit prices should reflect current knowledge at the time of the estimate. At this point in the life of the estimate there should be no placeholder for miscellaneous item allowance. Clearly document the development of, and adjustments to, line item quantities and prices. This is critical for both the review of the estimate and the review of bids prior to award. This data should be clearly defined and identified in the estimate file.

Historical bid-based methodologies should be used for most items of work where historical data is available. Cost-based estimating methodologies can be used for those items with little or no NDOT bid history, or to check major items of work significantly impacting the total project cost. Review the risks again and update the Project Risk Management Plan with the current base cost estimate information.

4.4.2 Potential Challenges

Reviews of estimates should be extensive and detailed and should include final independent QA/QC checks of calculations, prices and assumptions. The basis of estimate and overall estimate documentation package should be carefully reviewed to make sure they are complete, accurate and easily understood, and all numbers, from detailed backup to summary levels, are traceable.

- Major quantities and cost drivers should be carefully checked to assure they have been properly calculated (proper conversion factors have been used and allowances applied to neat line quantities if applicable).
- Specialty group estimates should be reviewed for both scope and cost.
- Contract special provisions should be carefully reviewed and cost and schedule impacts incorporated into the engineer's estimate.

5. Important Factors Impacting Base Cost Estimation

There are many important factors influencing a base cost estimate and its uncertainty. These factors and the amount they affect the base cost estimate needs to be clearly shown in the basis of estimate document. The impact they have on unit prices and quantities is not to be duplicated in the identified risks of the project.

5.1 Geographic Considerations

Geographic considerations can have a profound effect on the selection of unit bid prices. The project's location, whether it is in an urban, suburban, or rural setting should be considered in establishing unit bid prices. Remember that some of the cost considerations relating to a project's location may be accounted for by the contractor in the mobilization bid item.

A project in an urban setting generally has to contend with construction operations occurring in more confined workspaces, with greater volumes of traffic, and limited hours of operations, night-time work, etc. Some of these factors may be offset by availability of local contractors, materials, equipment and personnel.

Transportation costs can be significant if items and materials need to travel more than the usual distance to get to the project site. Projects located in rural or remote locations have factors that affect the establishment of unit bid prices contrary to projects located in urban settings. Construction operations may have less restricted work areas, less traffic to contend with, and additional hours to complete the work; all factors that increase productivity. On the other hand, materials, equipment and personnel may have to be brought in from out of the area which may increase costs related to transportation, support, wages, per diem, etc. Access issues can also affect unit bid prices.

On projects that utilize large quantities of aggregate, whether for base, surfacing, or earthwork, the location of material sources and disposal sites may have a large impact on costs. Nearby material sources or disposal sites reduce hauling costs. On rural projects, the cost of bringing in a concrete batch plant, hot mix asphalt plant, or similar facility, may increase unit bid prices.

Terrain may also be a consideration in establishing an items cost. Mountainous terrain and steep grades cause production rates to fall, whereas level terrain and straight roadways generally have the opposite effect.

Varying soil conditions are covered under geotechnical conditions.

5.2 Quantity Considerations

The quantity of a given material on a project impacts the unit cost of constructing and/or supplying that item. This is not simply a supply and demand issue, but also one of production efficiency and economy of scale. Generally speaking, the unit price for larger quantities of a given material will be less than smaller quantities. Suppliers offer discounts for larger quantity orders. Mobilization, overhead and profit are all spread out over a larger quantity, thus reducing their effect on each unit. Waste is also spread over a larger quantity thereby having a smaller impact on each unit. Larger quantities also give rise to efficiency by gained experience and expertise of the contractor's personnel in completing the work.

Projects with very large quantities of certain materials may cause an increase to the unit bid price. For example, a project with numerous or large structures may affect the market for a particular type of steel or the availability of cement.

Small quantities of items of work are less cost effective to construct and hence lead to higher unit prices. Not only do suppliers charge more for smaller purchases, but in some instances the minimum amount to be purchased is greater than the needed quantity. Small quantities do not generally allow for high production rates or other efficiencies and thus cause higher unit costs. Smaller quantity items are also frequently subcontracted out. This practice increases a contractor's overhead and usually results in a markup being applied to those items.

5.3 Scheduling/Lead Time

To be efficient, a contractor needs to optimize the scheduling of his resources including labor, equipment, and materials. When a contractor can plan for and maximize his resources, he can become more competitive in his bidding. However, the lead time needs to be considered in the estimating process by estimating the project based upon when it is expected to be built. For example, a project two seasons long may have the majority of its paving in either the first or the second year.

5.4 Difficult Construction/Site Constraints

Difficult construction and site constraints will increase the cost of construction for a contractor. Placing piles under water, working near active railroads, nearby historical buildings (possibly fragile), construction on or near culturally important or environmentally sensitive/hazardous sites, and limited room to construct an item are all examples of constraints that should be considered.

5.5 Methods of Payment

5.5.1 Lump Sum Items

From an estimating standpoint, lump sum bid items are often more difficult to price. Lump sum items can reduce administrative costs in contract administration, as well as allowing a contractor a variety of work means and methods, and thus do make sense in some instances. They also transfer the risk of performance and quantities to the contractor.

<u>If the work to be performed can be quantified, then a payment method including a quantity should be used.</u> However, lump sum bid items are often used when an item of work can only be defined in general terms, such as when the finished product can be defined but not all the components or details can be easily determined. This can make estimating lump sum items difficult.

The more information and breakdown of a lump sum item availability, the greater the likelihood accurate lump sums can be developed. A lump sum item should be defined in terms of its simplest, most basic components and should consider other factors not easily estimated. By breaking out a lump sum item into smaller items of work which have historical data, and then applying reasonable estimated prices to those subunits, a price for the overall lump sum item can be accurately established.

Lump sum items are typically bid at higher costs than component costs due to the transfer of risk from the owner to the contractor. Contractors cannot necessarily rely on overruns to cover work they did not foresee. Therefore, the use of lump sum items should be used with great care.

In some situations, as may be the case for a time-based lump sum bid item such as Traffic Control, the lump sum payment may provide the basis as an incentive to perform the work more quickly. In such a situation, hourly pay items offer no incentive, and may even cause the contractor to stay in the work zone as long as possible. However, in most situations using lump sum bid items will lead to higher contractor bids.

With this in mind lump sum items should only be used when the following conditions apply:

a) The lump sum item is a standard item with no appropriate alternative non-lump sum standard item available for use.
b) The work is not easily defined. In other words, the final product is known, but the construction techniques or other components are difficult to determine.
c) Complex items with many components (although the designer is encouraged to break down constituent items if possible).
d) The lump sum payment may be justified as an incentive to complete the work in a more timely or efficient manner than if other units of measure were used.
e) The lump sum item may be justified as less expensive than a force account item (see below) or where the risk assumed by the contractor is low.

The use of a lump sum item must be justified, and the work breakdowns documented in the estimate file.

5.5.2 Force Account

Force account is a method of payment that pays the contractor his actual expenses for all labor, materials, and equipment to complete the work. Markups for material costs, labor surcharges, overhead and profit may be added to this figure. The force account method of payment is used primarily for “extra work” (i.e., work unforeseen at the time a project is let or advertised and is discovered during construction) or for items of work poorly defined and may or may not be used during construction.

Remember, since the contractor does not usually bid on this work, there is little incentive for him to reduce costs or prosecute the work diligently. Because of this, the force account method of payment should only be used when necessary.

When a reasonable cost estimate for a force account item is required, a scope of work should be established for the work needing to be accomplished. Once the scope is developed, it can be compared to historical bid price data for similar items of work. If no comparable history exists, the force account item should be broken out into its anticipated core components. Historical bid data can be relied upon for those items and the given limitations to come up with a reasonable force account estimate. If no such data exists for even the smaller core items of work, the amount and costs of labor, materials, and equipment to execute the work may need to be estimated (i.e.: use the cost-based method of estimating).

Note: Force account may also be considered a tool for transferring risk from the contractor to the owner. If the work is properly directed by the project inspector, force account may actually cost less than an equivalent lump sum item.

Use of force account items and their estimated cost must be documented and justified in the project estimate file.

5.6 Timing of Advertisement

When a project is advertised and subsequently bid has a major influence on the bid prices. Contractors typically have a time of year that is busier than others. This is when contractors prefer to do the majority of their work. This is normally directly correlated with the weather and occurs when the conditions are the most conducive for construction activities (such as asphalt paving).

Appropriate timing of advertisement can also be affected by other items like permit windows and HMA paving windows or other outside constraints. The best time to advertise a project is several months before the work season for that type of work to allow time for contract execution and for the contractor to mobilize their resources in time to take full advantage of the work season.

If a contractor has fully allocated his resources for the season then they are less likely to bid on a project and, if they do bid, it is in a less competitive environment. For this reason, there is a benefit to NDOT to advertise a project as soon as possible prior to the peak season, to allow the contractor time to plan, schedule and seek as many opportunities as possible to find efficiencies in their work plan. This also creates a more competitive bid climate and lower bid prices.

The person preparing the final base cost estimate needs to be aware of the timing of the advertisement and account for any expected fluctuations in bid prices due to the season such as lower production during temperature extremes, additional protections for weather sensitive materials, and so forth.

5.7 Specialty Work

Specialty items are not necessarily new items or new construction methods but are items somehow different than the majority of the work on a given project. For example, a pavement rehabilitation project the signal work may be classified as specialty work, although it would not be classified as such on a project predominately signal and lighting work. Projects including specialty work or comprising totally of specialty work items need to be characterized correctly when estimating. Estimating the cost of specialty items requires a thorough understanding of the work and the resources required to complete the items.

When estimating specialty work, seek the advice of subject matter experts. When estimating specialty items utilizing historical bid data, the similarities and differences between the historical project(s) and the project at hand must be fully accounted for in the development of the estimate.

Another factor to consider is the number of qualified contractors capable of doing the project or elements of work. Other examples of specialty work may be landscaping, guideposts, fencing or mechanical rehabilitation of moveable bridge components. Specialty work should be reviewed by staff familiar with that particular type of work.

5.8 Standard Items vs. Non-Standard Items

Standard items are familiar to both NDOT and the contractors. These items of work typically represent a known quantity and quality to both NDOT and the contractor, and bid history tends to reflect that. When an item is changed in some way to become a non-standard item then uncertainty is introduced. This uncertainty typically results in an increased price for the item, especially the first-time contractors see it in a contract. Typical practice should be to use standard items whenever possible. When a standard item is changed and becomes “non-standard” it should be recognized the price will differ from the historical prices.

5.9 First Time Used

On occasion, items of work are included in a project NDOT has little or no historical data to use to establish unit prices. In these instances, similar items may provide some guidance, but additional investigative work may be necessary. If the item is thought to be of minor significance, there may be little benefit in spending much time in determining a reasonable bid price. If the item is considered major or is likely to be significant to the overall project bid, research should be conducted to establish a cost.

Contacting others who are familiar in the use of the item can usually help in determining a cost. Suppliers, other state departments of transportation, Port Authorities, R.S. Means Publications, and even contractors can be valuable resources in establishing costs. Be wary of relying on estimates from a single contractor or source. Multiple sources should be utilized in developing an estimate for first time used items.

If the item in question is unique in some manner (innovative, new or experimental) or it is considered a specialty item, costs may need to be adjusted to account for the contractor's lack of experience with it and the potential increased risk in construction. If the work is likely to be subcontracted out then the prime contractor may also add a markup to the subcontractor's price.

5.10 Geotechnical Conditions

General assumptions about soil conditions may be made early in the estimating process, but they may turn out to be wrong. As the estimate progresses, geotechnical data may help improve the information and prevent costly change orders and claims. In the early estimates the assumptions regarding soil conditions and the potential effects of unknown soil conditions should be clearly documented. Geotechnical conditions can have significant impacts to structural cost, thus, coordination between geotechnical conditions and structural estimates is important.

A common estimate omission is an improper allowance for shrink and swell of material. The Materials Division should be consulted to determine the appropriate shrink or swell factor to use. Soil conditions can be a significant cost risk to a project. Risk-based cost estimation techniques should be utilized to quantify geotechnical risks if they pose a significant threat or opportunity.

5.11 Permit Conditions

Throughout the stages of planning, scoping, and design, various projections of permit conditions for construction can be obtained from the Environmental Services Division. Engaging these groups early may help identify specific permits or conditions that can drive up construction costs and identify opportunities to avoid costly environmental conflicts.

Considerable costs may be required due to storm water collection and treatment, wetland protection and mitigation, hazardous material testing, containment and treatment, and removal and disposal of underground fuel tanks, creosote timbers, contaminated soils, and potential groundwater contamination.

5.12 Market Conditions

Do not adjust base cost estimate unit bid prices to account for market conditions, identify the risks instead. NDOT does however include amounts (bid items) for fuel, asphalt oil and steel escalation as part of the base cost estimate, but there should not be a blanket escalation factor for all bid items to account for market conditions.

5.12.1 Other Contracts

Multiple projects being advertised at the same time can influence bid prices in much the same way as lack of competition and availability. The contractors only have so many resources available to develop bids for projects. In the case of large projects, a contractor may not have the resources to develop bids for more than one project at a time. The most prudent course of action in this case is to manage the program of projects to ensure that this does not become an influencing factor on the bids.

Typically, with two to four bidders the effect on the bid amount is negligible. Consideration should be given to what extent the reduction above the normal number of two to four bidders will influence the bid amount. The probability of the occurrence of this risk should be evaluated by the Project Manager. Common mitigation strategies include timing of the Advertisement, and work packaging.

Another factor to consider in a multiple contract environment is the resources required for the projects and if multiple active projects will create conflicts in an area. For example, multiple large-scale bridge projects in a given area may create a shortage in structural steel or skilled labor. In these cases, the ability of the market to support multiple projects must be taken into consideration.

Having multiple contracts in an area may create conflicts between the projects. These could include traffic control, labor issues, direct coordination issues, and similar issues. These conflicts need to be considered in the calculation of production rates and subsequent bid item prices. Project Managers should be aware of adjoining projects and nearby work (even from other Districts or local agencies). There may be opportunities for collaboration and coordination that will result in more competitive bids and better maintenance of traffic.

5.12.2 Item Availability

Item availability is another type of market condition that should be treated as a risk. Materials that are readily available, or ones that are commonly used, are generally less expensive to purchase and install/construct. Materials that are in short supply are more expensive.

Large quantities of materials required in a short period of time may result in a temporary shortfall in product availability and potential cost increase or delay to a project.

5.12.3 Expected Competition/Contractor Availability

Contractor availability should be treated as a risk. Projects that are advertised for bids late in the season or after contractors have scheduled their work for the year, can expect higher bid prices. This is due to the lack of competition or contractor availability. Projects that are bid during a period of time when a large number of contractors are available are bid more competitively. Contractors know that they must bid the lowest possible price to be able to get the contract.

5.13 Other Funding Sources/Agreement Work for Others

Whether or not a project is expected to receive contributions from outside funding sources should be documented in the Basis of Estimate. Federal funding, participation from local agencies (e.g.; participation in intersection improvements), or funding from public/private partnerships should all be documented. The source of funding may introduce additional requirements that must be accounted for. For example, federal funding includes requirements associated with Buy America and participation that may impact project cost and/or schedule.

5.14 Project Delivery Methods

The type of transportation project delivery mechanism typically is determined based on the project risk factors, schedule, funding, and goals. Cost adjustments should be on a case by case basis. Any adjustments to unit bid prices based on alternative delivery method need to be clearly documented in the Basis of Estimate and uncertainties.

Possible delivery mechanism may include:

Design-Bid-Build (DBB) - DBB is the traditional project delivery method in which NDOT designs a project and awards a construction contract to the lowest bidder based on the agency's completed construction documents. NDOT "owns" the details of design during construction and the risk associated with any changed conditions, unknowns, errors, or omissions that are encountered during construction. NDOT has an extensive dataset on historical unit bid prices throughout the State for DBB projects.

Design-Build (DB) – A project delivery method that combines two, usually separate services (engineering services and construction) into a single, fixed-fee contract. DB is a project delivery method in which NDOT contracts a single entity to complete design and construction of a project. The design-build entity may be a single firm, a consortium, joint venture or other organization assembled for a particular project. Characteristically, a project can be approximately 25 to 30 percent designed with a well-defined scope and knowledge of project risks at the point invitations to bid are requested via a value-based procurement. NDOT and the design-builder would share risks on a DB project which would typically result in the design-builder retaining risks associated with design, quantities, constructability, etc. Under DBB, these risks are normally retained by NDOT. A design-builder that adequately prices their allocated risks in a bid can result in greater cost and schedule certainty for NDOT once the contract is awarded. DB projects can result in higher "soft" cost due to insurance, co-located offices, and expedited work.

Construction Manager At-Risk (CMAR) - Owner interviews and selects a CMAR firm based upon qualifications and experience before the design and bidding documents are complete. The CMAR, Designer and Owner work together to develop and design the project. Guaranteed Maximum Price (GMP) is provided by the CMAR during design phase. The CMAR then receives proposals from and awards subcontracts to subcontractors. The Design Team is selected separately and reports to Owner.

CMAR is a project delivery method by which NDOT leads a coordinated team, which works to develop design and construction documents in a manner to minimize overall project risk, improve project delivery schedule, and apply potential innovation to meet or exceed project goals. The other two members of the team, the designer and contractor, individually and independently are contracted and directly are accountable to NDOT.

Characteristically, a project can be approximately 30 to 50 percent designed with a partially defined scope, and vague knowledge and definition of associated risk when invitations to participate on the project's pre-construction team are released. The procurement of the contractor is done through qualifications and/or value-based selection for pre-construction services with the potential for the contractor to receive construction services. The contractor is obtained early in the design phase, allowing for the contractor to offer expertise with regard to the schedule, budget, constructability, as well as the identification, evaluation, and mitigation of risk.

Upon final design of the project, or a portion thereof, NDOT will ask the contractor to submit a fixed-price bid. The agency and the contractor may negotiate reassignment of risk if NDOT finds the bid too high. If the parties cannot agree on a price, NDOT may release the project for bid using the DBB method. CMAR project estimation should consider additional pre-construction costs and potential for slightly higher unit bid prices.

During project development milestones, such as intermediate and QA/QC submittals the CMAR will develop Opinion of Probable Construction Costs (OPCC) to identify an approximate project cost. The OPCC is generally a production based estimate and is developed in the same manner the CMAR would develop a bid estimate on a DBB project. During the CMAR's OPCC development, the Department will develop an Independent Cost Estimate (ICE) in parallel. The ICE estimate is also a production based estimate performed by an independent team usually comprised of team members with previous contracting and bidding experience. The OPCC and ICE estimates are compared to provide validation and serve as a negotiation tool in developing and potentially accepting the CMAR's final Guaranteed Maximum Price (GMP).

The contractor may enter into a fixed-price contract with NDOT based on a reasonable final cost (GMP) and time of construction (agreeable to NDOT) to complete the project. This method allows the agency to control the development of scope, understand and allocate project risk, encourage the use of new construction techniques, and phase project delivery to reduce overall delivery costs and schedule.

CMAR is also called Construction Manager-General Contractor (CMGC) or Construction Manager (CM).

Historical unit prices should not be adjusted based on the method of project delivery. For design-build it is typical to include an opportunity in the risk register for contractor innovation. Section **14.4 Risk Allocation/Ownership** discusses the transfer of risk depending on the method of project delivery and examples of the types of risks that are transferred. Also see the NDOT Project Delivery Selection Approach (PDSA) as discussed in Appendix C in the NDOT Pioneer Program Guidelines (PPG).

PPG link: https://www.nevadadot.com/home/showpublisheddocument?id=4496.

6. Base Cost Estimation Markups

Along with the cost of work items markups, or ancillary costs for mobilization, preliminary engineering (PE), miscellaneous item allowance in design (only for historical bid-based, cost-based, and risk-based methods), construction engineering (CE) and construction contingencies need to be applied to the base cost estimate.

6.1 Mobilization

Mobilization is a contract pay item used to cover a contractor's preconstruction expenses and the costs of preparatory work and operations. Since there is no clear list defining this work effort and since contractors have the ability to adjust their bids as needed to cover these expenses, there are no true rules as to what percentage should be used per contract.

When determining mobilization for a project, consideration should be given to a variety of factors such as: location, complexity, the need for specialized equipment, the type of work, and the working season if it extends over more than one construction season. Projects that might require a higher mobilization percentage include rural vs. urban, projects with multiple work sites, projects with numerous preparatory removal items, projects with large quantities of excavation, or projects extending over two seasons where the contractor would be expected to demobilize and remobilize the following season.

For projects over $100 million the mobilization percentage should be specified at 7% of the construction bid items by default. Approval from the Project Manager is needed if a lower or higher percentage for mobilization is warranted within the base cost estimate.

6.1.1 Alternative Delivery Methods

Mobilization is calculated the same for construction manager at-risk (CMAR) methods of project delivery. A slight increase in mobilization should be considered and discussed with the Project Manager based on insurance and office space requirements.

6.2 Miscellaneous Item Allowance

Sometimes referred to as "minor items" or "design allowance", miscellaneous item allowance is typically meant to cover a variety of cost items that are not yet specifically identified or quantified. It is also used to account for a lack of project definition during the preparation of planning estimates.

Care should be given when defining design and construction cost allowances,. such allowances are not intended to cover added scope or significant risk items, and should be reserved to cover the item(s) for which they were originally intended.

During the Planning Phase the miscellaneous item allowance is typically a percentage of the identified construction items.

As the project moves into the Environmental Phase the allowance amounts should be subdivided by discipline so they can be managed appropriately as the design progresses. An example would be that a miscellaneous item allowance for storm sewer system would be placed under the drainage section of the estimate. This will assist in review of the estimate and help the Project Manager and Team, manage this item appropriately.

In Final Design these percentages need to be changed to individual dollar amounts. As the design progresses and items and additional quantities are identified from the miscellaneous item allowance amounts should be reduced.

6.2.1 Alternative Delivery Methods

Miscellaneous item allowances are calculated and used in the same way for design-build and construction manager at-risk (CMAR) methods of project delivery.

6.3 Preliminary Engineering

Preliminary Engineering (PE) percentages can be used at early stages (planning and environmental) to estimate the cost of design for a project. These percentages will vary by project type and total dollar amount of the project. On average, historical PE costs for NDOT designed projects are approximately 6-10% of construction costs depending on the project. Smaller value projects, generally less than $25 million, will see the higher range near 10%; while larger projects with well-defined scopes would typically be in the lower 6% range

As the project moves through final design, the PE cost should reflect actual costs to date plus the anticipated costs. This should be the case regardless of whether the project is NDOT designed, consultant designed or a combined NDOT/consultant design. The PE cost should reflect the entire PE costs not just NDOT designed or consultant designed costs.

For projects that include consultant design, PE costs can be higher than for projects designed by NDOT. The cost of design by consultant is almost always more than the typical NDOT design costs due to a variety of factors. All consultant design costs are developed and approved based on a scope of work and a man-hour estimate.

The cost to support right-of-way activities is not included within the PE cost. Right-of-way support and acquisition costs are a separate line within the base cost estimate and are typically supplied by the Right of Way Division.

6.3.1 Alternative Delivery Methods

If design-build is selected as the method of project delivery, then the cost of preliminary engineering is split between the owner (20-40%) and the design-builder (60-80%). With design-build project delivery, NDOT has historically used consultants to assist with contract preparation and construction administration. In addition to the design costs, a stipend may be paid to the proposers in accordance with procedures outlined in the Pioneer Program Guidelines.

If the delivery method of construction manager at-risk (CMAR) is used, then additional funds may need to be added to the PE costs to cover the costs of the preconstruction support services provided by the contractor and provided by an independent cost estimator.

6.4 Construction Engineering

Construction Engineering percentages are only a guideline and can be altered upon recommendation of the Construction Engineering Division or the Project Manager. As a starting point the following percentages can be used:

- 10% - projects costing over $7 million
- 10% - projects costing $4 million to $7 million
- 15% - projects costing under $4 million

Alternatively:

- 5% - 15% at the discretion of the project manager with input from the Construction Engineering Division, and input from the Design Division if an in-house project.

6.4.1 Alternative Delivery Methods

For design-build projects, the cost of construction engineering for the owner is typically in the range of 60-75% relative to a similar design-bid-build project. This amount would not include the design review done by the owner. The remaining 25-40% of the construction engineering amount would go towards the design-builders QA/QC costs. With design-build project delivery, NDOT has historically always used consultants to assist with the contract preparation and construction administration.

6.5 Construction Contingency

"Contingency percentages" are set up to handle unforeseen changes in a project during construction, including additional work, quantity over-runs, and additional items.

For NDOT projects, construction contingency should be set to:

- 7% of the construction contract total if the estimate is less than $3 million
- 5% if the estimate is between $3 million and $25 million
- 3% if the estimate is greater than $25 million.

Caution should be exercised by the risk elicitors during CRA workshops to not double count the construction contingencies with identified risks.

6.5.1 Alternative Delivery Methods

Design-Build and CMAR project delivery methods generally need the same amount of contingency to handle unforeseen changes in a project during construction, including field changes and additional items; however, design-related change orders should (in theory) be lower under alternative delivery methods because design-related risks are transferred to the contractor.

6.6 Escalation

Escalation data for construction, right-of-way, and engineering elements should be determined to a sufficient level that these factors may be applied in the quantitative risk analysis.

<u>All base-cost estimates shall be expressed in current year dollars.</u> The base cost estimate is built using current market prices, or historical bid prices escalated to current market values, to estimate project costs. Major project expenditures typically will be incurred over several years, so the future prices of goods and supplies must be accounted for during the risk assessment workshop. Future prices are determined by forecasting escalation rates, which represent the annual rates of growth.

Escalation is tracked for key construction elements as well as broad construction indices. These annual growth rate forecasts are constructed using historical datasets of construction elements drawn from various sources.

For construction materials, sources such as the Bureau of Labor Statistics (BLS) and the Engineering News-Record (ENR) are used to develop escalation rate forecasts based on historical data in combination with market analysis and insight. Because project engineering costs are mostly dependent on local wages for labor, local wage series are used in developing escalation rates.

Right-of-way acquisition cost escalation is influenced by local real estate trends in property valuation. A number of indices can be used to evaluate these local market trends, including the Federal Housing Finance Agency indices of property values and the S&P Case-Shiller home price indices.

Escalation can vary for individual construction elements because each is subject to its own supply and demand forces, which in turn may be influenced by local, national, or international factors. The estimation of future escalation rates is drawn from consideration of historical price changes, potential changes in the market conditions, and the ensuing supply and demand responses. Construction cost escalation rates are comprised of several common cost components which may vary depending on the nature of the work. These components may include:

- Concrete
- Steel
- Asphalt
- Aggregate
- Fuel
- Lumber and wood products
- Machinery and equipment
- Electrical and lighting equipment
- Miscellaneous materials
- Labor

Overall construction cost escalation is based on a weighted combination of the individual escalation rates of the applicable construction cost components.

Because future escalation rates are inherently uncertain, uncertainty in these rates should be included in any quantitative risk analysis. The escalation tables used for risk-based cost estimation, and accompanying guidance for use, shall be provided by the NDOT Project Management Division.

6.7 Application of Markups

To avoid duplication of costs, markups should be applied (calculated) within the base cost estimate as shown in Table 4 below. The percentages used in the table are for example purposes only.

Table 4 – Applying markups within the Base Cost Estimate

Description	Amount
Identified Bid Items	$1,000,000
Miscellaneous Item Allowance (15%, see Section 6.2 for discussion)	$150,000
Bid Item Sub-Total	**$1,150,000**
Mobilization (7%, see Section 6.1 for discussion)	$80,500
Contract Total	**$1,230,500**
Construction Engineering (15%, see Section 6.4 for discussion)	$184,575
Preliminary Engineering (10%, see Section 6.3 for discussion)	$123,050
Construction Contingency (7%, see Section 6.5 for discussion)	$86,135
Right of Way Support (Determined on a project by project basis)	$20,000
Right of Way Acquisition (Determined on a project by project basis)	$100,000
Utility Relocation (Determined on a project by project basis)	$75,000
Project Total (Base Cost)	**$ 1,819,260**

Any percentage for miscellaneous item allowance needs to be added to the identified bid items before mobilization can be calculated. This gives us the Contract Total for the project.

Items such as construction and preliminary engineering, contingency are all percentages of the Contract Total.

Right-of-way costs and NDOT paid utility relocations are added to the Contract Total to give the Base Cost or Project Total.

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7. Documentation/Basis of Estimate

Documentation is a key element in good estimating practice. The estimate file should be a well organized, easy to follow history from the first estimate at the beginning of the planning phase through preparation of the final estimate. The basis of estimate document, described in this section, contains recommended organization, topics and format.

Each estimate should track changes from the previous estimate, updating the scope, assumptions, quantity and price calculations, and risks from the previous estimate. At each update the differences between the previous estimate and the current estimate should be highlighted. This contributes to transparency and accountability in estimating and promotes the consistency between estimates.

Clear documentation is particularly important as the project passes from one group to another, or as team member's change, the BOE needs to be transparent to reviewers both inside and outside NDOT. The project estimate file should follow the project through the various stages so that each new estimate can be easily tied to the previous one.

7.1 Techniques

Several techniques can be employed to ensure clear documentation. It is recommended that estimating be specifically scheduled in the project management plan for each phase of the project. This ensures that adequate time and resources are allotted for performing the estimate.

A specific schedule should be developed for each estimate that includes the steps shown in Figure 5 in Chapter **2. Cost Estimating Process** of this manual.

As part of the estimate review process, an external estimator to the Project Team (NDOT staff or consultant) should perform a review of the estimate file. This external review will help ensure that the assumptions and decisions made in the estimating process have been clearly recorded.

7.2 Basis of Estimate (BOE)

The BOE is characterized as the one deliverable that defines the scope of the project, and ultimately becomes the basis for change management. When the BOE is prepared correctly, NDOT and project stakeholders can use it to understand and assess the estimate, independent of any other supporting documentation. The BOE's detail and level of effort should match the project's complexity with an appropriate level of effort and documentation. Smaller and less complex projects may justify a brief and concise BOE, while more complex and longer duration projects may require additional documentation for assumptions and changes that occur over the project's development.

A well-written BOE achieves these goals by clearly and concisely stating the purpose of the prepared estimate (i.e. cost study, project options, benefit/cost study, funding, etc.), the project scope, pricing basis, allowances, assumptions, exclusions, cost risks and opportunities, and any deviations from standard practices.

The BOE is a documented record of pertinent communications that have occurred and agreements that have been made between the Project Manager, Project Team and other project stakeholders. A template to help in the development of a Basis of Estimate document is included in the appendix of this manual.

A well prepared basis of estimate will:

- Document the overall project scope.
- Document the items that are excluded from the project scope.
- Document the key project assumptions.
- Communicate the knowledge of the project by demonstrating an understanding of scope and schedule as it relates to cost.
- Alert the Project Team to potential cost risks and opportunities.
- Provide a record of key communications made during estimate preparation.
- Provide a record of all documents used to prepare the estimate.
- Act as a source of support during dispute resolutions and for bid analysis.
- Establish the initial baseline for scope, quantities and cost for use in cost trend evaluation throughout the project.
- Provide the historical relationships between estimates throughout the project lifecycle.
- Facilitate the review and validation of the cost estimate.

The primary intent of this document is to provide a guideline for the topics and contents to be included in typical BOE. Objectives of significance when preparing a BOE include:

- Factually complete, yet concise.
- Ability to support your facts and findings.
- Identify estimating team members and their roles (including specialty groups).
- Describe the tools, techniques, estimating methodology, and data used to develop the cost estimate.
- Identify other projects that were referenced or benchmarked during estimate preparation.
- Develop and update the cost estimate and the BOE concurrently.
- Establish the context of the estimate, and support review and validation.
- Qualify any rates or factors that are referenced either in the estimate or BOE; e.g. productivity can be expressed as either units/time (linear feet/hour) or time/units (hours/linear foot).

The following headings should be included in the basis of estimate document:

Project Purpose

This initial section of the BOE provides a brief and concise description of the project. The type and purpose of project should be identified; as well as the location of the project, and the overall timing of the project.

Project Scope Description

This section of the BOE should be organized to correspond with the project's work breakdown structure (i.e., roadway, bridge, structure, etc.). A concise description of the scope of work should be provided for each major segment of the project. Identify major items of work. Be as thorough as necessary, without being overly descriptive, so as to adequately explain the scope of work being estimated.

Estimate Methodology

This section describes the primary estimating methodology used to prepare the cost estimate. This should include documentation of the use of cost resources, historical data and project benchmarking. Documenting the level of effort (i.e.; man-hours and resource allocation) used in preparation of the estimate may also be helpful. The schedule for the estimate can be listed here.

Design Basis

In this section of the BOE, the types and status of engineering and design deliverables that were provided to prepare the estimate including any design basis assumptions will be identified. NDOT Design standards and guidelines will typically specify the technical and project information required for the classification of the estimate that is being prepared.

Attachments to the estimate basis should be referenced, such as a listing of all engineering drawings (including revision number and date), a well as other design information, such as specifications, equipment lists, units of measure, planning, scoping, etc.

In addition, it may be useful for certain projects to document specific quantity metrics, such as excavation and backfill quantities, concrete volumes, piping quantities, etc. These may be organized by the work breakdown structure of the major items of work.

Planning Basis

This section of the BOE documents the project management, engineering, design, procurement, fabrication, and construction approaches to the project. The contracting and resource strategies should be identified, as well as any assumptions that were made with regard to the workweek schedule (hours worked per day, days worked per week, shifts worked per day, work windows, night/day work, phasing, etc.) and planned use of overtime. Appropriate contracting and resource strategies may not be available into the latter levels of project development and understanding of proposed limitations of operations and project phasing.

Any assumptions made regarding constructability, modularization, use of specialized construction equipment should also be noted here. The project schedule and key milestones should also be identified.

Cost Basis

This section of the BOE describes the methods and sources used to determine the cost for each listed item. Identify the following pricing sources used: (NDOT Historical, Cost-based, etc.)

- Pricing source and methodology for all Contracting Agency costs (project management, engineering, design, etc.).
- Mobilization percentage used (if different than 7%) and why.
- Escalation indices used, and the method of calculation (including duration). (NOTE: this is to bring historical prices to current dollars. It is not for estimating or predicting future prices.)
- Location factors used and the basis for these factors.
- Influence of local market conditions.
- Portions of the estimate provided by specialty groups.
- Right-of-way cost and pricing source (including acquisition and relocation costs, if applicable).

- Any other pricing factors or external influences that may have a significant impact on project cost should be identified.

Miscellaneous Item Allowances

This section of the BOE should describe any other costs that have not been detailed in the body of the estimate, such as lump sum allowances for specific areas of the scope or any other factored costs not described elsewhere in the estimate basis. This is sometimes called design allowance or minor items. See Section **6.2 Miscellaneous Item Allowance** of this manual for additional detail.

Miscellaneous item allowances are typically meant to cover a variety of cost items that have been identified but not specifically quantified. They can also be used to account for a lack of project definition during the preparation of planning estimates. Care should be given when defining design and construction cost allowances. For example, such allowances are not intended to cover added scope or significant risk items and should be reserved to cover the item(s) for which they were originally intended. The allowances percentages should be commensurate with the level of design and estimate development.

Assumptions

Any other assumptions made by the designers or Project Team but not documented elsewhere in the estimate basis should be included in this section. This may include such assumptions as raw materials costs such as asphalt oil, cement, steel, etc. See Chapter **5. Important Factors impacting Base Cost Estimation** of this manual.

This should also include the effect of jobsite conditions on labor rates and productivity, and material/equipment costs; crew/equipment compositions for major items of work that are considered “cost drivers” to the overall estimate and how these composition assumptions translate into unit rates; sequence-of-work assumptions that may not be obvious in the accompanying project schedule; traffic management assumptions; and work calendar assumptions, to include whether certain work must be performed at night or on weekends and why this is the case.

Small assumptions can change into major assumptions throughout the life of a project. Therefore, it is best to document all assumptions.

Exclusions

In this section, all potential items of cost that a reviewer might associate with the project, but for which no costs have been included in the estimate should be documented. Wetland mitigation, removal of hazardous wastes, creosote pilings, right of way acquisition, etc. are examples of potential items that may need to be identified. Where NDOT or a third party is providing materials or other scope items to the contractor this should be noted. Documenting exclusions is also helpful when developing a project risk register to ensure that the excluded items are considered as potential project risks.

Exceptions

In this section any anomalies or variances to the NDOT’s standard estimating practices should be identified. Any significant deviations from the project and/or engineering deliverables normally required for the applicable level of estimate should be documented as well. Use the checklist as an attachment to the BOE that will document any exceptions that are identified.

Threats and Opportunities

In this section any areas of the estimate containing significant risks (threats or opportunities) should be identified. If a formal risk analysis study (CRA) has been prepared then it should be included. In particular, this section should identify those cost elements that have been identified with high or very high risk (threat or opportunity) values. The risk analysis report (or summary) should be provided as an attachment to the BOE. This information should be added as the estimate is prepared.

Estimate Quality Assurance

Since estimate reviews are the means for testing the quality of the estimate, this section of the BOE should identify all estimate reviews that have taken place to date and any additional reviews that are scheduled to take place. All review comments or analysis should be included as an attachment to the BOE. For guidance on estimate reviews, see Chapter **9. Independent Estimate/Estimate Review**.

Reconciliation

This section should provide an overview of the major differences between the current estimate and the last published estimate prepared for this project. Identify the cost impacts due to scope changes, pricing updates, labor productivity adjustments, estimate refinement, etc. Also provide a reconciliation of all reviews preformed and how they were incorporated into the estimate. A more detailed reconciliation or cost trending report can be provided as an additional attachment if necessary.

Benchmarking

This section should document any comparisons of overall estimate metrics, ratios, and factors with similar projects, historical data, and industry data. Projects used in the benchmark comparisons should be similar in process type and overall value. If significant variations of the estimated project costs versus the benchmarks exist, those inconsistencies should be identified and commented upon. A more detailed benchmark analysis report may be included as an attachment to the BOE.

Project Funding and Scheduling

The request for scheduling and programming was submitted to Financial Management on MM/DD/YY and revised on MM/DD/YY.

The Project Scope/Budget Change and Update and Programming/STIP Revision Request Form were submitted on MM/DD/YY. This form shall be updated and submitted whenever significant changes occur to the project scope, schedule, or budget.

Estimating Team

In this final section, all members of the estimating team should be identified and their roles and responsibilities defined.

Attachments

Several supporting documents will generally be included with the Basis of Estimate.

Attachment A: Base Cost Estimate

Include a current copy of the line item base cost estimate with uncertainties (see Figures 6-9 in Section 3.3). The base cost estimate needs to include the appropriate markups (Figure 10) according to Chapter **6. Base Cost Estimation Markups**.

					Contract Total	**$186,961,606**	**$205,847,304**	**$224,570,146**
					Project Uncertainty	**-9.2%**		**9.1%**
IV.Non-Bid Items								
Preliminary Engineering	EST (10%)					$18,696,161	$20,584,730	$22,457,015
Construction Engineering	EST (5%)					$9,348,080	$10,292,365	$11,228,507
NDOT Std Construction Contingency	EST (3%)					$5,608,848	$6,175,419	$6,737,104
Right of Way Support						$2,000,000	$2,000,000	$2,000,000
Right of Way Acquisition						$12,762,000	$12,762,000	$12,762,000
Utility Relocations						$2,000,000	$2,000,000	$2,000,000
					Project Total	**$237,376,695**	**$259,661,819**	**$281,754,773**

Figure 10 – Example Application of Markups (w/Uncertainty)

Attachment B: Reference Documents

Document the drawings, manuals, texts, notes, specifications, and other references used in developing the estimate. Identify the revisions and date of issue for key documents. All documents used as references or resources upon which the estimate was based should be listed in a way similar to the formality of a bibliography, including revision numbers and document dates.

Attachment C: Schedule Documents

Document the project design and construction schedule, including working days, shift assumptions, key milestones and critical path activities.

Additional Attachments

Include any other attachments that may be necessary or required (reconciliation report, benchmarking report, risk analysis report, escalation calculations, etc.).

Level of Detail in the Basis of Estimate

It is often not a simple matter to determine just how much detail should be provided in a BOE. Several factors may come into play during the preparation of the cost estimate that will help determine the answer.

Level of Project Definition

Estimates are prepared at various stages of a project. While a more detailed estimate will generally require a more detailed BOE; this is not always the case. A conceptual estimate will probably be based on a limited amount of scope definition but it may require a more detailed basis of estimate.

It's not uncommon for the BOE for a conceptual estimate to be more thorough than one prepared for a more detailed estimate because there are often more assumptions made at the conceptual stage of a project that require greater documentation. Conversely, there may be times when the project definition is so complete or simplistic that a BOE does not require a great amount of detail. In the later case, a three or four page document may be sufficient to convey the BOE.

Cost Value of the Project

A more expensive project will typically require a more detailed BOE. However, projects of lesser cost may also require an extensive BOE to fully communicate major assumptions that constrain or reduce the cost.

Type of Project

The type of project can also affect the level of detail in a BOE. For example, the BOE for an overlay project in a rural area may be less detailed than a new interchange project on the interstate.

Other Factors

Other factors that may affect the level of detail in a BOE are the projects milestones and deliverables list, consideration for new technologies, contracting strategy, etc. The BOE should contain a concise level of detail to fully support the review of the estimate by those that have not been a part of the preparation of the estimate. The BOE provides a definition of the scope of the project as estimated and should establish the basis for change management subsequent to publication of the estimate.

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8. Project Schedule

The schedule is a critical component of the management and delivery of any major project, which significantly influences public perception of an agency's success in delivering the needed infrastructure. Projects are often driven by political delivery expectations, which must be balanced against limiting constraints such as environmental or regulatory requirements, property acquisition, and construction logistics.

The risk-based cost estimation process requires development of a project schedule to a sufficient level of detail to define the activities necessary for the program delivery. The considerations for and development of the project schedule for input into the risk-based cost estimation process are described below.

8.1 Gantt Chart

The schedule should be created using software approved by the Project Management Division for developing critical path schedules. The resultant product is typically shown as a Gantt chart identifying the critical work path, durations for activities, logic, and total float in each activity, and other such requirements.

This schedule does not necessarily need to be developed to the detail required for project management and/or construction, but it should show the areas of concern in completing the project, help with risk assessment, identify funding availability, show phasing (if applicable), and also show the expected duration of the entire project or program. Items should be at a summary level, and the level of detail should be summarized by activity, phase, and discipline of work.

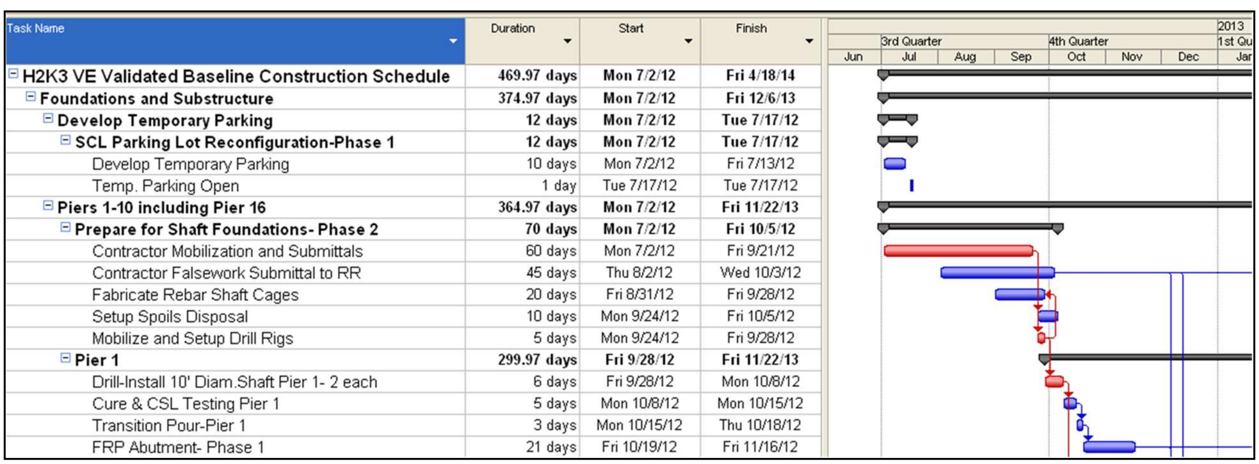
Task Name	Duration	Start	Finish
H2K3 VE Validated Baseline Construction Schedule	469.97 days	Mon 7/2/12	Fri 4/18/14
Foundations and Substructure	374.97 days	Mon 7/2/12	Fri 12/6/13
Develop Temporary Parking	12 days	Mon 7/2/12	Tue 7/17/12
SCL Parking Lot Reconfiguration-Phase 1	12 days	Mon 7/2/12	Tue 7/17/12
Develop Temporary Parking	10 days	Mon 7/2/12	Fri 7/13/12
Temp. Parking Open	1 day	Tue 7/17/12	Tue 7/17/12
Piers 1-10 including Pier 16	364.97 days	Mon 7/2/12	Fri 11/22/13
Prepare for Shaft Foundations- Phase 2	70 days	Mon 7/2/12	Fri 10/5/12
Contractor Mobilization and Submittals	60 days	Mon 7/2/12	Fri 9/21/12
Contractor Falsework Submittal to RR	45 days	Thu 8/2/12	Wed 10/3/12
Fabricate Rebar Shaft Cages	20 days	Fri 8/31/12	Fri 9/28/12
Setup Spoils Disposal	10 days	Mon 9/24/12	Fri 10/5/12
Mobilize and Setup Drill Rigs	5 days	Mon 9/24/12	Fri 9/28/12
Pier 1	299.97 days	Fri 9/28/12	Fri 11/22/13
Drill-Install 10' Diam.Shaft Pier 1- 2 each	6 days	Fri 9/28/12	Mon 10/8/12
Cure & CSL Testing Pier 1	5 days	Mon 10/8/12	Mon 10/15/12
Transition Pour-Pier 1	3 days	Mon 10/15/12	Thu 10/18/12
FRP Abutment- Phase 1	21 days	Fri 10/19/12	Fri 11/16/12

Figure 11 – Example of a Gantt Chart

Contract requirements should be the basis for the schedule, including scope of work, any milestone dates, and stakeholder requirements. Once NEPA is completed and Final Design begins, the contract delivery system should be known, such as whether traditional design-bid-build or other alternative delivery methods will be used. Include the appropriate milestones within the project schedule based on the project delivery method.

Any right-of-way (R/W) required for the project should be addressed and included as an activity or activities in this schedule. This will be a critical activity, with potential impact on the start of construction. The best knowledge of local land acquisition procedures should be used as a basis for determining the duration of these activities and the logic ties to the start of construction activities.

Relocation of existing utilities can affect the start of construction. The schedule should include activities for major crossings or those within the R/W that may take time to relocate, such as major electric transmission lines or large pipelines. Major utility impacts take time to design, procure materials, and schedule construction of relocation. Minor utilities with roadways and intersections may become an activity, although it is probably not critical to the project duration.

Final design should be an activity but will vary depending on the program delivery method. If traditional design-bid-build is proposed, there should be an activity for the design or portion remaining as of the date of the schedule. This activity would then be a predecessor to project letting. Under a design-build scenario, the majority of the design engineering activity would be associated with the design-builder and would reflect a duration of time to develop a sufficient design to enable the start of construction with remaining time allocated for final design completion.

Using preliminary plans, the scheduler should analyze the expected work plan and develop the appropriate activities and logic. Factors considered should at a minimum include:

- Areas with minimal R/W acquisition impact
- Areas with no major utility relocations
- Phasing of work such as constructing frontage roads first
- Major structures and interchanges
- Overall traffic phasing to minimize impact on the traveling public
- Opening of new work to traffic flow
- Stakeholder requirements
- UPRR design review times and execution of agreements (if applicable)

The schedule should be developed with use of the best available design plans. With an approximate 30% plan set, the scheduler can determine the duration, cost, and manpower requirements for major work items. The scheduler should check the dollar value of work put in place monthly compared to other major projects to ensure appropriate and reasonable values have been utilizied. Factors can be used to estimate man-hours required for construction and manpower requirements at peak and average times. These checks will show whether the construction time is realistic as compared to projects of similar size, scope, and complexity.

8.2 Project Flowchart

The flowchart is a simplified representation of the overall project schedule. The flowchart serves a number of purposes in the risk analysis process including: 1) as a basic for calculating schedule uncertainty by assigning specific risks to specific activities, 2) developing a summary-level cost-loaded schedule to calculate cost escalation and indirect costs of delay, and 3) to serve as a communication tool to help ensure understanding and buy-in to the overall schedule by all project team members, discipline representatives, and other stakeholders. The flowchart should reflect all major project activities and illustrate the logical flow of the project, from preconstruction through project completion.

Based on existing project documentation and schedules, the risk team will develop a flowchart of the project that reflects key activities, predecessor-successor relationships, and base durations. Base durations represent the amount of time each activity is expected to consume without any allowances for delays or schedule float. When building the flowchart, excess activity durations or “float” should be removed as the flowchart should represent reasonably achievable activity durations, in the absence of risk.

The flowchart is different from a Gantt chart as it focuses on key activities that may face similar types of risks at the strategic level rather than at the operational level. For example, a Gantt chart may contain a detailed listing of sequential or interrelated line-item activities related to a particular utility relocation; the flowchart would simplify these activities by combining them into a single combined activity duration. Risks related to this broad activity would be linked directly to it, with potential impacts defined relative to the base duration.

All activities on the flowchart should include a title, activity number, and duration. Predecessor-successor relationships between activities should be clearly identified. The flowchart does not need to be made to scale as long as activity durations and relationships are clearly marked and readable. A sample flowchart is provided in Figure 12. The number of activities within a flowchart will vary based on the nature of the project; however, there should generally be between 10 and 50 activities.

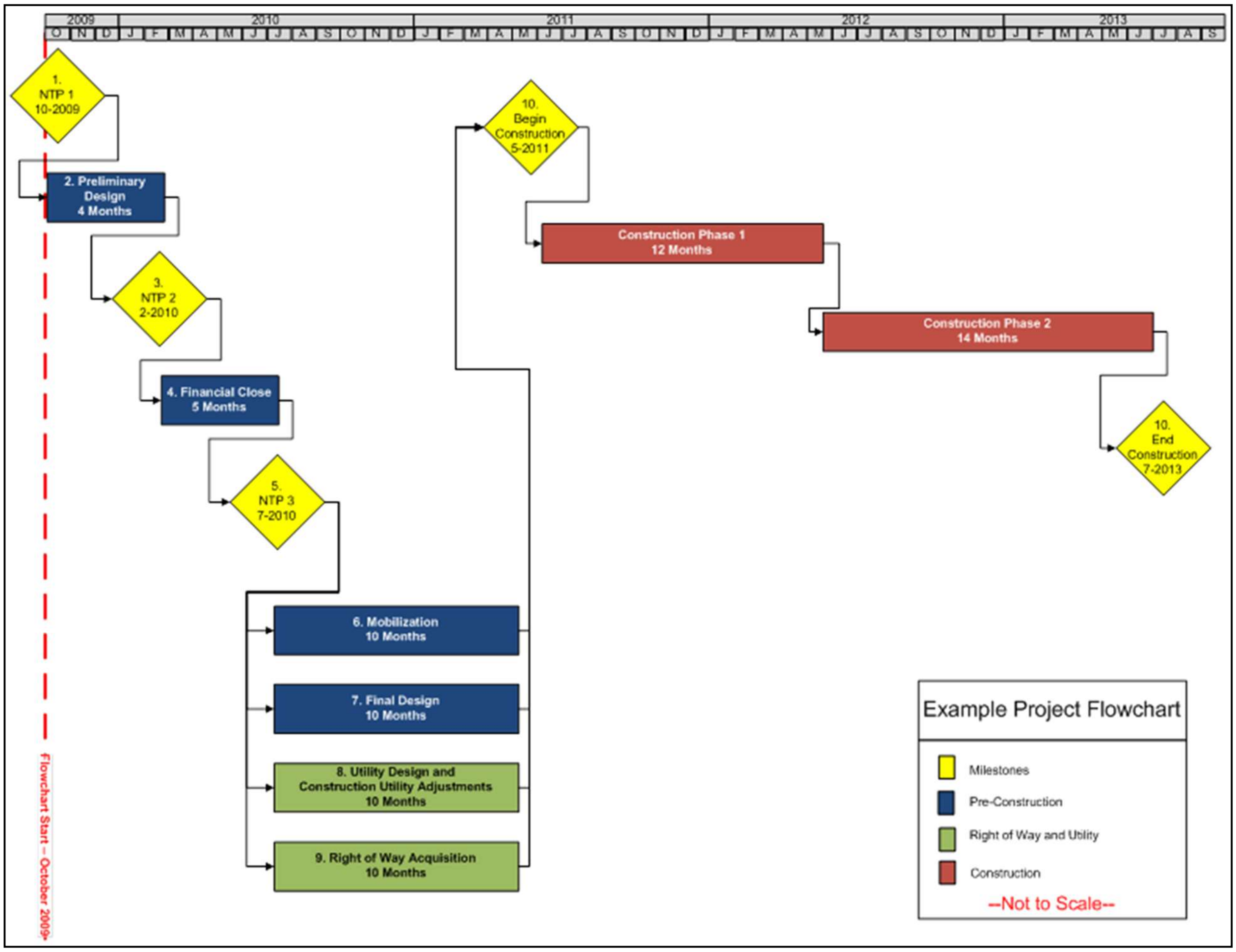

Figure 12 – Sample Flow Chart

The sample flowchart in Figure 12 shows 13 activities, ranging from project initiation to the completion of construction. The flowchart does not have to be to scale; however, it should represent the logical flow of project activities, showing key project activities, funding availability, milestones, and the relationships between them, as shown by the dependency arrows. The flowchart needs to include any applicable constraints such as exclusionary work windows.

In the sample flowchart, milestones are shown as yellow diamonds. Pre-construction activities such as Final Design are shown in blue, utility work and R/W acquisition are shown in green, and construction activities are shown in red. As costs and risks will differ between activity types, it is helpful to provide visual indications of activity types within the flowchart.

Once a flowchart has been established and confirmed with all team members or risk workshop participants, the information can be tabulated for additional verification before applying the activities' durations and dependencies to the schedule portion of the risk model. Table 5 summarizes the project flowchart shown in Figure 12, listing the activity number, activity name, start and end dates, duration, and dependencies. All of the start and end dates as well as the specific dependencies are clearly identified in this table to ensure accurate interpretation of the flowchart.

Table 5 – Summary of Project Activities from Flowchart

Activity Number	Activity Name	Activity Start	Activity End	Duration (months)	Dependency Activity Number
1	NTP 1	Oct-2020	Oct-2020	0.0	None
2	Preliminary Design	Oct-2020	Feb-2021	4.0	1
3	NTP 2	Feb-2021	Feb-2021	0.0	2
4	Financial Close	Feb-2021	Jul-2021	5.0	3
5	NTP 3	Jul-2021	Jul-2021	0.0	4
6	Mobilization	Jul-2021	May-2022	10.0	5
7	Final Design	Jul-2021	May-2022	10.0	5
8	Construction Utility Adjustments	Jul-2021	May-2022	10.0	5
9	Right-of-Way Acquisition	Jul-2021	May-2022	10.0	5
10	Begin Construction	May-2022	May-2022	0.0	6, 7, 8, 9
11	Construction Phase 1	May-2022	May-2023	12.0	10
12	Construction Phase 2	May-2023	Jul-2024	14.0	11
13	End Construction	Jul-2024	Jul-2024	0.0	12
	OVERALL	**Oct-2020**	**Jul-2024**	**45.0**	

The table represents the first step in modeling the schedule in order to assess risk impacts. For example, Activity 10, Begin Construction, occurs in May 2011. This activity is dependent on the completion of Activities 6, 7, 8 and 9, as shown in the table. Milestones have zero duration as they mark a key event but are not an activity of their own.

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9. Independent Estimate/Estimate Review

Each base cost estimate should have some level of review, as indicated on the flow chart provided in **Cost Estimating Process** section. Project complexity is the most important driver of the level of estimate review. The level of review should be carefully chosen by the Project Manager.

Estimates are key outputs of the project management process and are fundamental documents upon which key management decisions are based. At the Project Manager's discretion, all cost estimates may be independently reviewed by estimating staff specialists, subject matter experts, and others as appropriate. The estimate will then be reconciled and revised as needed to respond to independent reviewer comments. In the event of a significant difference of opinion, an estimate reconciliation meeting will be held, and the results documented. The final results of the independent review and reconciliation meeting must receive management endorsement before any project is advertised.

Independent reviews (check estimates) should be made by experienced designers who are familiar with the type of work inherent in the project, and who have had no involvement in the development of the project estimate to date. The independent source consults with other independent sources such as other design engineers, construction managers, or other subject matter experts as needed on specialty items of work. Checks performed by independent designers will include but not be limited to:

- Reviewing the estimate file and Basis of Estimate document for completeness and readability
- Ensuring that the name(s) of individual(s) involved in preparing the estimate are shown
- Ensuring that the estimating methodologies are noted by individual item of work
- Reviewing the overall estimate documentation to ensure that it is clear and that figures are traceable from detailed back-up to summary levels
- Conducting a detailed check of the estimate to include:
  - Checking the development of unit rates and quantities of those items that drive the majority of the bottom-line cost (the 20% of the items that typically comprise 80% of the estimated project cost)
  - Making note of comments on unit rates and quantities
  - Checking for mathematical errors

9.1 Internal Project Team

This type of review is the first level of estimate review and is recommended for all estimates. The internal Project Team review should include a quality control check of quantities and prices as well as a quality assurance check that the proper procedures were followed, the documents are complete and clearly understandable and the final costs and schedule is deemed reasonable for the project scope, size, location and complexity.

The advantages of the internal Project Team review are that the Project Team's schedule is easier to coordinate than outside resources and the reviewers have a base knowledge of the project. A disadvantage is that internal reviews tend to be conducted with the same vision, framework, and assumptions as the Project Team's. This can lead to a review that does not objectively assess all the parameters that affect the estimate.

9.2 Peer Review

This type of review is similar to the internal Project Team review but uses another Project Team or office to conduct the review. Offices can often perform reviews for each other in this way. The advantage to this type of review over the internal review is that the project gets a review with a fresh perspective on the estimate. This can provide an increased level of confidence in the estimate. This is also a good way to share lessons learned and information between project offices and serves to efficiently utilize fixed engineering resources within the department.

A disadvantage with this type of review is that it is still subject to "group think" because the internal project teams generally all have the same project management and cost estimation philosophy.

9.3 Division Review

This type of review at the Division level is typically more formal. One advantage to this type of review is that the reviewers are external to the Project Team and thus can provide a truly independent perspective on the project. However, the biggest advantage is that the reviewers typically have significantly more experience in performing this type of independent review.

The base cost estimate review process within the NDOT Roadway Design Division:

1) The Estimator/Roadway Designer prepares the base cost estimate. This includes compiling the information that is provided by other specialty groups such as bridge, environmental, etc.
2) The base cost estimate is then reviewed by the Principal Road Design Engineer and Project Manager. The Estimator and Unit leader work together and come to agreement on the various work units and unit bid prices.
3) Project Estimation Specialist ensures that the base cost estimate complies with all NDOT guidelines.
4) Working with the Estimator and Principal Road Design Engineer the Price Checker reviews all the unit bid prices. The Price Checker has the final say regarding the unit bid prices used in the base cost estimate.
5) The Specification Reviewer ensures that all the contract specifications, both standard and project specials are included to describe the work associated with the base cost estimate.

9.4 External

If the project is over $100 million in total cost, a cost risk Assessment or CRA will be needed. An external review of the estimate is required for all CRA processes. This review can provide significant confidence in the estimate that might not be otherwise attainable from internal NDOT resources. Once independent review comments have been satisfactorily incorporated, the revised estimates should be presented to the Project Manager and Project Management Chief for acceptance.

10. Risk Management Planning

10.1 Introduction

Good risk management planning begins with sound project management practices including review of NDOT organizational policies and guidance, project initiation and team alignment, and project planning steps. Risk management must commence early in the project development process and proceed as project knowledge evolves and project information increases in quantity and quality.

Monitoring project development and risk exposure continues with formal assessments of risk which may occur several times through the life of the project. The Project Manager and Team involved in the project, project management plan development, and risk management plan development must consider the resources needed for project risk management and build it into their project development budget and schedule. Risk management activities, including risk workshops (such as CRA or other meetings) should be part of the project work plan and built into the project schedule and budget.

As the project develops and moves through scoping and early design phases, more knowledge about the project becomes available, see Figure 13. With the rising knowledge about a project's scope comes an understanding that contending with some elements of the project will require significant additional resources. Such elements could be related to scope, environmental mitigation and permitting, rising cost of right-of-way as corridors develop in advance of the project, utilities, specialty design (e.g., seismic), and other considerations.

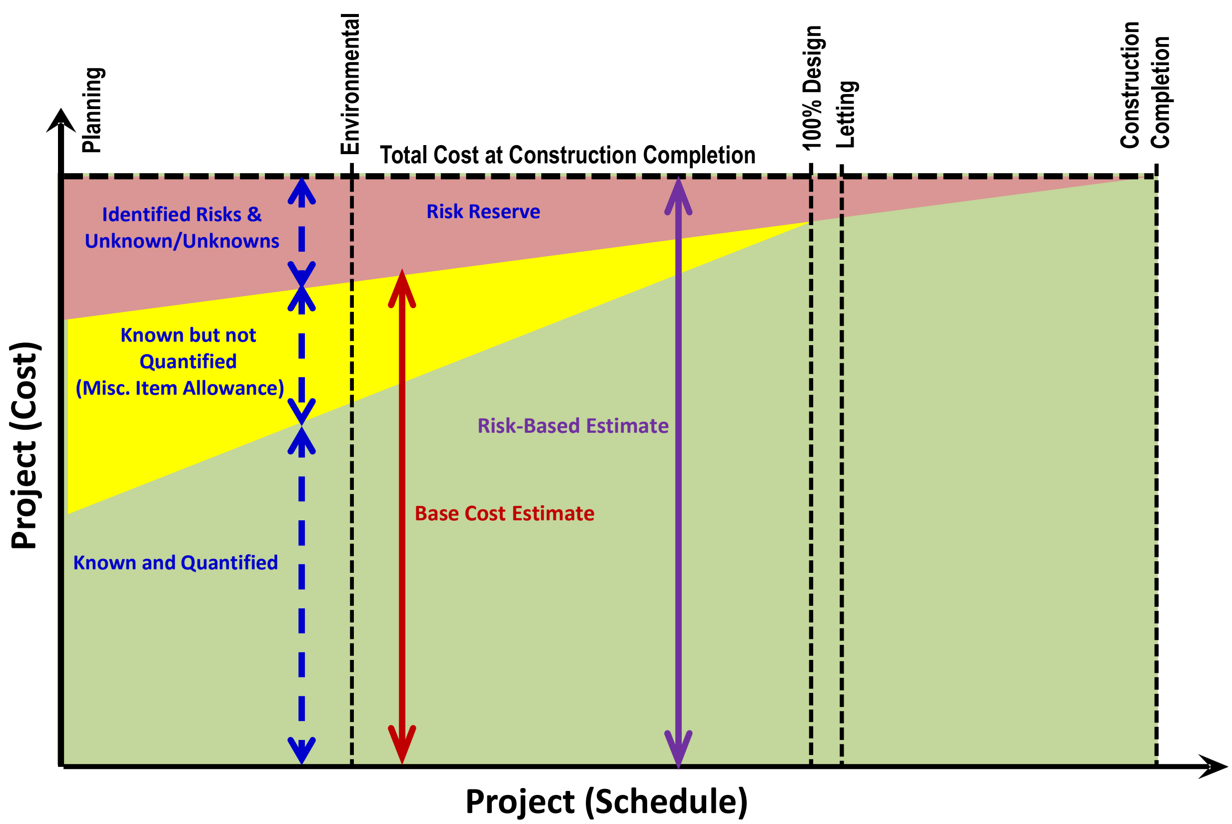

Figure 13 – Assessment of Project Cost

Risk management is an integral part of the project management process. The primary goal of risk management is to reduce uncertainty and risk exposure and minimize cost/schedule overruns. By identifying project risks and anticipating potential problems during early project development, strategies can be implemented to manage project risks and thus improve project performance.

Risks commonly fall into two broad categories: 1) those that can be identified by the Project Team (sometimes termed "known unknowns") and 2) those that are beyond the grasp of the Project Team at a particular point in time (sometimes called "unknown unknowns"). Although risk management is commonly applied to the first type of risks – the known unknowns – a good, properly implemented risk management process can help to quantify the risk impact and develop sound plans for alleviating the effect of unanticipated risks – the unknown unknowns. To manage a project effectively, the Project Management Team must account for and be prepared to manage both anticipated and unanticipated risks. Experience on similar projects can provide insight into the types of problems that might be encountered on later stages of the current project. Experienced personnel, both internal and/or external to the department, representing each key discipline can be utilized to help identify potential risks.

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

10.2 Planning for Project Risk Management

A formal project risk management plan is "a detailed plan of action for the management of project risk." Project risk planning involves the thoughtful development, implementation, and monitoring of appropriate risk response strategies. It is the process to develop and document an organized, comprehensive, and interactive risk management strategy; determine the methods to be used to execute a risk management strategy; and plan for adequate resources.

The project risk management plan may be specific in some areas and general in others. The key to this tool is its scalability. Every project should have a formal risk management plan, but the level of detail varies with the project complexity. The project risk management plan is a living document that should be reviewed and updated throughout the project's development.

10.2.1 What is a Project Risk Management Plan?

The risk management plan is a document that gives a summary of the project and outlines the steps of the risk management process and how the Project Manager and Project Team will approach them. The risk management plan will vary based on the complexity of the project, but most project risk management plans should include an outline similar to the following:

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

10.2.2 Why use a project risk management plan?

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

10.2.3 What does a project risk management plan do?

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

10.2.4 When to develop and use a project risk management plan?

The formal plan should be developed during the Planning phase and updated during subsequent project development phases.

10.2.5 How to use a project risk management plan?

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

10.2.6 What is the risk management process?

Risk management, as an integral part of project management. Risk mitigation and management must start on day one and be continuous throughout the project's development. With proactive risk management we look at projects in a comprehensive manner and assess and document risks and uncertainty. Proactive risk management does not require a formal process and needs to be a consideration in all project decisions. The risk management process consists of a series of steps which should always be followed and considered. These steps consist of the following:

- **Risk Management Planning (Structuring)**: Risk Management Planning is the systematic process of deciding how to approach, plan, and execute risk management activities throughout the life of a project. It is intended to maximize the beneficial outcome of the opportunities and minimize or eliminate the consequences of adverse risk events. In this step the project baselines are adequately defined. The planned project scope, cost, schedule, and corresponding assumptions are defined and documented. This process directs the project team's resources to those significant risk items that pose the greatest threat or opportunity.
- **Risk Identification**: Risk identification involves determining which risks (threats and opportunities) might affect the project and documenting their characteristics. It may be a simple risk assessment organized by the Project Team, or an outcome of the CRA workshop process. This list is maintained in a risk register and updated regularly as the project is developed. (see **Chapter 11. Risk Identification**)

- **Risk Analysis**: Risk analysis assesses the impact and likelihood of the identified risks and develops prioritized lists of these risks for further analysis or direct mitigation. The team assesses each identified risk for its probability of occurrence and its impact on project objectives. Project Teams may elicit assistance from subject matter experts or functional units to assess the risks in their respective fields. The relative severity of the risk (impacts to scope, budget, schedule, quality, etc.) is analyzed and prioritized for management strategies. Depending on the size and complexity of the project risk analysis is done either qualitatively (see **Chapter 12. Qualitative Risk Analysis**) or quantitatively (see **Chapter 13. Quantitative Risk Analysis**).
- **Risk Response Plan**: Risk response strategy is the process of developing options and determining actions to enhance opportunities and reduce threats to the project's objectives. It identifies and assigns parties to take responsibility for each risk response. This process ensures that each risk requiring a response has an "owner". The Project Manager and the Project Team identify which strategy is best for each risk, and then selects specific actions to implement that strategy (see **Chapter 14. Risk Response & Value Engineering**).
- **Monitoring and Control**: Risk Monitoring and Control tracks identified risks, monitors residual risks, and identifies new risks—ensuring the execution of risk plans, and evaluating their effectiveness in reducing risk. Risk Monitoring and Control is an ongoing process for the life of the project (see **Chapter 15. Risk Monitoring and Control**).

  This step involves:

  - Incorporating risk management activities into the project schedule;
  - Making risk management an agenda item for regularly scheduled project meetings;
  - Communicating the importance of risk management to the entire Project Team; and
  - Establishing the expectation that risk will be managed, documented and reported.
  - Quantifying the results of the risk management plan by determining, in dollars or time, how much threat was avoided, how much threat was encountered, how much opportunity was capitalized on and how much opportunity was missed.

10.3 Scheduling a Risk Analysis Workshop?

Project Managers sometimes ask "When is the best time to conduct a risk (informal or CRA) workshop?" After project baselines are established, the Project Manager and the Project/Scoping Team should identify, categorize, and document all risks and opportunities that could impact the project's baselines. Risk analysis is then performed to adequately determine the significance of each risk (probability and impact).

Project risk management is ongoing and iterative, periodically workshop members can regroup to evaluate the project and associated uncertainty and risks, workshops typically occur for a project every at key project milestones.

Key time frames in which risk workshops should be held include:

- Feasibility Study (if conducted)
- Environmental Level
  - Draft EIS
  - Final EIS/ROD
  - FONSI (if Environmental Assessment)
- Design Level
  - Preliminary Design
  - Intermediate Design
  - PS&E Review
- Alternative Delivery
  - Design-Build – Prior to procurement document development/release
  - CMAR – In conjunction with OPCC development

Project risks and mitigation efforts should be discussed at regular project meetings, changes made as appropriate, and following those changes re-run the risk model. Value is gained when action is taken to respond to risks resulting in a cost and schedule savings to the project. In addition to the workshop schedule above, workshops should take into consideration FHWA requirements for initial financial plans and associated updates.

When preparing materials and planning for a workshop that includes quantitative analysis be sure to contact the NDOT Project Management Division for guidance through the process, including scheduling consultants and NDOT resources to effect the completion of a quantitative analysis.

When a Project Team prepares for a workshop much of the work that is performed on a daily or regular basis becomes the input for the analysis. This includes scope of work, schedule estimate (with backup and assumptions), cost estimate – including the basis of estimate, assumptions and backup information. Estimates are used to make financial decisions; therefore materials should be developed that result in an informed decision-making process.

10.4 Other Risk Planning Suggestions

- Risk assessment should begin early, but there must be enough known about the project to understand what is being assessed. This will be to varying levels of detail depending on the point in project development at which the risk assessment is conducted (planning, environmental, final design), hence schedule risk assessments at appropriate times.
- Allow time in the schedule for preparation activities, this includes review and QA/QC of project schedules and cost estimates at appropriate times.
- Allow adequate budget for risk assessment, risk management and risk response activities.
- Report on status of Project Risk in regularly scheduled project meetings.
- Know the organization’s tolerance for risk.
  - Are Project Managers (and upper management) risk averse or risk seeking?
  - How much risk is the organization willing to accept?
  - Knowing the answers to these questions will help with risk management and contribute to the decision-making process when determining risk-response actions.

- Risk management must be partnered with a well-organized and properly documented project base cost estimate and schedule. Risk management introduces reality into the project management process by recognizing that every project has a risk of cost and schedule overrun – this does not mean such overrun is inevitable; it means it is possible.
- In order to fully understand the project the Project Manager and Team must determine what is known and what is not known about a project. There are a good deal of resources to clearly explain what is known about a project, NDOT has specialty offices that gather and provide data in support of project delivery, including: surveying, site investigations, bid histories, real estate services, right-of-way, access management, utilities, environmental, hydraulics, structures, Geotech, railroad, planning and programming, ad/bid/award, construction, and others. Just as important is to devote some energy and resources to assess what is not known and/or is uncertain about a project. One tool for accomplishing this is intentional, thoughtful and deliberate project risk management – as part of an overall project management plan.

10.5 Risk Management Plan Implementation

Implementation of a risk management plan consists of executing the risk management processes while focusing on the ultimate goal of project delivery, on-time and on-budget. The success of the plan implementation is dependent upon commitment, responsibility, and resources. The Project Team, as well as the department, must commit to the risk management plan throughout the life of the project. The responsibility of risk ownership may bear solely on the Project Manager or it may be delegated to team members. In either case, ownership must be clearly defined for plan implementation to prove successful. Resources must be allocated for the execution of the risk management plan. A plan without any practical means of implementation is nothing more than a collection of papers.

Because many of the components of the risk management plan are iterative – risk identification, risk analysis, risk response strategy, etc. Implementation of the plan is an evolving process. As risks change throughout the project the implementation of the plan should be reevaluated to confirm it is still aligned with project performance optimization. Reevaluation of the risk management plan may include:

- Continuous identification of project risks
- Tracking risk triggers
- Updating the assessment and analysis of risks as necessary
- Monitoring project risks
- Monitoring project progress and how it affects project risks
- Executing risk response strategies
- Adjusting project baselines and managing project allowances
- Documenting the processes

Documentation of the risk management process is to provide a record of actual data for future use. Included should be whether the risk did or did not occur, if it occurred, when it was realized and what was the impact to the project objectives. The response strategies and their effectiveness at reducing or eliminating risk should be documented. The costs of the response strategies, in addition to the estimated savings of managed risks, should be documented as well.

Detailed documentation of the risk management process increases the opportunity for meaningful evaluation of “lessons learned” at the completion of a project.

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11. Risk Identification

Risk identification occurs throughout each of the four phases of project development. As projects evolve through project development, the risk profile evolves as project knowledge and understanding grows. Previously identified risks may change and new risks are typically identified throughout the life of the project.

The Project Team should initially identify risks to the maximum extent that is practicable. Risks identification is an iterative process and should be performed throughout the duration of the project. Early and continual identification of risks is critical to the success of the risk management processes. The team should identify risks that are:

- Specific – The risk should be identified and described to the level of detail that the project phase will allow. For the planning phase the risks should be less specific than what may be expected during the final design phase. For example:
  - Planning Phase: Right-of-way may need to be acquired
  - Final Design: Right-of-way must be acquired for the construction of retaining wall #4.
- Tangible – The risk should be tangible enough that impacts can be measured and assessed. The probability of that risk occurring should be reasonably assessed and the event that triggers the risk should be identifiable.
- Relevant – The risk identified should have impacts to the project baselines and should be able to be triggered or managed during the duration of the project.

Risk identification includes recognizing and understanding risk triggers: warning signs that indicate the probability of a risk occurring is increasing. Risk identification also includes recognizing and understanding how a risk may be impacted or affected by another risk or event.

Regardless of the stage of project development, the list of identified risks should be comprehensive and non-overlapping. During conceptual design, the risk register may consist of a few specific identifiable risks along with a set of broader, more categorial risks for each discipline to capture the "unknown unknowns" as previously discussed. As the project develops, the general risks can then be broken down into more specific identifiable risks.

Participants should be encouraged to focus on potential events but consider all potential triggers for the event. For example, a risk event associated with relocation of a particular high-pressure gas line may be identified by different discipline groups for different reasons (e.g., current depth may be insufficient to support placement of fill, location may conflict with new bridge pier, location may conflict with new drainage facilities, etc.). Each of these reasons (triggers) would ultimately result in the same event (relocation of the utility). Thus, the risk event should only be listed once in the register but the probability of that event occurring should consider all the possible triggers.

Participants should be reminded that the inputs to the risk analysis are derived from the collective professional judgment and experience of those assembled to participate and should be encouraged to offer their perspectives, share their experience, and ask probing questions of one another. The group should not simply accept the first opinion expressed without careful consideration, and consensus should be strived for. Independent perspectives from staff outside the core project team should be solicited where appropriate, e.g., from experienced headquarters personnel not currently supporting the project and/or from outside the department.

11.1 Inputs, Tools and Techniques, Outputs

11.1.1 Risk Identification Inputs

The first and most important input is a defined project. In order to fully understand and assess the risks that our projects are exposed to we must first ensure that there is a mutual understanding of the project under evaluation. Before risk identification begins the project must be defined in terms of scope, schedule and budget (estimate) - commensurate with the level of project development at the time of risk analysis.

Alternative delivery methods such as design-build or construction manager at-risk (CMAR) can have an effect on bid prices, markups, schedule and other items. The project delivery method should be clearly defined prior to risk identification because it can have effect on risk ownership and the size and type of risks.

Design-build delivery has the opportunity to transfer risk to the design-builder, however, there is a cost to the Department associated with that, however, that risk is now the responsibility of the design-builder to manage. In most cases it is difficult to “share” risk between the Department and design-builder without very specific language on how that risk is shared.

Construction manager at-risk delivery simplifies the ability for the Department and CMAR to share and manage risk throughout the project. A CMAR contract provides more flexibility during the project’s design, costing, and risk contingency that a design-build contract.

If the project delivery method is unknown at the time of risk identification, then cost and schedule risk and opportunities should be based on a design-bid-build scenario..

11.1.2 Risk Identification Tools and Techniques

Try to identify as many risks as possible that may affect project objectives. State the assumptions for risk identification and analysis and delineate thresholds for risks.

For example, a Project Team may want to characterize all cost risks with potential impact below $100,000 and all schedule risks with potential impact less than 2 weeks as being “minor” thereby not spending inordinate amounts of time on those risks and allowing them to focus on more significant risks, particularly in a time-sensitive workshop setting.

The assumptions and thresholds for risk assessment will be influenced by the size and complexity of the project, project environment, and the owners’ tolerance for risk. There are a wide variety of techniques used for risk identification. Some common techniques are provided below.

The following is a list of some of the tools and techniques commonly used for identifying risks:

- **Historical Review of Projects** – Identify probable project risks by reviewing previous projects and identifying common risks encountered in the past. A list of commonly used risks is included in Appendix C. These risks should be discussed at the workshop and used to solicit participation and process understanding from workshop attendees.
- **Project Assessment** – Identify probable risks through a detailed assessment of the current project.

- **Assumptions and Constraints Analysis** – List all project assumptions and constraints and evaluate the probability of those being true or false and how that would impact project baselines.
- **Brainstorming** – The Project Team brainstorms potential risks, and systematically evaluates each risk for relevance and probability of occurring on the current project.
- **Cause and Effect Diagrams** – Identifying causes that contribute to certain outcomes. Those outcomes are the project risks and should be identified only if they affect a project objective. These are often referred to as "bowtie" diagrams.
- **Checklists** – As with Historical Review of Projects, a checklist of common project risks is created, and the Project Team decides which risks are applicable. This technique can also lead to identification of related risks that are not included on the checklist.
- **Past Experience** – Facilitating a survey of the technical experts to identify risks in their area of expertise, the results are then complied and circulated to the Project Team for review and comment, which can lead to refinement of risks identified or identification of additional risks.

11.1.3 Risk Identification Outputs

An expected deliverable from risk identification includes a preliminary "risk register" which documents the following information:

Identification # for each risk identified - A unique number is assigned to each risk for tracking purposes. If available this can be done utilizing an established Risk Breakdown Structure (RBS). As an example the WSDOT RBS is provided in the appendix of this document.

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

Name of Risk (does the risk pose a threat or present an opportunity?) - Each identified risk should have an appropriate name, for example "NEPA Delay" or "Reduction in Condemnation"; the nature of the risk with respect to project objectives (threat or opportunity) should also be documented. This can be done using the Risk Breakdown Structure (RBS) for naming conventions.

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

Risk Trigger - Each identified risk must include the risk trigger(s). Risks rarely just suddenly occur; usually there is some warning of imminent threat or opportunity. These warning signs should be clearly described and information about the risk trigger should be documented. For example "NEPA Approval Date" may be considered a risk trigger on a project that has a risk of a legal challenge, or other as appropriate.

Risk Type - Does the identified risk affect project schedule, cost, or both?

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

11.2 Risk Identification Suggestions

11.2.1 How to Identify Risk

1. Determine risk thresholds for the project (establish a minimum dollar amount and time duration considered significant for the project under evaluation).
2. Focus on identifying large significant risks which affect project objectives.
3. Carefully document and describe risks in a risk register.

11.2.2 Things to consider during Risk Identification

1. Determine, for the size of your project, what constitutes "significant" risk.
2. Thoroughly describe the risk.
3. Include specialty groups and/or other persons who may have meaningful input regarding the challenges the project may face.
4. Determine who "owns" the risk and who will develop a response.

11.3 Risk Register Guidelines

For a risk register to provide detailed and comprehensive documentation of the risks impacting the project, the following guidelines should be followed:

- Risks should be assigned unique identifiers to enable proper tracking.
- Risks should be categorized by functional assignment/disciplines.
- Within each functional assignment/discipline, risks should be ordered by importance.
- For each risk, its type should be identified as to whether it impacts cost, schedule, or both.
- For each risk, the activity impacted within the project, as per the project flowchart, should be clearly identified.
- Detailed descriptions of each event risk should be documented clearly.
- Risk triggers (events that would result in the risk materializing) should also be identified and described clearly.
- The risk register should also include a comments section for each risk, which would specify the circumstances under which the risk was identified, and any related issues or assumptions used to quantify the risk.
- Impacts should generally be documented as a distribution with a most likely, low, or high assigned value unless the uncertainty in the impact value is relatively small.
- The probability of each risk should also be identified within the risk register.
- For risks impacting costs, values can be in dollar terms or percentage of the base cost, while risks impacting schedule should be in months or in terms of percentages of baseline durations.
- Event risks that do not meet a predetermined minimum threshold, either in value-terms or duration, may be included in the risk register for tracking purposes but are not quantified. Allowances for the "minor" risks should be included in the analysis because, while individually small, their collective impact is not zero.

12. Qualitative Risk Analysis

Qualitative risk analysis assesses the impact and likelihood of the identified risks and develops prioritized lists of these risks for further analysis or direct mitigation. For projects up to $100 million, the Project Team can use a qualitative risk analysis approach in conjunction with a risk register. Qualitative analysis is often used:

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

Qualitative analysis provides a convenient way to identify, describe and characterize project risks. Qualitative analysis utilizes relative degrees of probability and consequence of each identified project risk event in descriptive non-numeric terms. Table 6 illustrates some of the differences between qualitative and quantitative methods of risk assessment and analysis along with some of the pros and cons of each.

Table 6 – Differences between Quantitative and Qualitative

	Quantitative	Qualitative
Characteristics	▪ Project value in both current year (CY) & year of expenditure (YOE) ▪ Quantitative risk impact and probability ▪ Response strategy cost-effectiveness ▪ Uses complex calculations such as Monte Carlo analysis	▪ No quantifiable data ▪ Rankings generally are yes/no, low/medium/high ▪ Rankings are based on judgment
Pros	▪ Processes and results are derived objectively, easily supported ▪ Calculations for value of project, risks, frequency and impacts, response strategy cost/benefits are consistent and repeatable ▪ Evaluating resulting risk management is easy ▪ Project valuations are explicit and defensible ▪ Can be automated, quicker, easier to understand, repeatable more reliable	▪ Requires less time (usually can be accomplished in 1 day on simple projects) ▪ Does not require specialized modeling or expertise
Cons	▪ Calculations are complex and require spreadsheets and/or software ▪ Information gathering is a considerable up-front task ▪ Can take 1-5 days depending on the size and complexity of the project	▪ Calculations for value of project, risks, frequency and impacts, response cost/benefit, are non-existent ▪ Process results are subjective and may not be repeatable ▪ Evaluating resulting risk management cannot be accomplished objectively ▪ Project values are very approximate and may not be realistic

Risk identification, as mentioned in the previous chapter, results in the generation of a risk register. The risk register can be sizeable, and it is necessary to evaluate and prioritize the risk events identified in the risk register. Prioritization can help focus risk mitigation efforts by providing specific, documented risk events that we can act on to shift the odds in favor of project success. Prioritizing risks, which present the highest potential for significantly affecting project objectives, gives Project Managers the information necessary to focus project resources.

12.1 How to perform Qualitative Risk Analysis

Once a risk is identified, including a thorough description of the risk and risk triggers, it can be characterized in terms of probability of occurrence and the consequence if it does occur.

1. Gather the Project Team and appropriate persons to discuss project risk. Establish which of the qualitative risk matrices you intend to use, define the terms you plan to use (High, Medium, or Low).
2. Review the risk information from the risk identification step.
3. Discuss the risk with the group.
4. Evaluate the consequences if the risk does occur by asking the group "What will be the impacts if this risk does occur?" Record the result that the group agrees on.
5. Evaluate the likelihood of the risk occurring and resulting in these impacts by asking the group "How likely is it that this risk will occur?" Record the result that the group agrees on.
6. Prioritize the risks based on the results of the qualitative analysis.

If it is desirable the risks can also be grouped by category (i.e. Environmental, Structures/Geotech) and ranked within each category.

12.2 Levels of Impact

To facilitate qualitative risk analysis defined levels of impact on schedule and cost-based on past experiences and project complexities needs to be defined. Table 7 below shows an example of how a spreadsheet could break down the probability and cost:

Table 7 – Example of Qualitative Percentages

Qualitative Score	Probability	Cost as % of Base Cost Estimate	Schedule as % of Base Schedule Estimate
High	> 75%	> 5%	> 10%
Moderate	25% to 75%	1% to 5%	1% to 10%
Low	< 25%	< 1%	< 1%

Once qualitative descriptors are developed for the given project, the team can input the identified risks and estimated impacts into a qualitative risk planning spreadsheet. Using the estimated impact values for each risk in conjunction with the qualitative descriptors, the Project Team can use the resulting risk register to aid in analyzing and prioritizing the project risks. Figures 14 and 15 show two halves of an example qualitative risk planning spreadsheet.

Project Name	From Here to There
Project Manager/Phone #	John Doe / 999-999-9999
PE Cost	$1.00 million
Right of Way Cost	$2.00 million
Construction Cost	$10.00 million
PE Duration	12.00 Months
Construction Duration	18.00 Months

Risk Identification						
Risk ID	Status	Date Identified	Threat / Opportunity	Risk Name	Risk Description	Activity Impacted
1	Active	12/30/2011	Threat	Utility Relocates	The risk is the utilities will not be relocated in time. The contractor will ask for additional time and compensation	CN

Figure 14 – Example Qualitative Risk Planning Spreadsheet

Less than		Greater than	
$0.03 M	to	$0.15 M	Impact to PE Cost
$0.05 M	to	$0.25 M	Impact to Right of Way Cost
$0.30 M	to	$1.50 M	Impact to Construction Cost
0.18 Months	to	1.80 Months	Impact to PE Duration
0.26 Months	to	2.60 Months	Impact to Construction Duration

Qualitative Analysis					Risk Response			Monitoring and Control	
Schedule Probabilty	Schedule Impact	Cost Probabilty	Cost Impact	Risk Rating	Risk Owner	Strategy	Response Plan	Next Review Date	Review Comments
M	H	L	L	7	Project Manager	Mitigate	Contact and coordinate early with the utility companies	1/30/2012	Set-up a monthly meeting with the utility companies

Figure 15 – Example Qualitative Risk Planning Spreadsheet

Once risks have been prioritized using qualitative analysis, timelines and actions for managing the risk should be established in conjunction with the risk management plan. As the project progresses the spreadsheet is used to identify new risks, monitor and control of existing risks, and track the status of risk responses.

Based on the scale of the project and/or the structure of the risk management plan, the Project Manager should choose to own the associated risks or delegate ownership to specific team members. Risk owners are responsible for monitoring specific risks and documenting the effect of designated risk response strategies. Risk owners will regularly update the Project Team on the status of their risks and the progress of the response strategies.

12.3 Helpful Hints for Qualitative Risk Analysis

- Invite appropriate participants (not too many, not too few).
- Define terms, including scales used to define impact and probability ratings.
- Stay focused – put a time limit on discussion if necessary.
- Record the results.
- Prioritize the risks based on the results.

Those relatively new to risk analysis sometimes claim, in exasperation, "This is nothing more than guessing". This does not represent the full actuality that assigning values for probability and impact relies on the expertise and professional judgment of experienced participants.

The determination of a value for the probability of occurrence and its consequence to project objectives, if it occurs, is for many a new activity and can seem strange at first. In any field, with experience, professionals develop intuition and an ability to understand projects to a greater degree than those not involved with project development and delivery. This experience and intuition is extremely valuable - in a risk workshop forum we surround ourselves with "wise counsel" to seriously and thoroughly discuss the project.

13. Quantitative Risk Analysis

Quantitative risk analysis uses a more detailed approach to evaluating and prioritizing risks by way of numerically estimating the probability that a project will meet its cost and time objectives.

Quantitative analysis is based on a simultaneous evaluation of the impacts of all identified and quantified risks. Risks and their corresponding cost and schedule impacts are entered into a probabilistic model to estimate the overall cost and schedule impacts to the project based on all of the active risks. The quantitative risk analysis can also be used establish and monitor risk-based budgets and schedules, and to determine which risks have the greatest potential impacts on those estimates.

All quantitative risk analysis preformed on NDOT projects shall use a statistical simulation technique such Monte Carlo simulation to model the collective impact of base and risk values.

When performing quantitative risk analysis, the Project Team must remove any conservatism and contingencies from project schedule and cost baselines and risks must be characterized relative to those baseline values and assumptions.

13.1 Types of Quantitative Workshops

13.1.1 Informal Workshop

For projects under $25 million an Informal workshop can be conducted using the "NDOT Risk Tracking and Analysis Tool for Small and Medium Size Projects" (NDOT Quantitative Risk Tool) This tool was designed for projects under $25 million.

Table 8 depicts the differences between an informal workshop and a cost risk assessment (CRA) workshop.

Table 8 – Include Risk Management Milestones in the project schedule.

Informal Workshop Milestones include:	Cost Risk Assessment Workshop Milestones include:
▪ Project Scope, Schedule and Estimate are complete (apt for the level of development) ▪ Prep meeting (initial review of areas of concern, determine tool qualitative or NDOT Quantitative Risk Tool) ▪ Risk Meeting (risks are identified and characterized) ▪ Risk Response Actions Developed ▪ Risk Response Actions Implemented	▪ Workshop Request Form submitted ▪ Project Scope, Schedule and Estimate are complete (apt for the level of development) ▪ Prep Session (flowchart project; determine subject matter experts; additional prep items) ▪ Workshop ▪ Risk modeling software ▪ Preliminary Results Presented ▪ Draft Report ▪ Final Report

For projects between $25 million and $100 million or projects that need a more detailed analysis than can be provided by qualitative methods it is suggested that the Project Teams conduct a facilitated CRA workshop.

The NDOT Quantitative Risk Tool guides the user through the analysis process by first requesting general project information then prompting risk inputs. The probability of the risk occurring as well as the cost and schedule impact estimates (low, high and most likely) are inputted. The risk register allows for anticipated response of risk probability or impact to be included for Monte Carlo analysis.

The tool will compute expected value estimates for the risks and produce a qualitative risk summary. The tool employs quantitative, Monte Carlo probabilistic modeling to generate a probability distribution for project cost and schedule based on the inputted risk data.

The results of the NDOT Quantitative Risk Tool are cost and schedule forecasts with pre- and post-response cumulative distribution functions ("S-curves"). Figure 16 is an example of an S-curve.

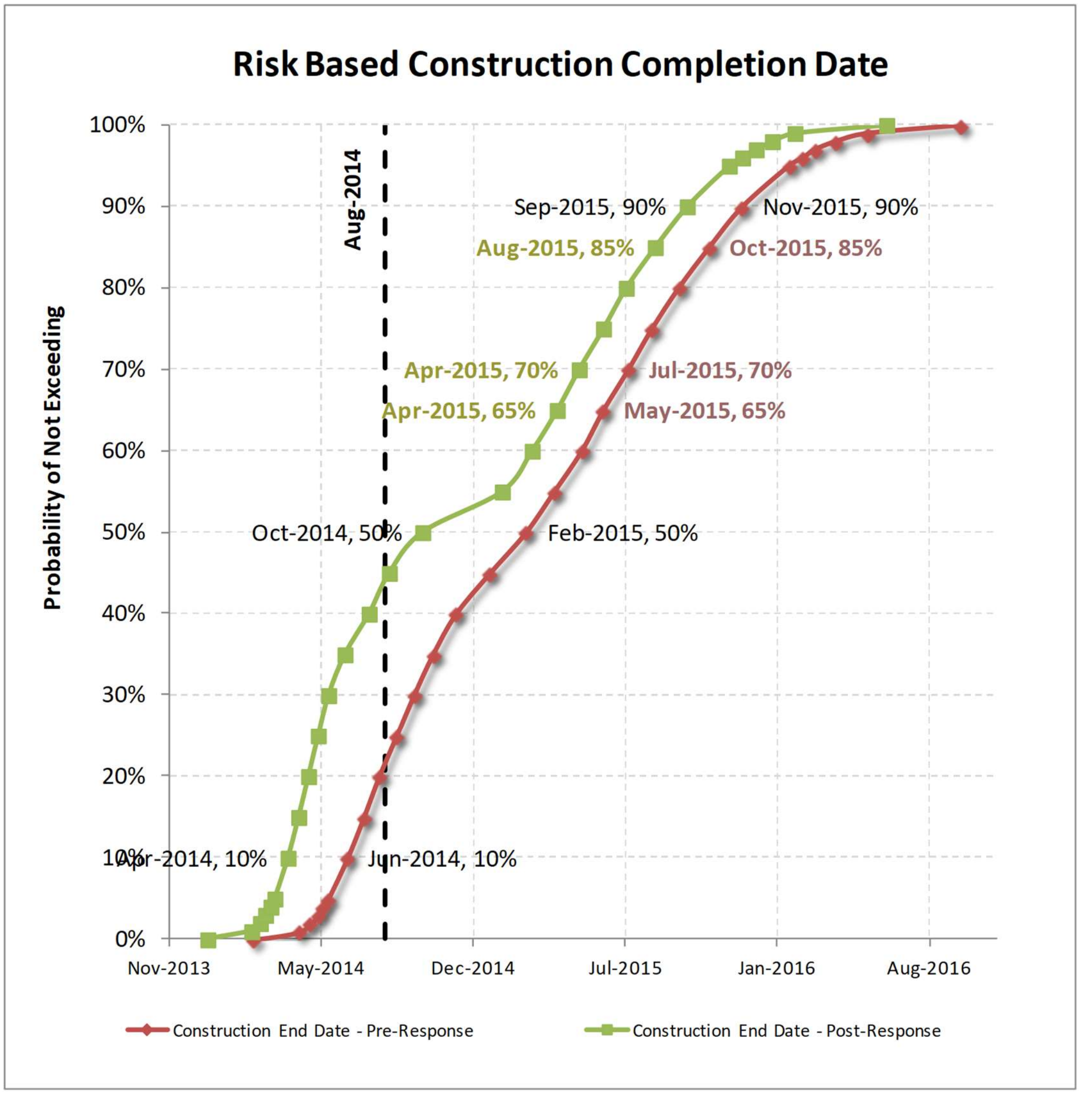


Figure 16 – Example S-curve of Construction Completion Date

S-curves provide a cumulative probability distribution for the risk analysis results for project cost and schedule. The charts show the probability of not exceeding a given cost or schedule on the vertical axis and the corresponding cost (in millions of year of expenditure dollars) or schedule (in terms of month and year) on the horizontal axis.

In addition to the S-curve, the model produces a prioritized list of quantified risks in the form of a Tornado diagram. The diagram in Figure 17 displays the top cost risks with the most severe potential impact to the project.

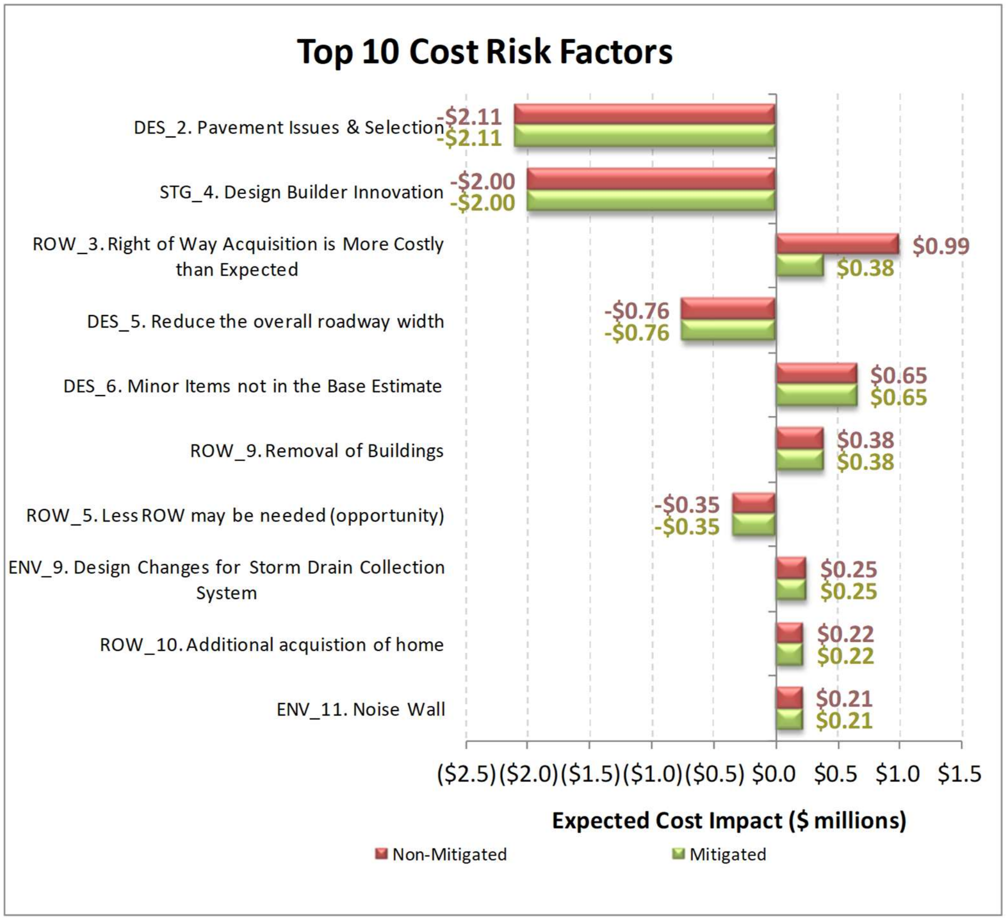


Figure 17 – Example Tornado diagram

The informal workshop analysis should be conducted several times throughout project development, typically after start of a project phase or major activity (scoping, environmental, right of way acquisition, etc.), as new risks are identified and existing risks are mitigated.

13.1.2 Cost Risk Assessment Workshop

A facilitated CRA workshop is required on projects greater than $100 million, and highly suggested for projects between $10 million and $100 million.

The result of these workshops is not only used for risk identification and management but is the resulting risk-based estimates are required for use in the preparation of finance plans for projects in excess of $100 million per FHWA requirements.

This process requires the use of a trained risk facilitator, who specializes in risk assessment and analysis, to facilitate CRA workshops and perform detailed probabilistic analysis of project risks to scope, budget and schedule.

At a minimum, the CRA must produce a risk register containing identified project risks as well as associated cost/schedule impacts and anticipated risk response strategies.

13.2 Recommended Participants

Preparation for the workshop may take one or more days depending on the project size, complexity, knowledge of the participants and stage of project development (planning, design, or construction). The Project Manager/Project Team should work with the risk lead to identify the best combination of participants (NDOT and/or consultants) at each meeting. Not all participants need to attend every day. The goal is to make an effective use of time for all parties in a manner that ensures a sound and objective analysis.

Workshop attendees include Project Team members from all functional units and functional managers (Division heads) that have expertise regarding potential impacts of identified project risks. Local and federal entity stakeholder representatives must be invited to attend these workshops to fully understand impacts of federal and local requirements to the project baselines and provide external perspective.

Table 9 – Workshop Team (Typical Participants)

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

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

- Be involved,
- Actively participate in discussion,
- Not be afraid to identify initial risks and impacts, and
- Be heard – in relation to their responsibility and/or expertise.

Key elements necessary for a successful workshop include:

- **Functional Team Attend Relevant Sessions** – The workshop should be attended by SMEs in sufficient numbers to represent each of the functional classifications for risk.
- **Project Management Attend All Sessions** – Beyond the functional team attendees, the project management team must be in attendance at the risk workshop to show that all elements of the project are accurately represented.
- **Provide Input on Risks in Session** – During the workshop, the attendees will be asked to provide the following information on the risk items that have been identified in the risk list, and to identify any additional risks not currently included on the risk list:
    - Any additional context to help describe the risk event and current estimating assumptions
    - The potential impact on the project if this risk occurs, and whether the risk applies to cost and/or schedule
    - The probability of a specific risk occurring and resulting in the impacts described
    - The schedule flowchart activity (or activities) that a specific risk impacts, such as construction, design, and ROW
    - Relationships to other risks, including direct (dependencies) and indirect (correlations) if applicable.

Participants are encouraged to think broadly about potential events that could impact the project, even if the likelihood is believed to be very low. For each identified risk, careful consideration should be given to the true range of potential impacts if the event were to occur, from a reasonable best case to a reasonable worst case (typically defined by 10^{th} and 90^{th} percentile conditional impacts). The probability of occurrence should be consistent with the defined impacts. For more complex risks, more sophisticated approaches such as scenario-based or "probability tree" structures can also be utilized where appropriate. Care should be given to ensure that the workshop participants are not being overly optimistic or overly pessimistic when providing input to the risk assessment.

13.3 How a Quantitative Risk Analysis is Performed

13.3.1 General Process

A quantitative risk analysis requires the following key inputs:

- Flowchart schedule without contingency or float
- Base cost estimate without contingency but including uncertainty, mapped to flowchart activities
- Risk register with risks assigned to flowchart activities

- Escalation factors by activity or activity group (R/W, design, construction, etc.)

Within the model, all costs and event risks must be assigned to a specific flowchart activity or set of activities. Escalation rates also should be assigned to each activity to account for the future cost at the time of expenditure. Additionally, for activities where schedule overruns will lead to additional indirect/overhead costs, monthly overhead delay costs should be assigned. Figure 18 provides an overview of the risk-based modeling approach.

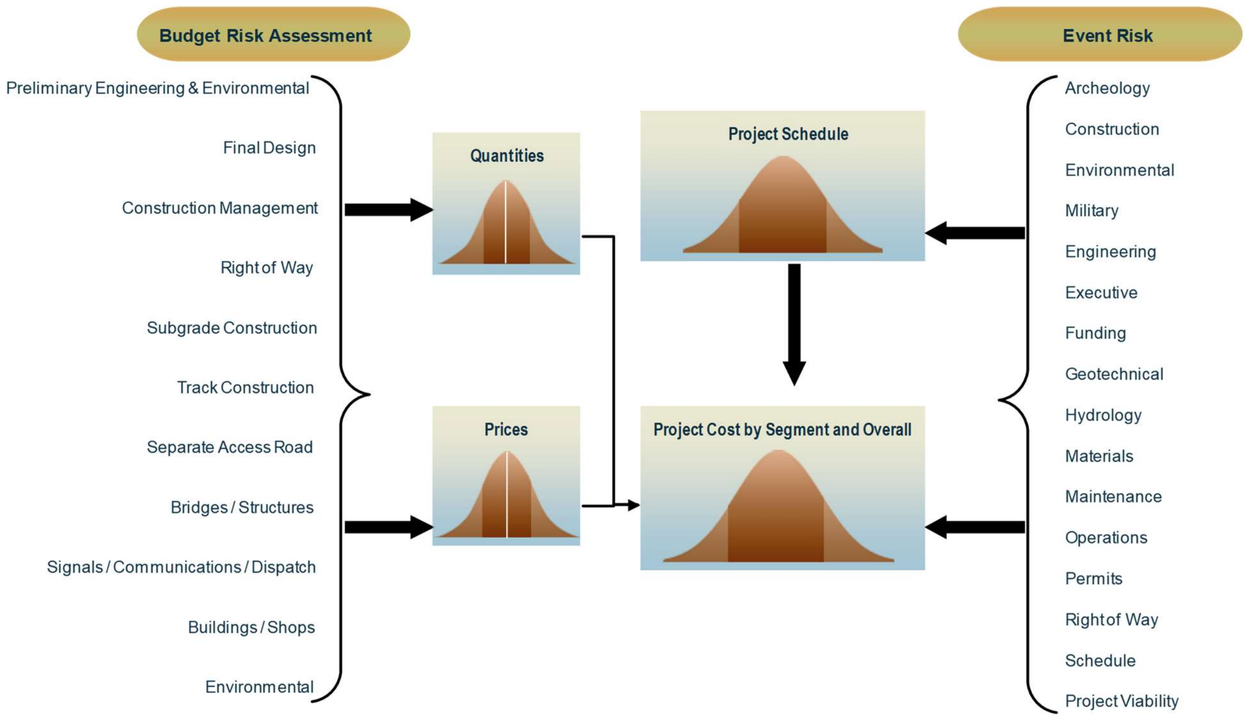


Figure 18 – Risk-Based Modeling Approach

13.3.2 Tools and Techniques

1. Gather and Represent Data

   - Interviews – can be formal or informal settings, such as smaller group meetings and/or larger formal workshops.
   - Subject Matter Expert (SME) input – participating collaboratively with the Project Team and cost-risk team, independent subject matter experts can participate in interviews/workshops or contribute opinions in other ways such as surveys (questionnaires). External SMEs can offer substantial value by providing independent perspective on key issues, such as possible contractors' approaches to the project, complex or unique design challenges, alternative delivery, etc.
   - Represent data in terms of probability and impact, impacts can be represented using discrete distributions or continuous distributions.

Figure 19 provides an example of risk quantification, showing the key elements of the quantification of the risk. At the completion of the workshop, the risk register should be populated with all key risk factors to the project.

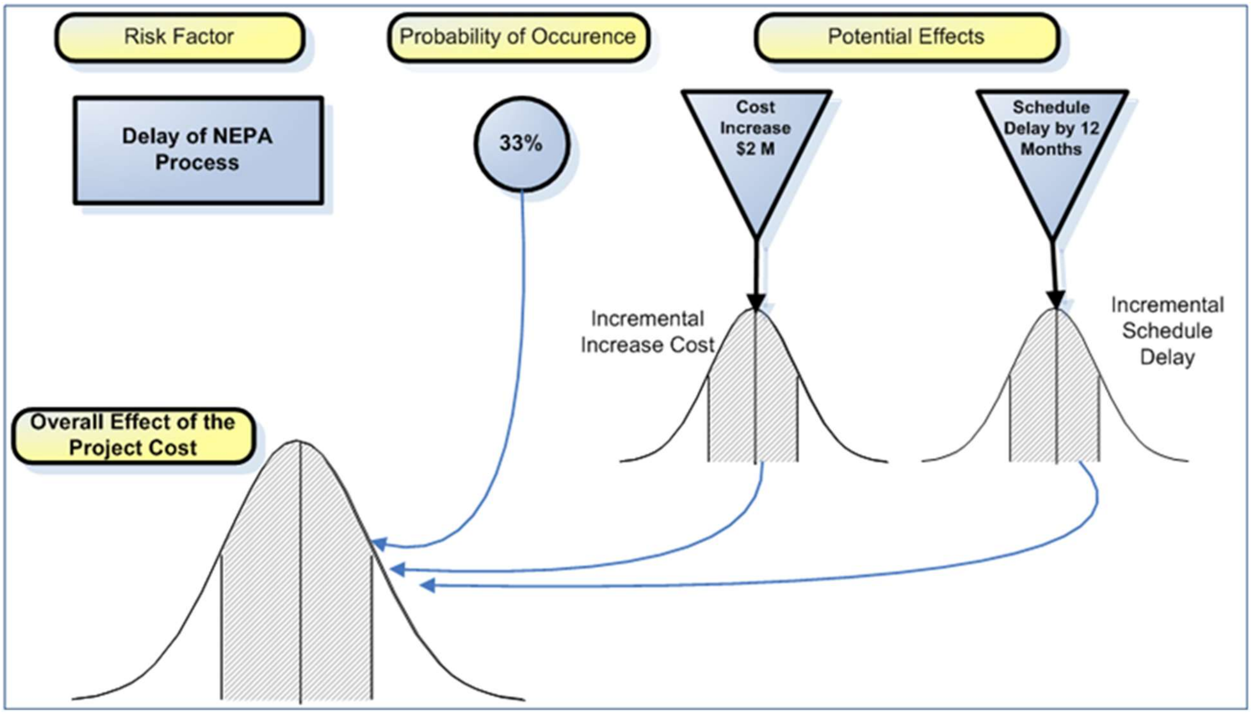


Figure 19 – Sample Risk Quantification

2. Quantitative Risk Analysis and Modeling
   - Project simulation using Monte Carlo technique to generate a probability distribution of project cost and schedule based on uncertainty and risk effects.

13.3.3 Quantitative Risk Analysis Outputs

1. Risk Register – the risk register begins during risk identification and is further developed during analysis (qualitative and/or quantitative); the risk register is a key component of the project management plan.
   - Prioritized list of quantified risks – those risks that have the most significant impact (threats or opportunities) to project objectives. (tornado diagrams, expected values, decision trees)
   - Probabilistic analysis of the project – probability distributions of estimated cost and milestone completion dates.
   - Quantitative analyses can be conducted several times throughout project development; trends can be identified, mitigation strategies can be implemented and monitored, the risk profile of a project evolves and changes as the project is developed and knowledge is gained and design changes occur.

13.3.4 Post-Workshop Adjustment and Validation

When the workshop is over, it is over! The workshop is a "snapshot" examination of the project and issues of concern should be brought up during the workshop. Elicitation of risks and their characteristics are completed by the end of the workshop. The modelers need to complete the modeling and analysis based on the information generated at the workshop, without interference and disruption due to post-workshop wrangling and debate.

Following the risk assessment workshop, the Project Team may be given the opportunity to review the populated risk register and follow up on any key items that are unresolved. At this stage, the following materials should be finalized:

- Base cost estimate, stripped of contingencies and escalation, with base cost uncertainty ranges
- Project flowchart schedule, representing the logical progression of the project delivery
- Risk register populated with input from the risk assessment workshop

Additionally, the Project Team should communicate with the risk team to determine the timeline for development of initial results and deliverables.

Following the completion of the analysis, risk response actions are to be developed and incorporated, by the Project Team, into the risk management plan. Benefits of the process are seen during the weeks and months following the workshop as the Project Team uses information gained from the workshop in their day-to-day decision making and project development activities.

14. Risk Response & Value Engineering

Following identification and analysis of project risks Project Managers and Project Teams must respond to the identified project risks, focusing on risks of most significance, in order to shift the odds in favor of project success.

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

14.1 Risk Response: Actions

Actions in response to risks:

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

14.1.1 Threats

For threats, risk response is a plan to seek answers to questions such as: what will one do if the event risk happens, can a risk be avoided, and what plans can one put in place prior to the event risk to minimize the impact if it occurs? Common risk response strategies for threats are:

- **Avoid** – Changing the project scope or approach to eliminate the impact of a risk. Some threats can be avoided entirely. This can be done by changing the way the project is performed or by de-scoping the portion of the project that contains the risk element. Getting the job done in a risk-free environment is likely to cost more. Eliminating the risky scope might disappoint a critical stakeholder or degrade the business reason for performing the project.
- **Transfer** – Moving a risk to another party who is more capable of handling the risk (such as the developer or insurance company). This may involve the payment of a fee (outsourcing to a skilled expert or fixed price construction contracts) or a premium (insurance). Transferring risk will almost always have an added cost and most likely will still be a project cost which must be considered. Some risk, such as schedule risk, cannot be transferred. Even though one can contract (transfer) the schedule responsibility to third parties, if they are late, the project is still late.
- **Mitigate** – The Project Team may seek to lessen the impact of a specific risk item, which may involve the consumption of additional time and/or money. Mitigation usually requires positive action which may affect the project base cost and schedule (for example, issuing a new work package for additional utility or geotechnical investigation). Mitigation can be a very effective strategy and is often better than a "do nothing" approach.

- **Accept** – Decide to not take action to deal with a specific risk. After trying to avoid, transfer, or mitigate the threats to the project, the project will be left with residual risks, which are threats that cannot be reduced further. In active acceptance, the Project Team sets up a contingency reserve fund to account for the residual expected value of the remaining risks. The passive form of acceptance involves merely acknowledging the risk and moving forward on the project without reserves, which may seem sensible for risks with small expected values. Another form of risk acceptance is denial. Professional risk management seeks to reduce the use of denial as a strategy.

14.1.2 Opportunities

For opportunities, risk response is a plan of action designed to capitalize on the potential beneficial project cost and schedule opportunities. Typical risk response strategies for opportunities are:

- **Exploit** – Proactively take advantage of an opportunity.
- **Share** – Assign ownership of the opportunity to a third-party who is best able to capture the benefit for the project. Examples of sharing opportunities include forming risk-sharing partnerships, teams, or joint ventures, which can be established with the express purpose of managing opportunities.
- **Enhance** – Take action to increase the probability and/or impact of the opportunity for the benefit of the project; seeking to facilitate or strengthen the cause of the opportunity, and proactively targeting and reinforcing its trigger conditions. Impact drivers can also be targeted, seeking to increase the project's susceptibility to the opportunity.
- **Accept** – Take no action when a response may be too costly to be effective or when the risks are uncontrollable and no practical action may be taken to specifically address it. At times, it is not possible or appropriate to take advantage of all opportunities, and the Project Team should document them and at least provide awareness that these exist and have been identified.

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

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

14.2 Risk Response Tools and Techniques

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

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

14.2.1 Planning Risk Response Actions

The risk response action that is selected is influenced by the level of the risk. High impact and high probability risks require aggressive responses (threats should be avoided and opportunities exploited if possible).

The Project Team should identify a risk response strategy and assess the costs and impacts for each identified risk. The goal of the risk response is to reduce the overall impacts of the risk on the project objectives.

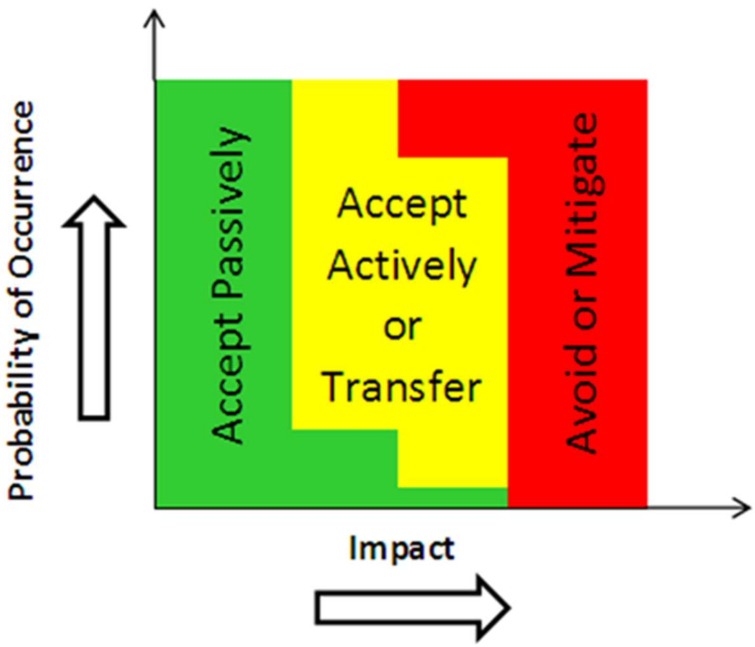


Figure 20 – Risk Response Planning Chart

The risk response planning chart graphically differentiates risk responses with regards to the probability of occurrence and impact of the specific risk. The colored response zones, illustrated in Figure 20, are general recommendations. The Project Manager and Project Team should adjust the zones to more accurately represent their project.

Risks with high potential impact should be avoided or mitigated an attempt to reduce overall impact on the project objectives. Risks with low impact or very low probability of occurrence should be passively accepted, i.e., risks with negligible effects should be acknowledged and monitored but require no additional action. Risks that fall in between high and low impact should be accepted actively or transferred.

The Project Manager and Project Team may choose whatever response they deem most effective, however, comparing the expected cost of transferring the risk to an external entity and the expected cost of actively accepting the risk provides a method to determine if the risk should be transferred or accepted actively. The costs associated with responding to a risk should be compared to the expected cost of the risk to determine if a response is beneficial. It is important to note that “costs” associated with risks should be measured in both money and time because risks affect both the cost and schedule of a project.

14.2.2 Documentation of Response Actions

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

14.3 Value Engineering

Value Engineering (VE) is the most effective technique known to identify and eliminate unnecessary costs in product design, testing, manufacturing, construction, operations, maintenance, data, and processes and practices.

Value engineering has been in existence for over 60 years and is called different things (e.g., value engineering, value analysis, value management, and value methodology) by different groups, but still, the basic concept/process is very similar. In 1997, SAVE International, an international society devoted to the advancement and promotion of value engineering, published a “Value Methodology Standard” in an effort to provide a generic description of the overall process.

Value Engineering is a systematic process used by a multidisciplinary team to improve the value of a project through the analysis of its functions. Value is defined as a fair return or equivalent in goods, services, or money for something exchanged. Value is commonly represented by the relationship:

Value ≈ Function/Resources

Where function is measured by the performance requirements of the customer and resources are measured in materials, labor, price, time, etc. required to accomplish that function. A value methodology focuses on improving value by identifying alternate ways to reliably accomplish a function that meets the performance expectations of the customer.

In order to qualify as a VE Study, the following conditions must be satisfied:

- The VE Team follows an organized Job Plan that includes, at a minimum, the six phases identified in the following section. Function Analysis, as defined in this document, is performed on the project.
- The VE Team is a multidisciplinary group of experienced professionals and project stakeholders. Team members are chosen based on their expertise and experience with the project. Sometimes individuals who have relevant expertise; but are not directly involved with the project are added to provide a different point of view.
- The VE Team Leader/facilitator is trained in value methodology techniques and is qualified to lead a VE Study Team using the Job Plan. The SAVE International Certification Board certifies, with the designation Certified Value Specialists (CVS), those individuals who have met specified training requirements and have demonstrated competency in the application of the Job Plan.

14.3.1 VE Job Plan

VE is a systematic process that follows a "Job Plan," which outlines specific steps to analyze an issue and achieve the maximum number of feasible alternatives to address the issue at hand. Within the context of risk response planning, the issue may be a specific event risk or a series of event risks that can potentially be addressed through value engineering.

Value engineering is applied by a multidisciplinary team to improve the value of a project through the analysis of functions.

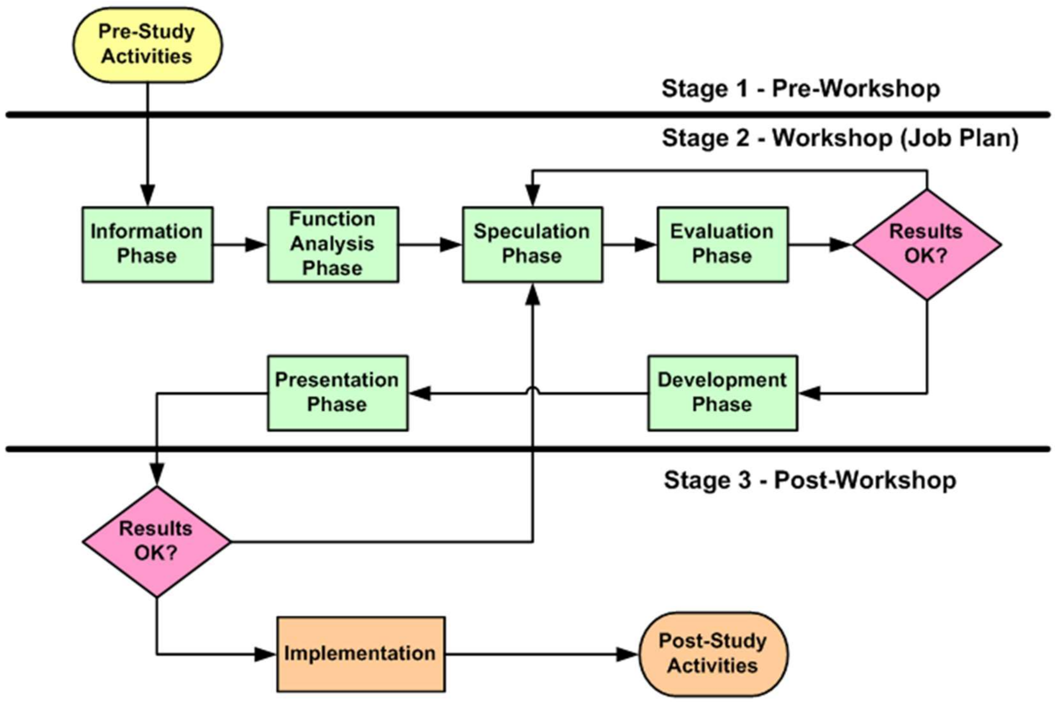


Figure 21 – Value Engineering Job Plan

The VE Job Plan as shown in Figure 21 consists of the following sequential phases:

Information Phase – The team reviews and defines the current conditions of the project and identifies the goals and issues that the team is facing.

Function Analysis Phase – The team defines the project functions using a two-word active verb/measurable noun context. The team reviews and analyzes these functions to determine which functions need improvement, elimination, or creation to meet the project's goals.

Creative Phase – The team employs creative techniques to identify other ways to perform the project's function(s).

Evaluation Phase – The team follows a structured evaluation process to select those ideas that offer the potential for value improvement while delivering the project's function(s) and considering performance requirements and resource limits.

Development Phase – The team develops the selected ideas into alternatives (or proposals) with a sufficient level of documentation to allow decision-makers to determine if the alternative should be implemented.

Presentation Phase – The team leader develops a report and/or presentation that documents and conveys the adequacy of the alternative(s) developed by the team and the associated value improvement opportunity.

14.3.2 Combining Cost Risk Assessment and Value Engineering

Cost risk assessment/analysis and value engineering augment each other well. By participating in the risk assessment process and understanding the project risks, the value engineering team gains a much better understanding of the project and potential issues and can focus efforts on the most critical elements of the project. Additionally, VE recommendations that are identified for further evaluation by the project team can be included as opportunities or risk mitigation responses in a concurrent or subsequent CRA update.

The following is an example of how the value engineering phases can be aligned with the risk analysis process:

- **Information** – Participate in the development of the risk register, and review contingencies and bid items that are set up to mitigate risk.
- **Functional Analysis** – Include the secondary function of "reduce risk."
- **Creative** – Brainstorm ideas on how to respond to risk (avoid, mitigate, transfer, or accept).
- **Evaluation** – Include a risk assessment as part of the evaluation criteria.
- **Development** – Develop recommendations that reduce risk and include a risk assessment for value engineering recommendations that modify the original design.
- **Presentation** – Present both the value engineering findings as well as risk analysis findings.

During the information phase of the workshop, members of the Project Team should explain the development of the risk register and educate the value engineering team about the baseline project as well as potential event risks. As the VE process moves into the creative phase the VE Team begins brainstorming various ideas to address the major project event risks.

Identification of Value Engineering Alternatives

The threats and opportunities defined in the risk assessment workshop are carried over into the brainstorm list to be evaluated along with ideas defined by the value engineering team. Ideas are generated based on the functions identified in the functional analysis phase; additional speculation is performed on the function of "reduce risk" to address the major risk factors identified in the risk assessment. The ideas are evaluated and drafted into recommendations.

Incorporating Value Engineering Recommendations into Risk Analysis

Not all VE recommendations fit into the original risk profile as risk response strategies. Some of the recommendations do not mitigate a risk; they simply add value to the project e.g., by providing a more cost-effective solution. Any such recommendations that the project team elects to pursue can be treated as a new opportunity in the risk register with a potential impact to cost/schedule and likelihood of the recommendation ultimately being implemented and the savings realized. This likelihood will be assigned by the Project Team or project management, as it is ultimately a project team decision regarding whether to adopt the value engineering recommendation.

VE recommendations specifically intended as risk mitigation strategies can be incorporated into the CRA by adjusting the likelihood and/or impact of an existing risk either implicitly (considering both the likelihood of risk occurrence and the likelihood of successful implementation) or explicitly using a probability tree or scenario approach.

The base cost and schedule should also be updated as appropriate to reflect the cost and time impact of any adopted recommendations.

VE and CRA workshops can be performed either sequentially or concurrently. A concurrent approach can save time and, potentially, cost by utilizing a common pool of experts; however, a sequential process allows time between workshops for review and consideration of findings and recommendations and allows all team members to participate in all discussions by avoiding parallel sessions. The recommended approach is summarized below:

- Perform an initial CRA to establish and validate the base estimates and identify and prioritize the risks.
- Conduct a VE workshop which considers possible risk mitigation strategies in addition to traditional VE recommendations.
- Perform a CRA update to incorporate any adopted VE recommendations and identified risk mitigation strategies into the quantitative analysis.

14.4 Risk Allocation/Ownership

In recent years, NDOT has selected the design-build delivery method for certain projects to better manage their risk. One reason is that project delivery via design-build provides more flexibility in risk allocation. Using design-build or other Pioneer Program delivery method allows for the transfer or sharing of risks traditionally borne by NDOT to the design-builder or contractor.

Appropriate allocation of project risks is critical during the development of any project. Risk allocation is even more critical for design-build contracts because many of the risks that are traditionally managed by NDOT can and do become the responsibility of the design-builder. While these risks may be transferred to the Design-Builder or contractor the additional costs must be considered as part of the overall project costs. These potential costs may be reduced, however, a contractor will not fully accept a risk, they will price it based on their comfort level of taking on that risk. Potential design-build risk transfer or sharing examples could include utility relocations and agreements; railroad coordination and approval; and demolition methods. While sharing of risk under a design-build contract can be accomplished, particular attention must be applied to the technical provisions and contract to ensure appropriate allocation of the risk. Most notably, the risk for errors and omissions in final plans and specifications is inherently transferred from NDOT to the design-builder. However, this flexibility should not result in shifting all possible risks to the design-builder because it leads to the potential for higher price proposals, excessive changes, and disputes. The flexibility can be beneficial only upon proper allocation of the risks.

Allocation of risk through CMAR contracts can be more of dynamic process since there is more interaction between the CMAR and NDOT staff during the identification and quantification of risks during design development. CMAR development of the OPCC also identifies direct risks the CMAR anticipates and provide the Department an opportunity to directly discuss the risk with the CMAR and best methods to allocate and reduce the potential risk impact to the project.

Conversely on an unsolicited proposal per the Pioneer Program guidelines, it is highly likely the proposer will be transferring to or sharing risk with the Department in effort to make the proposal look more attractive. An unsolicited proposal may also include long-term maintenance. This will require NDOT to consider long-term risks such as maintenance, future development, and other risk typically not considered. It is critical that as part of the unsolicited proposal, the Project Review Team thoroughly review the proposal for risk responsibility (Proposer, NDOT, or shared).

Identification of which risks to transfer begins at project inception. Throughout the project development, NDOT must work to advance the design far enough so that the related risks are clearly identified and tolerable for the contractor, design-builder, CMAR, or unsolicited proposer. The central premise is to then clearly allocate the risks to the party that can best control them to avoid any confusion, disputes, and litigation. FHWA's design-build contracting rule recommends identifying and allocating various project risks such as:

- Governmental risks, including the potential for delays, modifications, withdrawal, scope changes, or additions that result from multi-level Federal, State, and local participation and sponsorship;
- Regulatory compliance risks, including environmental and third party issues, such as permitting, railroad, and utility company risks;
- Construction phase risks, including differing site conditions, traffic control, interim drainage, public access, weather issues, and schedule;
- Post-construction risks, including public liability and meeting stipulated performance standards; and
- Right of way risks including acquisition costs, appraisals, relocation delays, condemnation proceedings, including court costs and others.

The proportion of NDOT's risk ownership in a project varies depending on the project delivery method used (see **Section 5.14 Project Delivery Methods**). Design-Bid-Build, Design-Build and Construction Manager at Risk (CMAR) each have their own risks (opportunities and threats).

Figure 22 on the next page give a synopsis of these risks. Please refer to the NDOT Project Delivery Selection Approach (PDSA) as discussed in Appendix C in the NDOT Pioneer Program Guidelines (PPG).

PPG link: https://www.nevadadot.com/home/showpublisheddocument?id=4496.

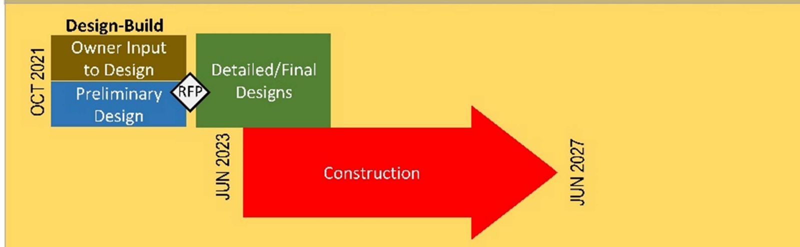
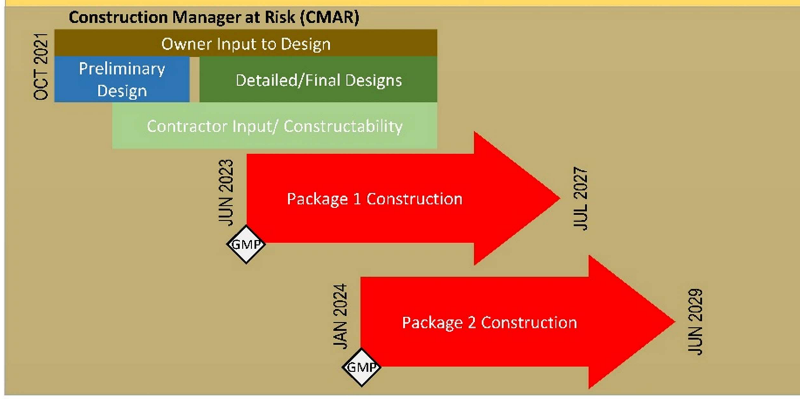
Project Delivery Alternatives	Structure/Schedule	Advantages/Opportunities	Disadvantages/Threats
Design-Bid-Build		• Traditional, well-known delivery method • Simple procurement process to manage • Defined scope • Lowest initial price • Good for simple, uncomplicated projects that are not schedule driven and not subject to change	• Linear process equals a longer schedule • No control over General Contractor selection • No control over Sub-Contractor selection • Lack of flexibility for change • Can create adversarial relationships • Not very well suited for complicated projects that are sequence, schedule or change sensitive
Design-Build		• Single point of accountability for design and construction • Enables fast-track delivery because construction begins before design is complete • Project cost defined early in the process	• Design-Build firm controls contingency • Not suited for small projects • Requires additional design effort • Change management may be expensive
Construction Manager at Risk (CMAR)		• CMAR selected on qualifications and competitive price proposals • Early CMAR involvement in design and estimating • Collaborative approach to completing the project • GMP early in the project • CMAR responsible for delivery of the project on time and within budget • Enables fast track delivery • Good for large, complex, schedule-driven projects • Owner and CMAR control contingency jointly	• Not suited for small projects • Owner/owner representative must actively participate in contingency management

Figure 22 – Comparison of Project Delivery Methods

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15. Risk Monitoring and Control

For the most part we may have little or no control over the external environment, but we do have control over how we interact with it. We have control over our state of readiness, we can look ahead and improvise and adapt. We can control the size of our response to identified risk events and the quality of our documentation. We have control over how we integrate risk management into our project management plans.

As the project develops, the nature and magnitude of risks will change. Typically, as the Project Team successfully responds to risks and the project knowledge increases, risk exposure will diminish. In effect, risk reserves can be reduced as event risks are successfully avoided or mitigated, or as risks have passed the time during which they are active. The risk management plan documents how risks will be monitored and controlled during project delivery and provides risk response strategies associated with them.

15.1 Documentation of Response Actions

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

An important aspect of risk management planning is to develop and document how the Project Team plans to respond to individual risks. There are three activities to accomplish this:

1. Incorporate risk monitoring into the risk register.
2. Identify risk monitoring criteria.
3. Review response strategies.

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

Determining the appropriate metrics for the project, ensuring they are not burdensome and affect behavior. Too often, metrics change behavior to provide better metrics not better performance. Set the amounts and conditions for use of the project risk reserves. Establish the final objectives of the project with stakeholders to improve the chances of project success. Confirm endorsement of team members and stakeholders as the project plan evolves.

15.1.1 Incorporating Risk Monitoring into the Risk Register

The project's risk register can serve as a risk tracking tool and contains columns for risk response planning and tracking. A subset of the risk register containing the risk response section is shown in Figure 23. The Project Team should assign a "risk owner" to track and record the effectiveness of the strategies and any changes to the project risk profile, as follows:

- Document the response action by describing the action, the work activities it will affect, and the cost of the response action.
- Identify the person(s) responsible for successful implementation of the response action.
- Document whether response actions have a positive or negative effect on achieving project objectives in the risk management plan.

- Consider the time impacts of the response action and how the risk response may affect the overall project and/or other risks.

Functional Assignment	Risk Owner	Risk Name	Review Frequency	Risk Response Strategy	Risk Action Plan (Steps Needed)
C3	C4	C5	C16	C17	C18
Environmental	Contractor	Delay in Environmental Assessment Re-Evaluation	Monthly	Accept	Track status monthly with FHWA.
Roadway Design	Agency	Need for Design Exceptions	Quarterly	Mitigate	Move to finalize design, review risk quarterly to determine need for possible design exceptions.

Figure 23 – Sample of Risk Response Section within Risk Register

Not all risks identified require immediate management. Often, a Project Team needs to prioritize the risks for which it plans to develop strategies in the future in an effort to make the best use of the time available. An example would be to begin with the risks with the highest cost and schedule impacts. The following is the methodology for developing risk response strategies. Value engineering can be used to assist in the development of risk response strategies.

15.1.2 Identifying Risk Monitoring Criteria

Given the demands on NDOT staff in the delivery of their projects and on Project Teams with limited resources, it is often difficult to provide proactive management and monitoring for every risk identified. Therefore, criteria must be established for the number of risks, dollar value for significant risks, cost of planned response actions, etc. One good tool in establishing these criteria is the Pareto Principle. The Pareto principle (also known as the 80-20 rule) states that, for many events, roughly 80% of the effects come from 20% of the causes.

15.1.3 Reviewing Response Strategies

Periodic reviews of how effective the response strategies are in mitigating or avoiding the identified risk should be conducted. These reviews should include cost and time of implementation. The lessons learned and information generated from these reviews should be input into the project scope, schedule, and budget.

15.1.4 Helpful Hints

- Be thorough and tenacious in gathering status update information for risks.
- Monitor status and trends continuously (scope, schedule, cost estimates, quality of product, etc).
- Address problems and issues immediately; anticipate and discuss in advance if possible.
- Communicate.
- We can monitor and control a number of things in our risk management efforts, including:
    - Our state of readiness
    - Our commitment to looking ahead, and being prepared to improvise and adapt
    - The robustness of our risk response actions

  - The quality of our documentation
  - How earnestly we integrate risk management into our project management plan
  - Keeping our RMP up-to-date, including the RMP spreadsheet
- Our preparedness to provide the following performance data regarding our risk management efforts:
  - Number of risks identified
  - Number of significant risks, as determined through quantitative analysis
  - Dollar value of significant risks
  - Estimated cost of planned response actions
  - Estimated value of costs avoided through risk management
  - Actual cost of response actions
  - Estimated Actual value of costs avoided through risk management
  - Estimated amount of delay (months) avoided through risk management

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16. Use & Reporting of Risk-Based Cost Estimation Results

All efforts should be made to deliver the project within the established cost and schedule budget. Project Managers and Teams must not plan on using risk reserves from onset of a project. They should avoid or mitigate threats and exploit opportunities. If the avoidance of a risk is not possible, the team should try to minimize the likelihood of occurrence or reduce the impact of threat

Early in the project development process, a base cost estimate is established and then a risk assessment is conducted to provide the Project Manager the foundation that will be used to measure project delivery performance. This risk-based cost estimate will be escalated to the year of expenditure (YOE) and then used to establish the initial project budget.

16.1 Risk Reserve Approach

For all projects over $100 million in total cost along with other projects that have had a quantitative analysis a risk reserve approach is used to establish the project budget. The following steps should be used to establish a budget with a risk reserve:

1) Establish a base cost estimate that includes uncertainties.
2) Identify project risks and perform a quantitative risk analysis.
3) The risk reserve is the 70th percentile cost (YOE) minus the base cost estimate (YOE). Note: Caution should be taken when there are large opportunities and/or threats within the risk register. These risks can sway the 70th percentile cost and should be reviewed closely before establishing the project risk reserve. A post-mitigation update to the CRA analysis should be considered in some instances to better define the residual risks that the reserve needs to cover.
4) The Project Manager shall review the risk reserve with the Project Management Division Chief.
5) The project budget is the base cost plus the risk reserve.
6) Update the project budget at major project transition points by conducting a formal base cost estimate review and updated cost risk assessment and analysis.
7) The project cost range is reported the 10% percentile for the low estimate and the 90% percentile for the high estimate (see section **16.5 Reporting of the Results)**.

16.2 Risk Allowance Approach

For projects that have only had a qualitative risk analysis a risk allowance approach is used to establish a project budget.

1) Establish a base cost estimate that includes uncertainties.
2) Identify project risks and perform a qualitative risk analysis.
3) Select an appropriate percentage of risk allowance from Table 10 to account for risks associated with the project and/or the project phase. Table 10 is meant to be used as a guide only and contains an element of subjective assessment of risk. Use the table with judgment based on personal knowledge of project details and Project Team input.

Table 10 – Guide for Risk Allowance

Qualitative Risk Allowance Percentages			
Risk Impacts	Estimate Phase		
	Planning (Conceptual)	Environmental	Final Design (Preliminary Estimate)
High	+15%	+10%	+7%
Medium	+10%	+7%	+5%
Low	+7%	+5%	+3%

4) After selecting a percentage to use for risk allowance review the amount with the appropriate division chief in charge of the program that the project is being funded, e.g., the Project Management Chief for capacity improvement projects, the Roadway Design Chief for 3R projects, the Structures Division Chief for bridge rehabilitation projects, etc. and/or the project sponsor.
5) The project budget is base cost plus the appropriate risk allowance (Base Cost + (Base Cost * percentage)).
6) Update the project budget at major project transition points (e.g., planning to environmental to final design) and/or when a formal base cost estimate review is conducted (e.g., 60%, 90% design).
7) The project cost range is reported as base cost for low estimate and base cost plus risk allowance for high estimate (Base Cost + (Base Cost * percentage)).

As the project is developed and project risks are reduced, the risk allowance factor should also be reduced. For example, the Project Manager may decide to use a 15% risk allowance factor for establishing their budgets during the project's planning phase due to high level of project risks. During the environmental phase of the same project, they may decide to use a 5% factor since they have accounted for or addressed a number of risks associated with the project. This is only an approximation and it is strongly suggested that a quantitative risk assessment is conducted to establish the appropriate risk reserve for your project.

Market conditions, like having a minimum of potential bidders, may warrant an additional 1-5% added to the risk allowance.

If the selected amount of risk allowance exceeds the high risk impact at any point in design serious consideration needs to be given to having a quantitative risk assessment

16.3 Accounting for Schedule Risks

To account for risk and uncertainties in project duration a buffer can be established in the project schedule. The duration of the buffer is established through risk analysis (risk reserve). The buffer duration is the 70% percentile minus the base duration. If the risk-based buffer duration exceeds 30% of the base schedule, the Project Manager should seek approval of the Project Management Division prior to finalizing the project schedule. The project buffer, managed by the Project Team, allows for the protection of the project end date by managing risks associated with the schedule. The project buffer should be applied to tasks of the project that the risks are associated with.

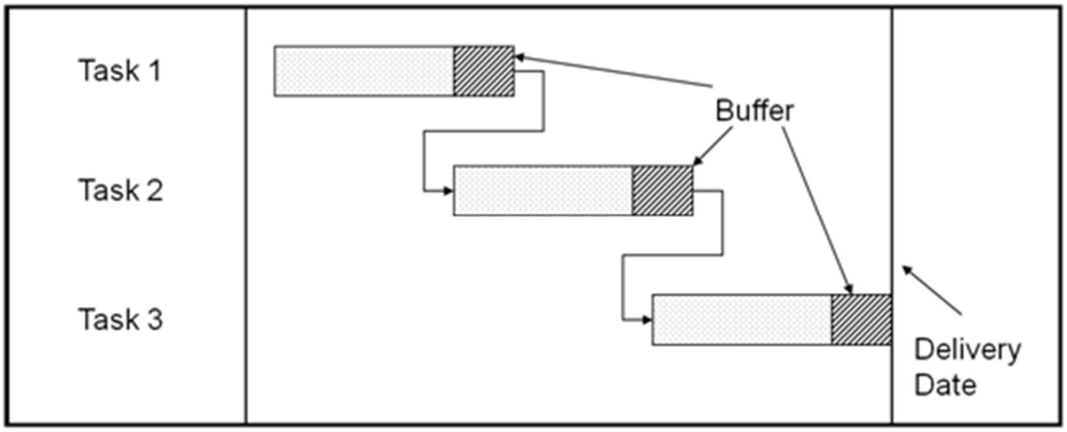

Figure 24 – Example schedule showing added risk

The buffer must be managed to ensure it is not wasted and it is available if needed. The task buffer can be used if needed when risks are realized, but the task should be managed to the early completion date without the buffer to maximize the potential for early completion. If a risk occurs and the buffer is used the Project Team must develop strategies to accelerate the remaining portions of the overall schedule. For example, the Project Team may work overtime, add additional staff, or hire consultants to complete the task.

For external reporting, the project schedule is reported as a range (start – finish). "Start" is the actual start date of the project or a project phase. "Finish" is the anticipated completion date of the project/phase with risks included.

16.4 Frequency of Estimate Updates

Evaluate/update the base cost estimate with its uncertainty every 4-6 months or when any of the following occur:

- New information is gathered or processed (quantity change or new items)
- Major design levels are completed (30%, 60%, and 90%)
- Volatile price fluctuations occur
- Highest cost items change
- Major scope changes
- Prior to each cost risk assessment workshop
- Retirement of a major risk

NOTE: The level of effort for estimate updates is scalable and should be appropriate for the amount of change.

16.5 Reporting of the Results

If post-response figures are not available, the pre-response figures may be reported, and adjusted later. Only report the escalated base cost estimates and the escalated risk reserve estimate. The risk reserve may be reported either by project phase or as a single number in the construction phase. Reports will then correspond to the 70th percentile estimate, using NDOT escalation tables.

For public reporting of the project cost and schedule it is recommended that the 10% and 90% percentiles be used as the outer ranges. See the examples in Figures 25 and 26.

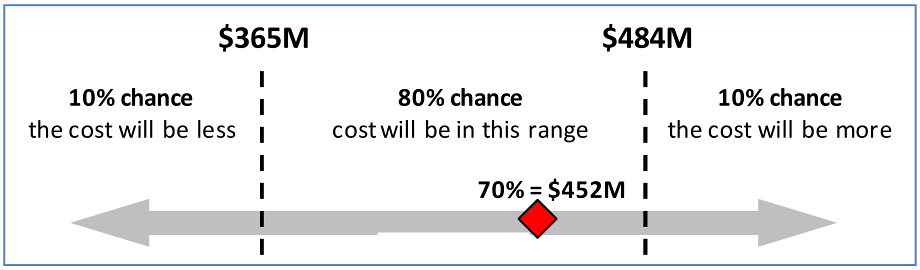

Figure 25 – Example Reporting Cost Range

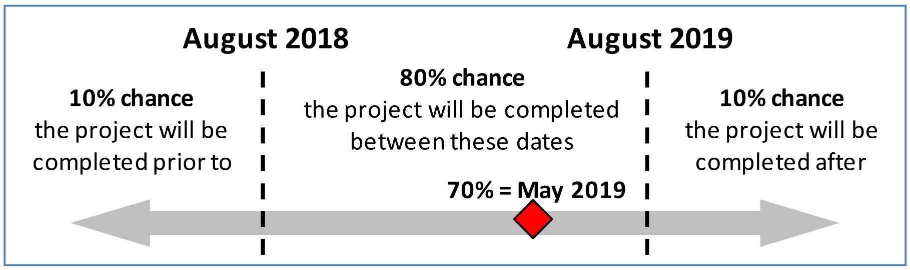

Figure 26 – Example Reporting Schedule Range

16.6 Risk-Based Estimate Management

Project Managers are responsible for managing their projects to the base cost estimate that has been escalated to the year of expenditure. The risk reserve or allowance is just that and should be held in reserve for use if and when risks materialize. Having a risk reserve/allowance provides the Project Manager and Team flexibility in managing project risks.

1) When risks occur the Project Manager is allowed to utilize up to half of the risk reserve/allowance amount without any prior approval from the Project Management Chief. The Project Manager may delegate ownership of individual risks to Project Team members as necessary.
2) When half of the risk reserve/allowance has been expended, the Project Manager must discuss how the remaining risks will be managed with the Project Management Chief.
3) When three fourths of the risk reserve/allowance has been expended, the Project Manager must obtain approval from the Project Management Chief before any additional amount of risk reserve/allowance can be used.
4) If the risk reserve nears depletion or is depleted, despite active risk management on the part of the Project Manager and Team, decisions will need to be made to either adjust the scope of the project or to increase the budget. These decisions will need to be made by the appropriate division chief.

Resources

Project Risk Management – Guidance for WSDOT Projects:
http://www.wsdot.wa.gov/publications/fulltext/cevp/ProjectRiskManagement.pdf

Cost Estimating Manual for WSDOT Projects:
http://www.wsdot.wa.gov/publications/manuals/fulltext/M3034/EstimatingGuidelines.pdf

Minnesota DOT Estimating web page:
http://www.dot.state.mn.us/cost-estimating/estimating/index.html

Minnesota DOT Cost Estimation and Cost Management Technical Reference Manual:
http://dotapp7.dot.state.mn.us/edms/download?docId=670233

Utah DOT Estimator's Corner:
http://www.udot.utah.gov/main/f?p=100:pg:0:::1:T,V:1624

WSDOT Plan Preparation Manual:
http://www.wsdot.wa.gov/Publications/Manuals/M22-31.htm

Cost Estimate Process:
http://www.wsdot.wa.gov/Projects/ProjectMgmt/RiskAssessment/Process/

CEVP Guidelines and Glossary:
http://www.wsdot.wa.gov/Projects/ProjectMgmt/RiskAssessment/workshop.htm

Estimating Tips and Watch-outs: http://www.wsdot.wa.gov/NR/rdonlyres/76111703-D435-4CB7-A965-1297F7F00599/30323/ESTIMATINGTIPSWATCHOUTS.doc

Instructional Letter: Inflation and Market Conditions Applied to Base Estimate:
http://wwwi.wsdot.wa.gov/docs/OperatingRulesProcedures/4071.pdf

WSDOT Online Project Management Guide:
http://www.wsdot.wa.gov/Projects/ProjectMgmt/PMOG.htm

RS Means: http://www.rsmeans.com/

20-07/Task 172 Recommended AASHTO Design-Build Procurement Guide

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Appendix A – Basis of Estimate Template

This Basis of Estimate (BOE) template prompts Project Teams to think about their projects and costs. Please include this form with all estimates and estimate updates. The Project Development Checklist (PDC) from the Project Development and Scoping Guidelines is also suggested for use during the Planning Phase of a project and can be found on SharePoint. The following BOE form is a suggested format for your use in documenting the Basis of the Estimate for your project. The text in blue is to be replaced with your estimate's project information.

Project Name:	
State Route(s):	
Location: City, County:	
Date Prepared:	

Project Information

Sponsor (Lead Agency):	Nevada DOT
Responsible Person:	Name/Title/Tel Number
Design Organization (Sponsor or Consultant):	Name and Contact Info
Estimator or Lead Designer:	Name and Contact Info
Estimator or Lead Designer's Organization:	Name
Start of Construction:	MM/YY
Estimating Processing Software:	Excel or Masterworks
Estimate available in Excel format:	Yes (desirable for estimates to be available in Excel, required for estimates to be available in Masterworks)
Work Breakdown Structure (WBS):	Very Basic (describe)
Project No.	#####
Database for cost estimate:	Sources
Method of Measurement:	Scaling and CAD

Purpose

Describe the project, its purpose, timing and location.

Scope

Mission/Design:	Improve safety and congestion at ###/## I/C
Estimate Type:	Parametric, Deterministic or Stochastic
Project Type :	Upgrade existing facility
New structures required:	Yes
Existing Structures which need to be modified:	Assumed structure is replaced
Demolition:	Bridge and buildings
Hazardous Materials:	Anticipated

Wetlands Issues:	Yes
Archeological Impacts:	Not anticipated, based on database research
Native American (Tribal) Issues:	Not anticipated, based on contacts made to date
Storm water regulation update:	Estimate based on updated information
Noise walls:	Anticipated

Describe in paragraph form the basic scope of the project.

Methodology

Describe the primary estimating methodology used for the cost estimate. Several different methodologies may be used in one estimate. Also list the schedule or timeline for the estimating process.

Design Basis

Describe the types and status of engineering and design deliverables used to prepare the estimate, including any design assumptions.

Planning Basis

Describe the project management, engineering, design, and construction approach used to prepare the estimate. This should include proposed or assumed working schedule, construction sequence, etc. List overall project milestones and project schedule.

Cost Basis

Describe methods and sources for determining bid item pricing. Provide detailed backup of the data in the attachments.

Allowances

Describe allowances in the cost estimate. Include their purpose and how the allowance amount was determined.

Assumptions

Discuss all assumptions not covered in other areas of the Basis of Estimate. Examples are listed in blue.

- Construction funding all at once
- Environmental regulations don't change
- Today's dollars, unknown future escalation rate (Mid-point of construction could change.)
- Undeveloped properties remain undeveloped. At this time there are no known proposed developments on the properties, although some of the properties are for sale.
- There are good soils.
- Captured major bid items
- Traffic control cost-based on past experience and District philosophy doesn't change
- Right of Way is not needed to relocate the gas line.
- The project is in the process of selecting a preferred alternative. At this time there are two alternatives, a preferred alternative should be selected by MONTH AND YEAR. The

estimate is based on alternative #### with the thought that it may be the more expensive of the two options.

- The quantity calculation precision guidelines and rounding rules as described in the NDOT Project Estimation Policy Guidelines and Estimate Building Procedures Manual were followed or were not followed for the following reasons (state the reasons).

Exclusions

List those items NOT INCLUDED in the cost estimate. Select those items that an outside person might think are included but are not.

Exceptions

Describe any item that does not follow NDOT standards for cost estimating.

Risks

Describe all threats and opportunities that surface during the preparation of the cost estimate. This can become the basis for a risk management plan, as required on all NDOT projects greater than $100 million.

Estimate Quality Assurance

Describe the quality assurance plan for the estimate. What reviews or benchmarking has been done on this estimate?

Reconciliation

How was review comments incorporated into the estimate? How does this estimate compare to the previous one preformed for this project? What are the differences and how are they explained?

Project Funding and Scheduling

The request for scheduling and programming was submitted to Financial Management on MM/DD/YY and revised on MM/DD/YY.

The Scope/Budget Change and Programming/STIP Revision Request Form were submitted on MM/DD/YY. This form shall be processed and submitted with each Preliminary, Intermediate, 90%, and PS&E project milestone submittals.

Estimating Team

List all parties involved in preparing the estimate. Phone and email records should be kept of all the people who had input into the estimate.

Lead:	Name and Contact Info
Quantity Survey:	Name and Contact Info
Unit Cost Development:	Name and Contact Info
Summarization and Presentation:	Name and Contact Info
Estimate Review & QA/QC:	Name and Contact Info

Attachments

Attachment A: Reference Drawings

Attachment B: Additional Attachments (as necessary)

Basis of Estimate Checklist

#	Question	Answer			Comments
1	Has NEPA/SEPA process begun?	Yes	No	N/A	
2	Has a preferred alternative been selected?	Yes	No	N/A	
3	Have any environmental mitigation measures been defined and included in the estimate?	Yes	No	N/A	
4	Has an alignment been established?	Yes	No	N/A	
5	Has a grade been established?	Yes	No	N/A	
6	Have right of way requirements been researched and priced?	Yes	No	N/A	
7	Has a typical section been established?	Yes	No	N/A	
8	Have the geotechnical site conditions been researched?	Yes	No	N/A	
9	Have potential geotechnical cost issues been factored into the estimate?	Yes	No	N/A	
10	Has a drainage report and concept plan been prepared?	Yes	No	N/A	
11	Has a noise analysis been performed?	Yes	No	N/A	
12	Are sound walls included in the estimate?	Yes	No	N/A	
13	Have retaining wall types been defined?	Yes	No	N/A	
14	Has a traffic analysis (modeling, HCM, LOS, etc,) been performed?	Yes	No	N/A	
15	Have pavement design reports been reviewed?	Yes	No	N/A	
16	Has a pavement life cycle cost analysis been performed?	Yes	No	N/A	
17	Has a preliminary construction phasing strategy been developed to help estimate traffic control, detours, temporary structures, temporary construction easements, lanes, etc.?	Yes	No	N/A	
18	Were potential detours evaluated for traffic volumes and vehicle classifications?	Yes	No	N/A	
19	Have any investigations been done in regards to potential major utility impacts?	Yes	No	N/A	
20	Has a conceptual landscaping and aesthetics plan been developed?	Yes	No	N/A	
21	Are there any design deviations that are or expected to be of concern?	Yes	No	N/A	
22	Were other projects used as metrics of comparison for the estimate? If so, please list projects.	Yes	No	N/A	
23	Has funding been identified for: Design/PS&E?	Yes	No	N/A	
24	Has funding been identified for: Right-of-Way?	Yes	No	N/A	
25	Has funding been identified for: Construction?	Yes	No	N/A	

Appendix B – Sample Risk Elements

(Adapted from Washington State DOT)

Technical Risks

- Design incomplete
- Right of Way analysis in error
- Environmental analysis incomplete or in error
- Unexpected geotechnical issues
- Change requests because of errors
- Inaccurate assumptions on technical issues in planning stage
- Surveys late and/or surveys in error
- Materials/geotechnical/foundation in error
- Structural designs incomplete or in error
- Hazardous waste site analysis incomplete or in error
- Need for design exceptions
- Consultant design not up to Department standards
- Context sensitive solutions
- Fact sheet requirements (exceptions to standards)
- Others

External Risks

- Landowners unwilling to sell
- Priorities change on program
- Inconsistent cost, time, scope, and quality objectives
- Local communities pose objections
- Funding changes for fiscal year
- Political factors change
- Stakeholders request late changes
- New stakeholders emerge and demand new work
- Influential stakeholders request additional needs to serve their own commercial purposes
- Threat of lawsuits
- Stakeholders choose time and/or cost over quality
- Others

Environmental Risks

- Permits or agency actions delayed or take longer than expected
- New information required for permits
- Environmental regulations change
- Water quality regulations change
- Reviewing agency requires higher-level review than assumed
- Lack of specialized staff (biology, anthropology, archeology, etc.)
- Historic site, endangered species, wetlands present

- EIS required
- Controversy on environmental grounds expected
- Environmental analysis on new alignments is required
- Formal NEPA/404 consultation is required
- Formal Section 7 consultation is required
- Section 106 issues expected
- Project in an area of high sensitivity for paleontology
- Section 4(f) resources affected
- Project on a Scenic Highway
- Project in a floodplain or a regulatory floodway
- Project does not conform to the state implementation plan for air quality at the program and plan level
- Water quality issues
- Negative community impacts expected
- Hazardous waste preliminary site investigation required
- Growth inducement issues
- Cumulative impact issues
- Pressure to compress the environmental schedule
- Permits expire
- Others

Organizational Risks

- Inexperienced staff assigned
- Losing critical staff at crucial point of the project
- Insufficient time to plan
- Unanticipated workload
- Delay getting approvals, decisions
- Functional units not available, overloaded
- Lack of understanding of complex internal funding procedures
- Not enough time to plan
- Priorities change on existing program
- New priority project inserted into program
- Inconsistent cost, time, scope and quality objectives
- Others

Project Management Risks

- Project purpose and need is poorly defined
- Project scope definition is poor or incomplete
- Project cost, scope, schedule, objectives, and deliverables are not clearly defined or understood
- No control over staff priorities
- Too many projects
- Consultant or contractor delays

- Estimating and/or scheduling errors
- Unplanned work that must be accommodated
- Communication breakdown with Project Team
- Pressure to deliver project on an accelerated schedule
- Lack of coordination/communication
- Lack of upper management support
- Change in key staffing throughout the project
- Inexperienced workforce/inadequate staff/resource availability
- Local agency issues
- Public awareness/support
- Agreements

Right of Way Risks

- Utility relocation may not happen in time
- Freeway agreements
- Railroad involvement
- Objections to Right of Way appraisal take more time and/or money
- Others

Construction Risks

- Inaccurate contract time estimates
- Permit work windows
- Utility
- Surveys
- Buried man-made objects/unidentified hazardous waste
- Weather related
- Others

Regulatory Risks

- Water quality regulations change
- New permits or new information required

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Appendix C – Risk Allocation/Sharing

Appropriate allocation of project risks is critical during the development of any project. Risk allocation is even more critical for design-build contracts because many of the risks that are traditionally managed by NDOT can and do become the responsibility of the design-builder.

Identification of which risks to transfer begins at project inception. Throughout the project development, NDOT must work to advance the design far enough so the related risks are tolerable for the design-builder. Risk should be allocated to the party that can best manage them.

Risk	Design-Bid-Build/CMAR			Change	Design-Build	
	Owner	Shared	Contractor		Owner	Design-Builder
Design Issues						
Definition of Scope	X				X	
Project Definition	X				X	
Establishing Performance Requirement	X				X	
Preliminary survey/base map	X				X	
Geotech Investigation - Initial Borings based on preliminary design	X				X	
Geotech Investigation - Initial Borings based on proposal	X			→		X
Establish/Define initial subsurface conditions	X				X	
Initial project Geotechnical Analysis/Report based on preliminary Design	X				X	
Proposal specific Geotechnical Analysis/Report	X			→		X
Plan conformance with regulations/guidelines/RFP	X			→		X
Plan accuracy	X			→		X
Design Criteria	X				X	
Conformance to Design Criteria	X			→		X
Design Review Process	X			→		X
Design QC	X			→		X
Design QA	X			→		X
Owner Review Time	X				X	
Changes in Scope	X				X	
Constructability of Design	X			→		X
Contaminated Materials	X				X	
Local Agency, Utility, Railroad Issues						
Identification of initial local agency impacts	X				X	
Obtaining Initial local agency permits	X				X	

Risk	Design-Bid-Build/CMAR			Change	Design-Build	
	Owner	Shared	Contractor		Owner	Design-Builder
Establishing initial local agency requirements	X				X	
Establishing final/actual local agency impacts	X			→		X
Modifications to existing local agency permits	X			→		X
Identification of initial utility impacts from preliminary design	X				X	
Establish initial Utility Locations / Conditions	X				X	
Defining required utility relocations from preliminary design	X				X	
Relocation of utilities prior to contract	X				X	
Relocation of utilities under agreement during contract			X			X
Modified agreement with private utility based on final design	X			→		X
Modified agreement with public utility based on final design	X			→		X
Damage to Utilities under Construction			X			X
Verification of Utility Locations/Conditions	X			→		X
Coordination with Utility Relocation Efforts during contract		X		→		X
Unforeseen delays - Utility/third party	X				X	
Utility/Third Party Delays resulting from proposal/modified design	X					X
Identification of RR impacts based on preliminary design	X				X	
Obtaining initial RR agreement based on preliminary design	X				X	
Coordinating with RR under agreement	X			→		X
Other work/Coordination		X		→		X
Third Party Agreements (Fed, Local, Private, etc.)	X				X	
Coordinating with Third Parties under agreement		X		→		X
Coordination/collection for third party betterments		X		→		X
Coordination with Other Projects		X		→		X
Coordination with Adjacent Property Owners		X		→		X
Construction						
DBE compliance			X			X
Safety / Safety QA			X			X
Construction Quality/Workmanship			X			X
Schedule			X			X
Materials Quality			X			X
Materials documentation			X			X
Material availability			X			X

Risk	Design-Bid-Build/CMAR			Change	Design-Build	
	Owner	Shared	Contractor		Owner	Design-Builder
Initial performance requirements of QA Plan	X				X	
Final Construction/Materials QC/QA Plan	X			→		X
Construction/Materials QA	X			→		X
Construction QC			X			X
Construction QA Procedural compliance auditing	X			→	X	
Construction IA testing/inspection	X				X	
Construction Staking		X		→		X
Erosion Control		X		→		X
Spill Prevention		X		→		X
Accidents within work zone / liability			X			X
Third Party Damages			X			X
Operations and Maintenance During Construction			X			X
Maintenance under Construction - new features			X			X
Maintenance under Construction - existing features			X			X
Maintenance of Traffic		X		→		X
Quantity/Cost of Nevada State Patrol Callbacks	X			→		X
Availability of Nevada State Patrol Callbacks	X				X	
Damage to Utilities under Construction			X			X
Falsework			X			X
Shop Drawings			X			X
Equipment failure/breakdown			X			X
Work Methods			X			X
Early Construction / At Risk Construction		X		→		X
Community Relations	X				X	
Performance of defined mitigation measures	X			→		X
Warranty	X			→		X
Force Majeure / Acts of God						
Strikes/Labor Disputes - on site labor	X			→		X
Tornado/Earthquake	X				X	
Epidemic, terrorism, rebellion, war, riot, sabotage	X				X	
Archaeological, paleontological discovery	X				X	
Suspension of any environmental approval	X				X	
Changes in Law	X				X	
Lawsuit against project	X				X	

Risk	Design-Bid-Build/CMAR			Change	Design-Build	
	Owner	Shared	Contractor		Owner	Design-Builder
Storm/Flooding	X				X	
Fire or other physical damage	X				X	
Differing Site Conditions/Changed Conditions						
Changed Conditions	X				X	
Differing Site Conditions	X				X	
Completion and Warranty						
Establishment/definition of any risk pool	X				X	
Long term ownership / Final Responsibility	X				X	
Insurance			X			X

Appendix D – Risk Breakdown Structure

Adapted from Washington State DOT Risk Breakdown Structure

Level 1	Project Risk									
Level 2	Environmental & Hydraulics ENV	Structures & Geotechnical STG	Design/PS&E DES	Right of Way (incl. Access and Acquisition) ROW	Utilities UTL	Railroad RR	Partnerships and Stakeholders PSP	Management & Funding MGT	Contracting and Procurement CTR	Construction CNS
Level 3	ENV 10 NEPA/SEPA Documentation Completion (incl. Section 4f, etc.) or NEPA/SEPA Challenges	STG 10 Potential Changes to Structures Design (Bridge Superstructure, Retaining Walls)	DES 10 Potential Changes to roadway design (including vertical and/or horizontal alignment, earthwork, pavement, etc.)	ROW 10 Issues Associated with Development of ROW Plan	UTL 10 Utility Design Coordination and Agreements	RR 10 Railroad Design Coordination and Agreements	PSP 10 Tribal Issues	MGT 10 Change in Project Managers and/or other key Leadership	CTR 10 Change in Project Delivery Method	CNS 10 Traffic Control and Staging Issues (MOT/WZTC)
	ENV 20 ESA Issues (incl. consultation, Biologic Assessments/ Biological Opinions, Fish Passage)	STG 20 Potential Changes to Geotechnical Design Foundations, Liquefaction, Mitigation, etc. or Challenging Geotech Conditions	DES 20 Approval of Design Deviations or Changes to roadway design criteria (i.e. shoulder width, sight distance, etc.)	ROW 20 Uncertainty in Future ROW Escalation Rate (Project-Specific, including change in land use, urbanization, etc.)	UTL 20 Utility relocations and conflicts	RR 20 Railroad Coordination during construction (flagging, work restrictions, work windows, etc.)	PSP 20 Public Involvement Issues Or Other Interagency Agreements (i.e. Sound Transit, USFS, cities, counties, etc.)	MGT 20 Delayed Decision Making	CTR 20 Issues Related to Contract Language (Contract Packaging, Warranties, Liquidated Damages, DBE, Insurance/Bonding, etc.)	CNS 20 Construction Permitting Issues (incl. work restrictions)
	ENV 30 Environmental Permitting (incl. Appeals)	STG 30 Changes to Structural Design Criteria (e.g., seismic)	DES 30 Changes to Architectural, CSS, Landscape Design	ROW 30 Limited Access (Interchange Justification Report - IJR, Access Hearing, etc.)		RR 30 Contractor Right of Entry Requirements	PSP 30 Additional Scope in Response to Third Party Concerns (e.g., artwork, shared-use pathways, intersection improvements, etc.)	MGT 30 Availability of Funding / Cash Flow Restrictions	CTR 30 Delays in Ad/Bid/Award Process (Addenda, Protests, etc.)	CNS 30 Work Windows (Weather, Fish, etc.)
	ENV 40 Archaeological/ Cultural Discoveries, historic property impacts & mitigation (Section 106)		DES 40 Projects by other agencies affected by or affecting this project (design coordination)	ROW 40 Managed Access (Appeal Hearing, etc.)				MGT 40 Political/Policy Changes	CTR 40 Market Conditions (noncompetitive bidding environment) Lack of Qualified Bidder	CNS 40 Construction Schedule Uncertainty (general, including timing of award)
	ENV 50 Hazardous Materials Groundwater and Soil Contamination (PE, RW, CN)		DES 50 Potential Changes to Design of Permanent Traffic Items (ITS, Illumination, Intersection, etc.)	ROW 50 ROW Acquisition Issues (Condemnation, relocations, demolitions, etc.)				MGT 50 State Workforce Limitations	CTR 50 Delays in Procurement of Specialty Materials or Equipment and associated cost premiums	CNS 50 Marine/ Over Water Construction Issues
	ENV 60 Wetlands / Stream / Habitat Mitigation		DES 60 Design / PS&E Reviews or Additional Scope Driven by Internal Considerations (e.g., Maintenance, Traffic Projections, Tolling, extend project termini, change to purpose and need, etc.)	ROW 60 Additional ROW is required (incl. full vs. partial takes): Temporary and Permanent Access Breaks - FHWA approval or Construction / Subterranean Easements					CTR 60 Contractor Non-Performance	CNS 70 Earthwork Issues (re-se, haul, disposal, etc.)
	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 Environmental Impacts during Construction (incl. water quality, TESC etc.)									CNS 90 Contractor Access / Staging Coordination and Constructability Issues
	ENV 90 Permanent Noise Mitigation									CNS 100 Construction Accidents
	ENV 900 Other Environmental 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 Issue	PSP 900 Other PSP Issues	MGT 900 Other MGT Issues	CTR 900 Other CTR Issues	CNS 900 Other Construction Issues (including unanticipated change orders/claims)