Construction Cost Estimating Guide

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1 ESTIMATING GUIDE PURPOSE AND OBJECTIVES

The reliability of project cost estimates at every stage in the project development process is necessary for responsible fiscal management. Reliable cost estimates result in effective programming and budgeting and will aid in staffing and budgeting decisions as well as effective use of department resources. Communication with decision makers on critical budget issues is also impacted by the quality of the estimate.

This guide provides instruction to design staff and project managers for a consistent approach to cost estimating. At the same time, it provides guidance on how to treat the common and recurring challenges encountered in the estimating process.

1.1 Purpose

The purpose of this guide is intended to assist in developing and managing reliable project costs. It provides procedures and tools to aid Department staff prepare project cost estimates and manage cost throughout the project development process.

Project cost estimates should be as accurate as possible. Estimates should never be artificially reduced to stay within the funding limits, nor should they be reduced to make available more funding for other projects. Conversely, project cost estimates should not be artificially raised beyond the contingency percentages unless adequately justified.

1.2 Key Objectives

The key objectives of the estimating process described in this guide include:

1. Department wide priority on estimating, managing, and controlling costs
    - Fully developed and integrated practices, processes, and tools for cost estimation, management, and control
    - Baseline estimates that align with early project scope development which can hold stabile for the duration of the entire project
    - Appropriate assessment of uncertainty and contingency
    - Clearly defined and documented cost management processes to manage changes in scope and cost after the baseline estimate is established

2. Performance
    - Better project management and decision making
    - Improved project team understanding
    - Improved confidence in cost estimates
    - Focused risk management
3. Reliable and accurate estimates
    - Well-documented and comprehensive cost estimates
    - Clearly spelled-out assumptions, risks, and uncertainties that can be easily communicated
4. Statewide uniformity and consistency
    - Uniform application and consistent statewide use of well-documented processes, tools, and templates
    - Use of best practices and tools during the planning, scoping, design, and letting phases
5. Improved communication and credibility with external stakeholders
    - Consistent and clear communication of cost estimates to external stakeholders at milestone points
    - The ability to communicate cost estimates with confidence, leading to stronger relationships with external stakeholders, greater possibility for collaboration, and increased funding support of transportation initiatives
6. Clear accountability
    - Accountability for cost estimating and cost management at all stages of the project
    - Defined roles and responsibilities for every person involved
    - Accountability that is tracked at key milestones in the process

2 GENERAL ESTIMATING CONCEPTS

Cost estimating is both a skill and art form. Cost estimating holds a crucial function in how we manage and control projects. Therefore, it is important that estimates are stable, accurate and can stand the test of time as a project evolves. Having stable estimates will offer better decision-making information and will play a major role in proactively managing project costs, scope, and risks. To successfully estimate project costs, the estimators should consider these general estimating concepts:

- Project cost estimates are first developed in early project planning and updated periodically throughout project development from project programming through project advertisement. As the project progresses, estimates should be reviewed and updated on a regular basis. This will provide the project manager an opportunity to evaluate any cost changes as the project approaches PS&E and advertisement. As more attention is given to the practice of estimating the better an estimate will be.

  At a minimum, below are the recommended events that should trigger an update.

    - Each year during the annual Idaho Transportation Improvement Program (ITIP) update. As a best practice, estimate updates should first be performed on all projects already included in the existing ITIP. Once the existing estimates are updated, adjustments (project advancements/delays) should be made to the current program to account for any estimated cost increases/decreases. These adjustments should be coordinated with the district planning and scoping groups.
    - When project scope changes occur that affect project costs
    - At preliminary, intermediate and final design stages
    - Prior to the PS&E submittal
    - Prior to project advertisement
- Estimates should be comprehensive (don't leave anything out and shouldn't double-count any costs) and should consider unique or difficult project conditions. For large or complicated scopes of work, it may be necessary to break the work down into manageable parts in order to organize and capture all details of the work involved.

- In general, total project cost estimates are comprised of the following:
    - (CN): Raw construction estimate
    - (CN): Construction contingency for change orders and quantity variances
    - (CN): Non-bid items such as incentives, escalation clauses, etc.
    - (PE & PC): Development
    - (RW & LP): Property acquisition
    - (CE & CC): Construction administration, inspection and testing and other construction engineering services
    - (UT): Utility accommodations and relocations

- Early in the project, include "allowances" as cost placeholders for known items that haven't yet been estimated in detail. As the project matures and details are better defined, the need for allowances should decrease.
- There are several methods and tools used to develop project cost estimates. Any given estimate may employ multiple methods to appropriately address a particular scope of work. Cost estimates should make use of the best-available costing information, like the latest relevant unit prices with suitable adjustments for potential price fluctuations by the time the project is advertised. Estimated values should then be adjusted to reflect the project’s construction year value.
- The estimate should be prepared by a multi-disciplined team that has experienced key personnel dedicated to the success of the project, with the requisite technical, managerial, leadership, and communication skills. The team should also have a thorough understanding of the project, including the ability to determine and evaluate critical issues and risks. There are a number of specialty items that can be estimated by designated sections. These items include bridges and structures, traffic items, right of way and other properties, environmental features, and utilities.
- Estimates should include suitable contingency to cover uncertainties and risks. The contingency should reflect the project's complexity, level of development, and size.

Contingency should also be applied to best reflect current-year dollars at the time the project is bid. In general, projects early in the development stage should carry higher contingencies. However, as the project matures through the design stages and details are better defined, contingency should decrease.

- The estimate should also include suitable inflation and market escalation to account for the anticipated cost in current-year dollars at the time the project is bid.

2.1 What is Estimating?

Estimating is the practice of forecasting the costs (labor, materials and equipment) of completing a project with a defined scope. Cost estimating is a project management discipline that is both an art and a science to better manage budgets and deliver projects that do not exceed the identified scope, and that are on time throughout the development process. It requires a thorough understanding of project scope, past price history, and current market conditions, as well as a generous application of human judgment.

2.2 What is an Estimator?

An estimator is a person with proper experience in preparing estimates at various levels, using proper judgement. When preparing an estimate, the estimator is responsible for including everything contained in the drawings and specifications. The estimator must maintain a high degree of organization throughout the estimate development. A systematically done, neat, clear and well-organized estimate improves the probability of predicting the cost of the work and will be easy to follow.

2.3 Why do we Estimate?

The need to solidify the estimation process can be seen in four areas:

- **State financial program:** Cost estimates are used to organize and allocate funding to a portfolio of projects to establish an annual transportation investment program. Having good estimates will allow the Department to schedule projects more efficiently and reduce the reallocation of funds to resolve estimate discrepancies.
- **Accountability:** Accountability is increased if transportation projects show and prove to the general public that they are timely and within budget. Public releases of estimated project costs need to be thoughtfully provided only after care is taken to produce a well-documented, quality estimate.
- **Project control:** Good cost estimates help keep projects within the appropriate fiscal boundaries and designated scope. Although not necessarily a typical checks-and-balance mechanism, the existence of the original estimate will keep the project from growing and expanding beyond its spending limit.
- **Confront Problems:** As projects encounter problems, and their estimates come under fire, great scrutiny is given to the project and its associated estimates. The ability to confront and resolve problems and obstacles relies in large part on the

quality of the estimate and its associated documentation, which, if done properly, will provide critical support to project success.

2.4 What is an Estimate?

An estimate is a summation of all the costs involved to successfully execute a project, from inception to completion. These project costs can be categorized in a number of ways and levels of detail, but the simplest classification divides costs into two main categories: direct costs and indirect costs.

- Direct costs are broadly classified as those directly associated with a single area (such as a project). Specifically, direct costs are expenses that can be billed exclusively to a specific project. They can include project team wages, the costs of resources to produce physical products, fuel for equipment, and money spent to address any project-specific risks.
- Indirect costs cannot be associated with a specific cost center and are instead incurred by a number of projects simultaneously, sometimes in varying amounts. In project management, quality control, security costs, and utilities are usually classified as indirect costs since they are shared across a number of projects and are not directly billable to any one project.

A cost estimate is more than a list of costs. It also includes a detailed Basis of Estimate (BOE) report that describes the assumptions, inclusions, exclusions, accuracy and other aspects that are needed to interpret the total project cost. Without this information, the estimate would result in an unsubstantiated number. Having a detailed BOE will provide a good medium to communicate the estimate to the various parties involved in decision making, but will also be important after the project is completed, when the performance of the project is compared with other projects.

2.5 What makes a Good Cost Estimate?

The usefulness of a cost estimate depends on how well it performs in areas like reliability, accuracy and sustainability. There are several characteristics for judging cost estimate quality. These include:

- Accuracy: A cost estimate is only as useful as it is accurate. Aside from selecting the most accurate estimating techniques available, accuracy can also be improved by regularly revising estimates as the project is detailed and by building in adequate allowances and contingencies into the estimate. In addition, as other similar projects are bid, monitor and compare the results and make adjustments as needed.
- Confidence level: It is important to communicate the amount of potential variability in any estimate to stakeholders as even the best estimates contain some degree of uncertainty. Confidence levels can be communicated as ranges, such as those produced by three-point estimating techniques (best-case, most likely and worst-case) or Monte Carlo simulated estimates.
- Sustainability: Estimates that can stand the test of time from the baseline, planning/scoping estimate to the final advertisement estimate will enhance the department's ability to maintain a stable program. Having stable estimates will offer

better decision-making information and will play a major role in proactively managing project costs, scope, and risks.

- Credibility: Estimates gain credibility when they are founded in established fact or in practical experience. Increased credibility can be achieved by incorporating expert judgment and by using set values for variables, such as unit costs and work rates.
- Documentation: It is important that the assumptions underlying estimates are identified and recorded in writing, and that it is updated regularly. Thorough documentation can prevent misunderstandings and helps stakeholders and reviewers understand the reasons behind estimate revisions.
- Reliability: Reliability is a concept based on the extent to which historical cost estimates for a certain type of project have been accurate. For new projects that are similar to successfully completed past projects, analogous estimating techniques will allow reliable estimates. When using historical bid data, it is a strong best practice to compare unit prices from past similar type projects.
- Risk detailing: All projects can be affected by negative risks, so it is important to build allowances or contingencies into an estimate to account for risk. Thorough risk identification and allocation of contingency is the most common approach.
- Verification: Checking that the mathematical operations used in an estimate were performed correctly and that nothing was overlooked or double counted. Reviews should be performed by members of the project team to build an increase level of confidence. Estimates can also be reviewed through a third party peer review. Cost verification is much easier if estimates are properly documented and have a good basis of estimate.

2.6 Key Assumptions and Exclusions

As a cost estimate is developed, it is important to describe in the basis of estimate the key assumptions (what is included in the project) and the key exclusions (what is not included in the project). Documenting these items clearly will aid in maintaining the intended project scope and budget as it matures and will assist in communicating the cost components of the project. Below is a list of some key assumptions to be included in a good basis of estimate.

- Project goals - purpose and need
- Project scope - what will be built
- Reference to comparable past projects
- Key project tasks to be completed and the associated schedule (design, ROW environmental, procurement, construction, etc.)
- Site Conditions – geotechnical, environmental, hydraulics, etc.
- Construction phasing
- Mobilization
- Specialty construction, equipment and materials
- Known difficult conditions - long hauls, remote location, short summer season, fish windows, etc.
- Construction windows
- Construction duration and work days/shifts

- Anticipated productivity
- Contract packaging
- Project delivery method/contracting method
- Right-of-way (acquisitions, easements, condemnations, etc.)
- Environmental process - documentation, section 106-Historic Preservation, 4(f)-use of publicly owned land, wetlands, cultural, etc.
- Utilities, Railroad and Irrigation
- Third-party agreements

3 PROJECT COSTS

The Department's vision for cost estimating and cost management calls for well documented and complete cost estimates with clearly spelled-out assumptions and risks that can be easily communicated. The key to realizing that vision is a universal understanding of all components of a project's cost estimate. The components of the total project cost estimate are essential to developing a shared understanding of all the costs that are potentially associated with a project. Broadly, the total project cost estimate includes the base estimate, various allowances, contingency (to account for the risks associated with the base estimate), market escalation, and inflation (to adjust the estimate to the year in which the project will go to construction).

The base estimate should be the most likely project cost in any phase at any time, not including project contingency. Depending on the size and the complexity of the project, the actual amounts corresponding to each cost component will vary. Therefore, the design team must consider all the components when estimating and communicating project costs. Table 1 illustrates example cost components to be included in the total base estimate.

Table 1: Example Components of the Total Project Cost Estimate

	Components	Sub-Components
Design	Project Development	• Design Administration • Preliminary design (ITD and/or Consultant) • Intermediate design (ITD and/or Consultant) • Final Design (ITD and/or Consultant) • Communications/Public Information • Drainage, Hydraulic, Geotechnical, Traffic, etc. engineering • ROW and survey engineering
	Environmental	• Environmental Documentation/Re-Evaluation • Historical studies • Cultural Resources • Wetlands • Permits • Noise modeling
	Agreements	• Local/Cooperative • Irrigation Districts • Railroads

		• Utilities
Right-of-Way	Standard Real Estate Purchase	• Partial and Total acquisitions • Permanent & Temporary easements • Damage compensations
	Relocation costs	• Residential • Commercial
	Eminent Domain	• Court and attorney fees • Damages • Special Witnesses, SME's, etc. • Court exhibit preparation
	Access Control Purchase	• Property access modifications • Damages
Construction	Primary Construction	• Raw construction cost at award (Low Bid)
	Construction Contingency	• Construction change orders • Material overruns
	Non-Bid Construction Items	• Time Incentives • Quality Incentives • Asphalt and fuel escalation adjustments • Claims
	Construction Engineering	• Construction Administration • Inspection and Material Testing (ITD) • Inspection and Material Testing (Consultant)
	Agreements	• Detours & haul roads not in the letting contract • Local/Cooperative • Utilities • Railroads • Irrigation Districts • Engineer of Record

3.1 Allowances

As part of the base cost estimate, allowances can be included to cover items known to be needed for the project but not yet specifically identified and/or quantified. It is different from a determined contingency amount and should be considered a place-holder for undefined work elements. Allowances should be shown as a separate line item in the baseline cost estimate and should be quantified as much as possible. Allowance amounts should be identified with an explanation as to what they are intended to cover so they can be managed and reduced appropriately as the design progresses. Having this information documented will assist in review of the estimate.

3.2 Mobilization

A difficult lump sum item to estimate is mobilization. Mobilization's purpose can be defined as an item for the bidder to cover the cost of transferring equipment and resources to a project, but the cost is not exclusively tied to doing this. It may also include a several other costs such as corporate overhead, project overhead, contract bond, specialized project expenses like railroad liability insurance, sub-contractor

mobilization, sub-contract mark-up, profit, general overhead, costs for items not included but needed on the project, up front start-up cost and numerous other items.

In general, mobilization is used to cover a contractor's pre-construction expenses and the costs of preparatory work and operations. Since there is no clear list as to what this work effort is and each contractor has the ability to adjust their bid as needed to cover these expenses, there are no true rules as to what percentage or value should be used per project.

Another major factor to consider when estimating mobilization costs is the contract specifications in regards to mobilization. Do the specifications include payment restrictions or limits? When will the contractor receive partial or full payment for mobilization? How much of the mobilization cost will the contractor be required to finance? Therefore, the specifications may play a significant role in determining an estimated value for mobilization.

Consideration should also be given to the location of a project, complexity, the need for specialized equipment, the various types of work and the working season. If the project will extend over more than one construction season, this should be considered when determining mobilization costs as the contractor may demobilize for the winter and remobilize in the spring. Rural projects vs. urban, projects with multiple work sites, projects with several preparatory removal items, projects with large quantities of excavation or projects extending over two seasons where the contractor would be expected to shut down operations and move out will typically require a higher mobilization percentage.

A roadway project typically involves the mobilization of several pieces of medium sized equipment to a temporary or mobile location. A structures project often involves the relocation of significant large pieces of equipment to a fixed location and most often require that large pieces of equipment be mobilized and demobilized multiple times depending upon the staging of the project. Each time equipment has to be mobilized to a project or moved to a different site within a project, there is an associated cost to relocate the equipment and resources.

Other major factors to consider when estimating mobilization are project location, multiple construction seasons and winter shutdowns. Projects in remote locations have higher costs to relocate equipment, labor, and other resources to the site. If historic data is used to estimate mobilization, adjustments for these costs need to be made. If a project carries over multiple construction seasons and will be shut down for the winter or other environmental restrictions, these additional costs need to be accounted for in the estimate. It could even be anticipated that a contractor will mobilize the equipment to another project and will have to remobilize. It could also be anticipated that the equipment and resources be idle during the shutdown. These factors need to be considered and appropriate adjustments made to better estimate mobilization costs for a project.

4 PROJECT DEVELOPMENT ESTIMATING LEVELS

As projects are initiated and ushered through project development and into construction, the level of estimating evolves as more and more project detail is revealed. Below are the estimating approaches that can be used in the various development stages.

4.1 Planning

The planning level estimate is used to estimate the probable funds needed for long range planning and prioritization for the ITIP. At this stage, estimates are prepared with minimal project definition and are usually conceptual in nature. As examples, the estimate can be prepared using estimating cost data that is based solely upon historic lane-mile cost averages for similar projects for roadway work, or upon square-foot cost averages for bridge work. Additional costs for utility work, roadside features, mitigation work, maintenance of traffic, etc. should also be included. At this point, it may be appropriate to use allowances and higher contingencies to account for items that can't fully be defined.

3.2 Scoping

A scoping level estimate is used to set the baseline cost for the project against which all future estimates will be compared. It is important to clearly document the scope definition and assumptions during this stage so that all future cost estimate changes can be accurately compared to this estimate. At the time of project scoping, the project should begin to have some project definition in order to develop approximate quantities based on overall project length and or structure sizes for items such as asphalt, concrete pavement, structures, or roadway excavation. For such quantifiable items, historical bids may be used to develop a base unit price that is then adjusted for potential cost driver impacts. At this stage, cost estimates are also developed and used to compare the estimated costs of alternatives under consideration for addressing the identified project need.

4.3 Development (Preliminary, Intermediate and Final Design)

Throughout the project design process, the known project work items and associated quantities and unit prices will be used to develop a more refined cost estimate. These milestone estimates will be used to compare against the current programmed amount. This will solidify many items in the scope such as right-of-way, likely permit conditions, environmental mitigation, and quantities of major items of work. The estimate may need to be updated due to such triggers as environmental clearance, commitments, and mitigation as well as any changes to the scope of the project.

As items and quantities become finalized, most of the contingencies and allowances will diminish and unit prices will reflect known conditions. These unit prices should then be compared or updated for current market conditions, with careful consideration for escalating costs on price-volatile items.

A mix of historical and cost based estimating practices can be implemented at this stage. The use of the cost based estimating technique may be very beneficial for major work items that need to be analyzed in greater depth. However, this technique, which will be discussed later in this guide demands more time and effort. Therefore, it should not be the primary method used.

4.4 PS&E and Pre-Advertisement

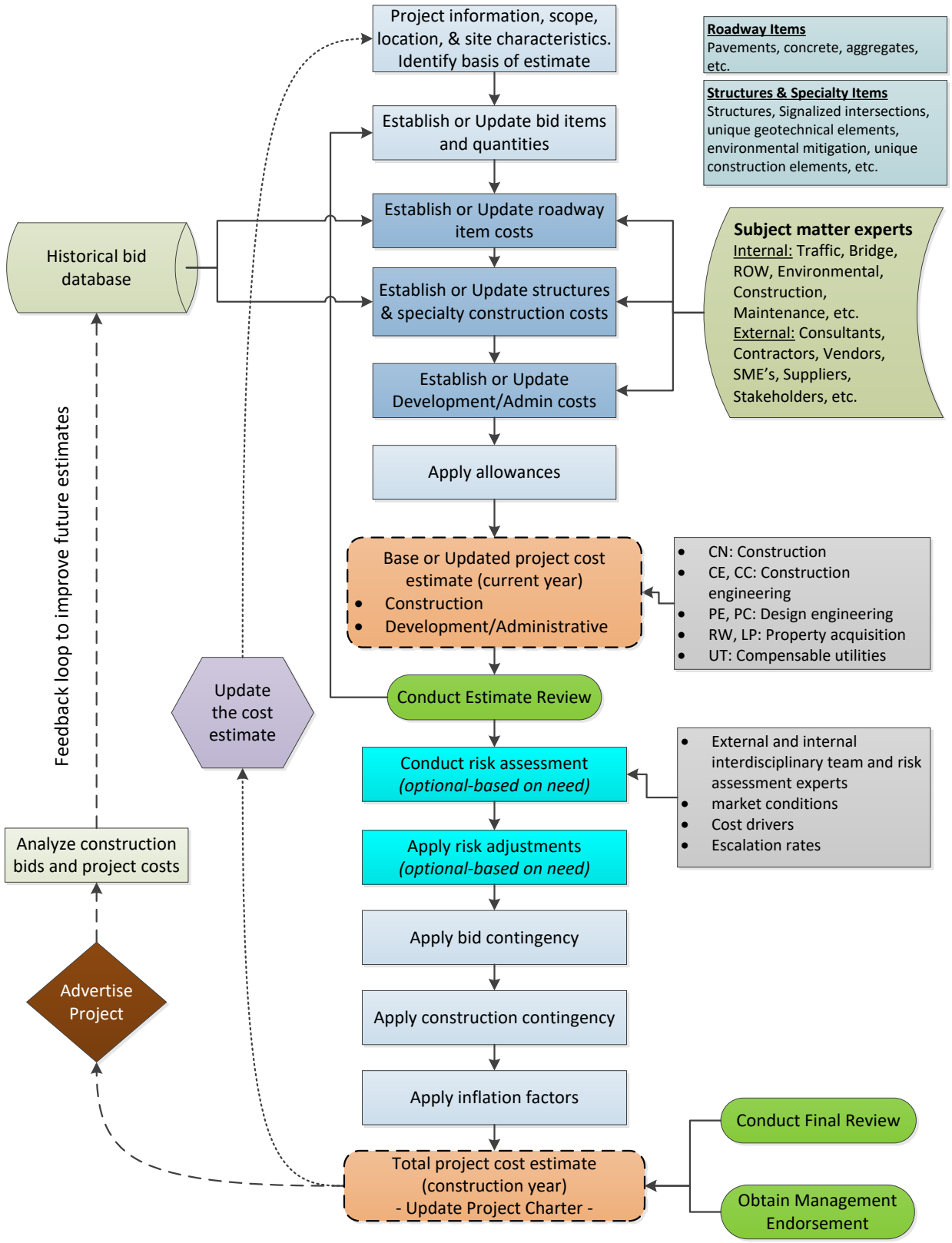
The Engineer's Estimate is developed for the final bid package in preparation for advertisement. In addition, the Engineer's Estimate is used to obligate construction funds and to evaluate contractor bids. By the end of this stage all contingencies should be quantified and accounted for within the final bid schedule. If a long period of time has passed since the PS&E submittal and the advertisement of the project, the estimate should be revisited and updated to reflect current market conditions. As a best practice, the last estimate update should occur no later than 3 to 5 months prior to advertising the project. This time frame should be tightened if market conditions are unstable.

5 ESTIMATING PROCESS

Regardless of the estimate phase or estimating method used, the preparation of an initial estimate or the follow-up effort to update an estimate at subsequent milestones should follow the basic process shown in Table 2, Estimating Steps or as illustrated in Figure 1: Cost Estimation Process.

Table 2: Estimating Steps	
Step	**Description**
1. Determine (or update) basis of estimate	Document (or update) project type and scope, including: • Scope documents • Drawings that are available (defining percent engineering and design completion) • Project design parameters • Project complexity • Unique project location characteristics • Assumptions and exclusions • Disciplines required to prepare the cost estimate
2. Prepare (or update) base estimate	Prepare (or update) estimate • Construction, Development and Administrative costs • Organize under a manageable work breakdown structure – bid items • Document estimate assumptions, types of cost data, and adjustments to cost data • Apply appropriate estimation techniques, parameters, and cost data consistent with level of scope definition • Account for all known project elements • Apply allowances • Consider all known project conditions • Ensure that estimates are consistent with past experience • Prepare an estimation file (hard copies or electronic) that compiles information and data used to prepare the project estimate
3. Determine risk and set contingency	Identify and quantify areas of uncertainty • Project knowns and unknowns • Potential risks associated with uncertainties • Cost triggers • Cost drivers • Set appropriate level of contingency suitable to cover project risks
4. Determine bid contingency, construction contingency, item escalation, and inflation	Identify and quantify appropriate price mark-ups based on: • Confidence level • Maturity of design • Market trends • Set appropriate level of contingency to cover confidence level
5. Review total estimate	Review estimate basis and assumptions: • Methods used to develop estimate parameters (e.g., quantities) and associated costs • Completeness of estimate relative to the project scope • Application of cost data, including project-specific adjustments • Reconciliation of current estimate with a previous, similar estimate

Figure 1: Cost Estimation Process



6 ELEMENTS OF A COST ESTIMATE

Each item of work on a project can be broken up into components needed to complete the work. These components comprise six basic elements that result in the cost for the work. The six elements are:

1. Materials: The element of material is simply the material that it takes to build the item of work, whether it is material left in place permanently or temporarily needed to construct the item such as formwork.
2. Equipment: Typically the mechanically operated machinery and items which are either rented or owned. Small tools are usually not included in the estimate.
3. Labor: The labor element establishes the personnel, hours of effort, and pay scales to build the work.
4. Time: The time that it takes to complete the work will drive the cost of the equipment, labor and any temporary material rental.
5. Overhead: The administrative functions of the company are commonly referred to as overhead and are needed to organize the time, equipment, labor, and material.
6. Profit: Contractors factor in a margin of profit to make the work worthwhile to the company owners.

6.1 Materials

Materials required in highway construction can be placed in two broad categories. One category is the material that stays in place when a project is complete. The other is temporary material needed to build the work. Prices for temporary items such as concrete formwork and shoring need to be included. Temporary material items might be reused or rented while other materials may only be used once and require the full price be applied to the item cost. In the process of identifying required material, this can be as simple as counting up the number of items needed but for other items this may require more extensive work.

- Procedure for Material Quantity Take-offs
    - List quantities in an order which allows easy back-checking.
    - Identify by drawing sheet, detail number, specification or other identifying locations.
    - Capture dimensions in this order: length, width (or thickness) and height. List walls by length, thickness and height consecutively; list slabs by length, width and thickness.
    - Use different take-off sheets for different trades (e.g. excavation, concrete, and guardrail).
    - Number the take-off sheets.
    - Color code, or use special numbering which effectively references the take-off to applicable drawings.
    - If possible, have all take-offs checked for correctness by someone other than the person capturing the original quantity or spot check math if an independent take-off cannot be accomplished.

- Material Cost Factors
    - Accuracy: The take-off is a matter of skilled plan reading and measuring. If the quantities are incorrect, the entire estimate is incorrect.
    - Material Behavior: The estimate needs to account for how the properties of a material changes when disturbed and handled by equipment. For example, when calculating soil excavation quantities, the estimate must factor in the volume of undisturbed earth, account for shrinking, swelling and compaction as the soil is excavated, hauled and placed into its final location.
    - Specifications: Recognize that the requirements in a material specification are important since each requirement generally adds cost to the material.
    - Tax: Sales taxes are a direct part of material costs. Unless it is confirmed that taxes are specifically excluded, they need to be added to the net prices. If a quotation is received from a material supplier, confirm if taxes have already been included.
    - Delivery to the Jobsite, Unloading, Storing and Protecting: It is important that the estimate indicates if the quotes received are FOB (freight on board) source or FOB jobsite. Whenever possible ask for a delivered price from the material supplier, but in many cases the estimate will need to include a separate hauling cost. Trucking companies that haul material for heavy construction jobs may be a source to determine hauling cost. Costs such as unloading from carriers, conveying to storage and protecting are separate costs from the delivery.
    - Waste Allowance: The amount of waste should be taken into account since bidders will have to compensate for the additional expense of the material wasted. Estimating the quantity of waste is a matter of judgment and experience. In general, the amount of waste can vary from 2-10% depending on the item of work in question. Items such as paving and aggregate base will result in higher waste amounts due to the nature of the work and the rigidity of the specifications. In contrast, an item of work that uses pre-manufactured products such as pipe placement and signals/signing will have little if any wasted material.
- Sources of Materials
    - Records from past construction projects can be used to identify sources. It may be helpful to contact source owners located near the project to get an average price. If at all possible, more than one source should be identified and queried for prices to obtain a competitive look at the market. When obtaining prices from suppliers, indicate that the price quotes will be kept confidential. Price quotes should never be shared with other suppliers and should always be kept confidential to ensure that no price negotiations take place. When obtaining quotes, have pertinent information available such as the specifications of material needed (quality), location of the project, quantity and when the material will be needed.

      Keep a record of quotes received for materials over time. By doing so, it should not be necessary to get a new quote for every job. However for large quantity

materials such as aggregate, asphalt, cement and steel, quotes should be updated on a per job basis due to variability in supply and project characteristics.

Below is an example of a simple materials quantity take-off for the installation of reinforced concrete pipe which includes quantity, unit price and applicable tax.

Table 3: Material Cost Calculation Example

Description	Quantity	Unit	Unit Price	Tax @ 6%	Subtotals
Reinforced Concrete Pipe	126	FT	$65.00	$3.90	$8,681.40
Reinforced Concrete Flared Sections	2	EA	$750.00	$45.00	$1,590.00
Pipe Bedding	660	CY	$6.00	$0.36	$4,197.60
Total Materials Cost					**$14,469.00**

6.2 Equipment

Most all highway work takes a significant amount of high cost equipment. The estimate for an item of highway work should not only include the time that the equipment will be needed for a particular task but also if that task will fully utilize that piece of equipment. Rental or leased equipment will incur costs even when idle on the jobsite.

Estimating the cost of equipment involves choosing the proper type of equipment, judging the time it will be used and applying the correct rate. For example, the time to compact gravel around foundations varies considerably in different conditions. In this situation, having a good background and knowledge will be needed to select a production rate from some point between the lowest (mostly hand work) and the highest (mostly machine work) to accomplish the work.

- Identify Required Equipment: To establish what type of equipment a certain task needs, the estimator will have to depend on personal experience or the experience of others such as field personnel. The identification of equipment in the estimating stage is generally hypothetical. The ideal equipment might not be available when needed or actual conditions affecting the type of equipment might differ from the estimator's conceptions. The estimator's selection of equipment may not be identical to the contractor, but should be a logical similarity and a cost equivalent.

  The work can indicate the equipment needed. For example, demolition of concrete suggests concrete saws, jackhammers, compressors, loaders and trucks. Structural excavation suggests trenchers, backhoes and excavators. As a resource, publications like RSMeans may be able to provide a good indication of what equipment is best suited for a particular task.

- Equipment Cost Factors: For the purpose of estimating, equipment cost is classified as bare equipment (without operator or fuel), ownership cost including depreciation, indirect costs, and major repairs. The equipment will also have operating costs in fuel, lubricants, tires, field repairs and maintenance, and operator expenses.

- Equipment Usage: Estimate the rental cost for equipment down to cost metrics such as per day or even per hour by evaluating the extent the equipment will be used. If the equipment will be needed on a regular basis on the project, it may be more appropriate to use the published monthly rental rate. If a monthly rate is used, it should be multiplied by the appropriate regional factors and divided by 176 hours/month to establish the hourly rate.
- Equipment Rate Procedure
  - Establish the desired production (i.e. cubic yards per hour).
  - Select the equipment which has a maximum production capability well above the desired level.
  - If the desired production rate is greater than the capability of any one piece of equipment, choose two or more pieces of equipment.
  - Estimate the probable production.
  - Divide the quantity of work by the probable production rate to find the number of hours that the equipment will be used.
  - Apply the owner's rate or rental rate (complete with operating costs).
  - Round to the next higher half or whole day.

- Resources: Once the equipment needs have been established, the estimator needs to know how much it will cost to have the equipment on the job. Resources for identifying necessary equipment include construction inspection staff and even interviews with contractors that perform the work in question. The estimator could also witness some similar work in action to capture equipment resources that the contractor implements for a particular operation. Pertinent information to be collected could include equipment brand name, model number, number of operators and general information regarding maintenance.

While it may not always be practical to formulate this information through interviews and real-world experience, there are resources that publish equipment rates. One such publication is the EquipmentWatch Cost Recovery (Rental Blue Book). This publication can be accessed at https://app.equipmentwatch.com/search.

This publication lists the daily, weekly, and monthly rental rate for various pieces of equipment as well as the operating cost for the equipment. This publication contains introduction sections that indicate how to use the equipment information as well as what is included in the operation costs. For example, fuel cost is generally included in operating cost but the fuel cost at the time of publication may not match present fuel prices. Items such as routine maintenance and oiling are included but wear on some ground or pavement equipment is not.

In continuation of the reinforced concrete pipe installation example, below is a list of equipment needed to perform the installation.

Table 4: Equipment Cost Example: (Monthly Rate/Hrs per month) + Operating Cost							
Description	**Quantity**	**Monthly Rental Rate**	**Hours/Mo**	**Operating Cost**	**Cost/Hr**	**Duration (Hrs)**	**Subtotals**
Track hoe	1	$9,455.00	176	$49.95	$103.67	60.00	$6,220.20
Skid Steer Loader	1	$1,690.00	176	$7.90	$17.50	60.00	$1,050.00
Trench Box	1	$99.00	176	$1.00	$1.56	50.00	$78.00
Trench Compactor	1	$3,065.00	176	$7.65	$25.06	60.00	$1,503.60
Total Equipment Cost							**$8,851.80**
The prices listed are from the Rental Blue Book using the monthly rental rates factored for a 176-hour month.							

6.3 Labor

Labor costs are determined by the personnel needed, hours of effort, and pay scales. When the quantity take-off is completed, determine the number of labor hours and trades necessary to perform the work. This is accomplished by using experience and/or standard publications such as the RSMeans catalog.

Labor Cost Factors. The cost of labor is determined by many factors including the following:

- Wage Rates: After the amount and type of labor is established, the pay level for the labor must be found. This is somewhat complicated since Idaho does not have a prevailing wage law that requires contractors, on state funded projects, have a minimum wage rate. However, prevailing wage determinations are enforced on federal projects. The federal government publishes prevailing wages by geographic region to be included in all contracts with any amount of federal funding. The prevailing wage rates will also list the fringe benefit amounts that the employers must pay towards workers' insurance and retirement. In areas with no prevailing wage rates there should still be a published minimum pay rate for heavy highway workers that can be used for a baseline.

  The payment of predetermined minimum wages on Federal-aid contracts is derived from the Davis-Bacon Act of 1931 as is prescribed by 23 U.S.C. 113. It applies to all Federal-aid highway construction projects exceeding $2,000 and to all related subcontracts, except for projects located on roadways classified as local roads or rural minor connectors, which are exempted: Notice of the wage rate decision is published in the Federal Register. In many cases, the market conditions dictate that the contractor pay the labor force more than the published minimum wage rate.

- Availability of Labor: Existing construction work within the region of the proposed construction contract will determine the availability of local residents for employment by the contractor, if the contractor has to hire people to supplement his own staff. If the contractor has to hire from outside the region, the contractor will probably have to pay a higher wage to draw in workers from outside the region of the project.

- Location of the Project: Prevailing wages vary by region, so the location of the project plays a factor in determining appropriate wage rates.

- Overtime: Overtime pay should be considered possible for the following circumstances:
  - Tight Schedule-Due to some particular situations, the contract may be scheduled on a fast-track work effort.
  - Location-Because of the location of certain particular construction work, the contractor may have access to the area only at certain times of the day or night requiring work to extend beyond the normal 8-hour workday.

- Night Work: Shift differential pay due to crews working night construction. Night construction may also impact the production rate and require additional equipment.

- Specialized Trades: The type of work to be performed within the project may require the use of specially trained workers whose wage rates may be higher than wage rates anticipated for most other elements of the contract.

- Labor Indirect Costs and Benefits: The contractor pays different amounts of fringe benefits, taxes and insurance to various agencies on the workers behalf. These costs are also known as burden. These indirect costs that are not paid directly to the employee may be applied as a percentage of labor costs and must be added to the base rate.

  Following is a listing of taxes and insurance paid by the contractor:
  - Social security
  - Health insurance
  - State unemployment compensation
  - Federal unemployment compensation
  - Pension
  - Vacation
  - Worker's compensation insurance
  - Holidays
  - General liability insurance
  - Sick leave

Items such as insurance may also vary based upon the contractor's safety record or the type of project. Labor rates obtained from union organizations or posted prevailing wages may have fringe benefit costs that cover all except for workmen's compensation, social security and unemployment insurance. A percentage of total labor cost is one way to handle these costs.

- Resources to Identify Labor Requirements: Possible resources for identifying labor requirements are the inspection staff, RS Means Publications, contractors and observation of construction operations in the field. When logging the labor force to be used, be sure to classify the type of labor doing the work. Using crew hours and appropriate pay scales are recommended.

Table 5: Labor Cost Calculation Example

Description	Quantity	Hourly Rate	Straight Time Cost/Hr.	Burden	Burdened Cost/Hr.	Duration (Hrs)	Subtotals
Foreman	1	$37.50	$37.50	20%	$45.00	45.00	$2,025.00
Operators	2	$32.50	$65.00	20%	$78.00	60.00	$9,360.00
Laborers	1	$26.50	$26.50	20%	$31.80	60.00	$1,908.00
Laborers (Skilled)	1	$28.50	$28.50	20%	$34.20	60.00	$2,052.00
Total Labor Cost			**$157.50**		**$189.00**		**$15,345.00**
20% labor burden (labor overhead) is used in this example							

6.4 Time

Contract time is the duration in which all physical project work, including any authorized additional or extra work, is to be completed. It involves detailing construction operations and applying anticipated production rates to the construction operations to estimate their durations. This determination may require close coordination between the designer and construction personnel.

As a matter of function, if the allowed contract time is too short, bid prices may be higher, quality may be reduced and the number of legal disputes may increase. If the contract time is too long, the public will endure unnecessary inconvenience and local businesses may suffer excessively. Optimal contract durations balance project cost against project quality and public costs. Ultimately, this depends on accurate estimates of construction costs. Basically, the cost increases if there is too little time or if there is too much time. If the contract time is too short, the estimate needs to include the cost for overtime and other production-increasing methods. If too much time is allotted than is actually required, the general conditions costs usually get excessive.

- Time Cost Factors
  - Material Acquisition Times: Evaluate the times necessary to obtain materials for the construction project. Fabricated materials, such as pipe, steel beams and pre-stressed concrete beams may require additional time to manufacture

and be delivered to the job site. Special materials or material shortages may also prolong contract time.

  - Other Projects in the Area: Accurate information of construction time is important, especially when a series of independent projects planned in the same area may be contingent on one another. A potential interference may occur where the start of one project depends on the completion of another. Examples include: (1) when large quantities of soil removed from one project must be used as fill material in another project; (2) when traffic control measures from one project significantly affect traffic control in another project; and (3) when a number of contracts working simultaneously result in shortages of materials, equipment and labor.
  - Resources: Project reports from previous projects are an excellent resource along with people who have witnessed the operations. Another helpful tool is to establish a production log for different types of work under different types of conditions. This can be as simple as how many feet of pipe per day can be installed in a low, medium or high production situation.
- Production Rates
  - Establish Production Rate: Once the activities are established, determine realistic production rates, or rate of how many units of the item of work can be complete per hour or day. Production rate is usually defined as a quantity of production accomplished over a specific time period (e.g. cubic yard of concrete placed per day).

    In simple terms, the total quantity of an item divided by the production rate of an item can be used to establish the length of time it will take to do the work. Rounding may be necessary due to the fact that a contractor will most likely have to pay the labor in full day increments along with the equipment rate. For example, if the item quantity divided by the production rate yields 8 and 2/3 days the estimate should reflect 9 days.

$$Time\ duration = \frac{\text{Quantity}}{\text{Production rate}}$$

6.1 Production

The determination of productivity plays a major role in assessing unit costs, especially in a cost-based estimate. Productivity is defined as the amount of work that can be performed in a unit of time. In the simplest terms it can be expressed in the following equation.

$$Production\ rate = \frac{\text{Quantity of work produced}}{\text{Time needed to complete the work}}$$

Determining productivity is necessary to accurately calculate the cost of each work item and can be influenced by one or more factors such as:

- Location
- Site conditions
- Terrain
- Site access
- Traffic levels
- Weather conditions
- Manpower and labor conditions
- Experience
- Work stoppages
- Governmental or regulatory requirements
- Work restrictions
- Resource availability
- Joint/Shared occupancy

For example, constructing a drilled shaft on dry soil may be faster than constructing one adjacent to a riverbank. Constructing a road on a mountain or hill may be much slower than constructing one on flat land. A sudden change in the weather can disrupt or delay construction operations. Rural highway projects face fewer complications than highway projects in metropolitan areas, which face frequent traffic congestion, strict environmental regulations, risky traffic safety, and right-of-way issues that reduce construction productivity. On the other hand, rural highway construction may face difficulties in acquiring skilled workers and highly productive equipment, driving down productivity.

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. Conversely though, materials, equipment and personnel may all have to be brought to the project site from out of the area, which may increase those costs related to transportation, support, wages, and per diem.

In all cases, productivity rates should be matched against project operations to determine the time and cost to complete the work. Additionally, keeping detailed records of actual equipment and manpower production rates on past construction contracts is also helpful for providing data from which to base estimating assumptions.

Tools and Equipment Production

Production from a crew is always tied to the construction tools and equipment used to aid the labor force. The selection of the appropriate type and size of construction equipment often affects the amount of time and effort and thus the job-site productivity of a project. Researching or being familiar with the characteristics of the major types of equipment most commonly used in construction will be of great value in determining adequate equipment production rates.

Once the equipment needs for an activity have been identified, conduct an equipment productivity analysis to select the optimum configuration. The objective is to determine

the number of units and the size of equipment that can adequately perform the work within the designated time and at a reasonable cost. For example, the productivity of a paving operation can be determined based on factors such as the paver capacity and speed, the quantity involved, haul conditions, cycle time of the asphalt/concrete delivery trucks, and the number of delivery trucks.

Haul Considerations

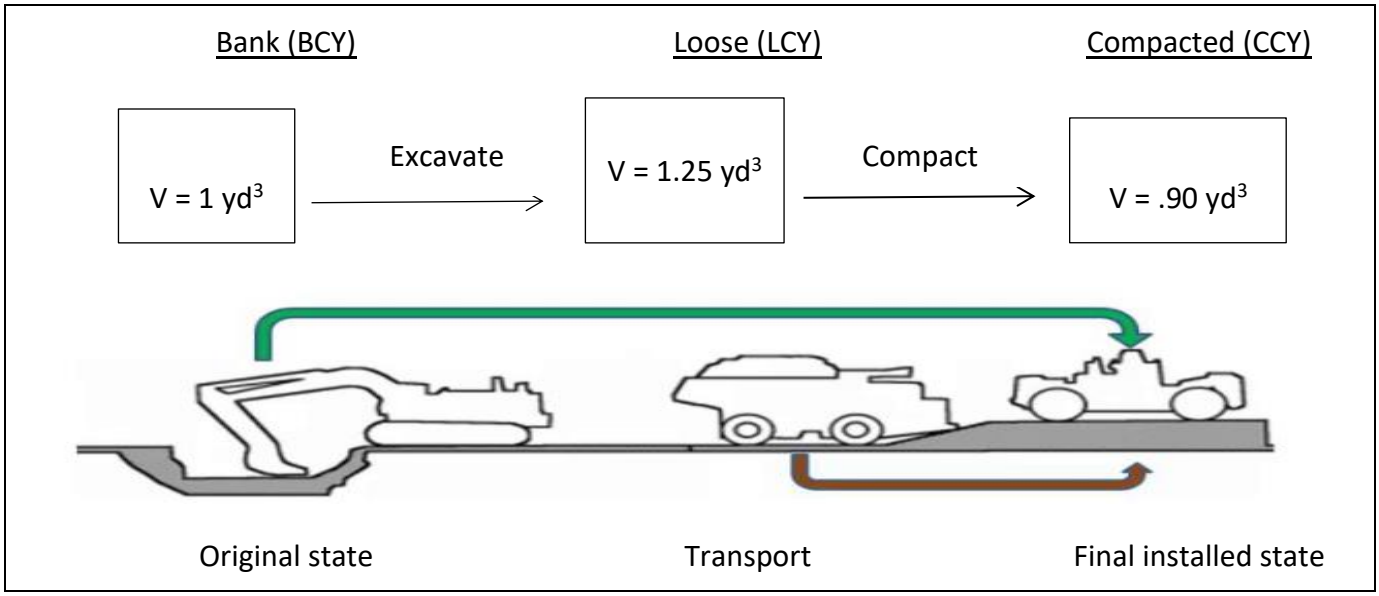
The expenses of hauling material can have a major impact on unit costs and productivity. Understanding major constructability issues, such as material haul distances, may provide good insight for making proper adjustments to estimated costs.

Haul is generally not a pay item which mean it is usually incidental to and included in other items of work. Haul of material includes the fixed costs (for the truck and driver) of spotting, loading, dumping, and turnaround in addition to the variable "underway" cost while hauling equipment is moving. The cost of hauling has several contributing factors such as:

- Length of haul
- Cost of fuel
- Terrain/grades/road conditions/access
- Number of haul units/efficiency
- Capacity

It is important to remember that materials can change in composition if disturbed and moved from one place to another, such as soils. In the case of soils, it is critical to consider shrink and swell factors in order to account for the material in the bank cubic yard (BCY), loose cubic yard (LCY) and compacted cubic yard (CCY) states. In general, soils always shrink from BCY and LCY to CCY because the compaction process decreases the amount of void space in soil. Below is an illustration of how this occurs during construction.

Figure 2: Shrink and Swell from Cut to Fill Example



In general, when calculating the cost of hauling material, the haul distance should be measured from the source to the center of the work. For example, when measuring embankment, the haul distance would be from the center of the embankment mass to the embankment source. For base or surfacing work, haul can be measured from the material source to the center of project.

For 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. Conversely, nearby material sources or disposal sites reduce hauling costs.

6.5 Overhead and Profit

The cost of labor, equipment and material cover the majority of the cost associated with an item of work, but the contractor still realizes costs that are not directly included in the overall project price. Items such as cost of ownership of office and plant property such as insurance, taxes, utilities and building maintenance; office labor including clerical, human resources and compliance personnel; cost of processing paperwork for labor, equipment and materials. These costs fit under the category of overhead.

The percentage of overhead may range from 7-20% of the volume of work based on the size of the contractor. Some contractors may factor an overhead cost on labor and equipment and have a separate mark-up rate for materials. Whatever the case may be, decide on the level of appropriate overhead and apply consistently to the estimate.

The table below can be used to review the many possible general and special overhead considerations. Few projects will require all of the items. To avoid double counting, thoroughly review the contract documents because some of the costs listed in the table are occasionally specified under sections within the contract specifications. As an

outside resource, average overhead costs for many of these indirect job expenses can be determined by cost data publications such as RSMeans.

Table 6: Indirect Project-Site Expenses		
General Conditions Expenses		
Surveying	Layout for structures	Contractor's office trailer
Inspector's office trailer	Portable toilets	Telephone service
Water hookup	Water monthly charges	Electric service
Security yard fence & gates	Project and safety signs	Office equipment, supplies & printing
Small tools	Misc equipment rental	Oil, fuel, tires, repairs, servicing
Pickup trucks	Superintendent vehicle	First aid and fire equipment
Dust & noise control	Progressive cleanup	Final cleanup
Superintendent		
Special Conditions Expenses		
Travel expenses	Freight costs to jobsite	Generator for electric power
Barricades	Scaffolding	Lights, flagmen
Sewer connection & service	Dewatering	Professional services & engineering fees
Progress schedules analyses	Special insurances and taxes	Premium for hot or cold weather work
Temporary access roads, detours	Area restoration	Overtime work
Extra drawings and specs	Underpinning	Watchmen
Office clerk	Timekeeper	Project Manager Draftsman Safety Engineer
Bonding of subcontractors	Extra foreman	Special equipment
Environmental protection	Safety provisions	Maintenance & protection of existing facilities

Profit is difficult to specifically quantify. Profit margins generally range from 3-10% of the sum of the total project cost, but this level can vary greatly depending on the risk of the project, competition and the actual time that it takes the contractor to complete the job. As a good practice, keep a consistent benchmark and estimate profit at the same level on all items on all projects. Periodic adjustments to the benchmark may be needed depending upon information learned and through experience.

Along with keeping the percentage of profit and overhead constant, it is also a good practice to be consistent with where profit and overhead are applied. It is recommended that profit and overhead are assessed on a per item basis. The reason for this is the fact that every item within an estimate may not be estimated using a cost-based method. Therefore, if a global profit and overhead are used, the mark-ups may inadvertently be applied twice on the same project since historic bid item estimates already have mark-up included.

Also, to truly have a benchmark cost per item, all costs of a particular item should be included. Having all of the mark-up in one pay item such as the mobilization pay item is not an accurate depiction of how the cash flow for the project will actually occur and can distort the true cost history of a work item.

Table 7: Total Cost Summary Calculation Example		
Description	**Calculation**	**Subtotals**
Total Materials		$14,469.00
Total Equipment		$8,851.80
Total Labor		$15,345.00
Total Materials, Equipment & Labor	**- - - - - - - -**	**$38,665.80**
Overhead	10%	$3,866.58
Profit	5%	$1,933.29
	Total Item Cost	**$44,465.67**
$44,465.67 / 126 FT = $352.90		
Unit Price - pay item for 126 FT of reinforced conc. pipe installation	**$352.90**	**FT**

7 COST ESTIMATING METHODS

Estimating methodologies that may be applied at various stages of project development include: (1) parametric, (2) historical bid-based, (3) cost-based, and (4) risk-based. These categories encompass a variety of individual techniques/tools to aid in preparing cost estimates. A single method may not be a good fit for the entire project; therefore, a combination of methods may be employed in any given estimate. In the following sections, a description is provided for the various estimating methods.

7.1 Parametric Method

The parametric method is most likely applied to projects in the planning, scoping, or early design stage. This method involves techniques that use historical data to define the cost of the typical transportation facility using measurements that are easily determined, such as cost per lane mile, cost per interchange, cost per square foot, or cost per intersection. Two techniques which are commonly used in parametric estimating include: (1) analogous (similar) projects and (2) historical percentages. It is important to understand that this not a highly accurate estimating method and is loaded with many undefined assumptions.

7.2 Historical Bid-Based Method

Historical bid-based methods are commonly used to develop construction cost estimates, and are appropriate when design definition has advanced to the point where detailed quantification of bid items is possible. The unit cost prices used are collected and stored from prior projects. Dependent upon the age of the historical data, it may need to be modified or adjusted to reflect current prices, market trends and project-specific conditions such as geographic location, quantity of item(s) needed, and the scheduled timing of project advertisement. The accuracy of this method increases greatly as data from similar, recent projects is used to determine unit pricing.

7.3 Cost-Based Method

The cost-based method is based on estimating the contractor's cost for materials, equipment, and labor for an item or a set of items. As part of this type of estimate, contractor overhead and profit should also be considered as well as material tax. This may be most appropriate in situations where historical unit prices are not available, or where historical bid-based information is not suitable for the project under consideration. A cost-based estimate can be developed based on a projected productivity, along with estimated labor, material, equipment, overhead and profit.

Properly prepared cost-based estimates require significantly more in terms of effort, time and skill to prepare than historic bid-based estimates. This type of estimate can provide a better idea of how much a project should cost but takes a greater commitment of time and resources to produce the estimate. Since time is limited in the estimating process to give equal consideration to every element of design and construction and to every aspect of cost on any given project, cost-based estimating should be reserved for high cost impact items that represents a substantial percentage of the total project estimate. For example, items with large quantities require greater attention because a slight variation in the estimated unit costs can make a significant difference to the estimate. Particular care must be taken to clearly identify and accurately estimate the cost of the items that will contribute most of the cost, while relatively less attention may be given to the remaining, less costly items of work. The cost of the less costly items can be determined using historical bid-based methods. This approach provides for a more efficient use of estimating resources and reduces the total time of preparing cost-based estimates.

The typical items that would be estimated using the cost-based approach are excavation, embankment, bituminous and concrete pavements, drainage, structural concrete, and structural steel. However, the items estimated using the cost-based method will vary depending on the type of project. Specialty items will most likely benefit from this method since historic data may be unavailable.

Cost-based estimating requires careful review of the construction requirements as described in the contract documents, visualizing the construction process, and modeling the costs to complete the work. These estimates are based on many sub-estimates of work crews and equipment completing tasks at assumed rates of productivity. Bid items are broken down into detailed task-by-task work activities. The direct cost for each task is developed with separate costs for the labor, equipment, material and subcontractor components of the work required to complete a task.

A cost-based estimating approach should take into account the unique character of the project's geographical influences, market factors and the volatility of material prices. When an estimate for an item is separated into labor, material, equipment, overhead and profit, it is easier to account for unique project cost-related characteristics. For example, special equipment needs or factors that address labor productivity can be documented in a cost-based estimate as opposed to a random increase or decrease of a historic unit cost of an item. Since contractors generally utilize a cost-based estimating

approach to prepare bids, this method can provide more accurate and defendable costs to support the decision for contract award/rejection.

Cost-Based Process: The following steps are a recommended sequence to be used in determining the estimated cost of an item of work through the cost-based method.

1. Identify Items for cost-based estimating approach
2. Define and list work associated with identified items. This may require a team effort that employs subject matter experts who are familiar with the components associated with a particular scope of work.
3. Review construction schedule information.
4. Review contract requirements.
5. Determine material, equipment and labor requirements.
6. Time (establish anticipated productivity rates).
7. Compute base cost of labor, materials and equipment.
8. Add overhead.
9. Add profit.
10. Add appropriate tax to materials.
11. Compute unit price.

Below is an example of a cost-based estimate. Within this type of estimate, an anticipated productivity rate is initially assumed. This will define the duration of the work and it will also set the parameter to which labor and equipment resources will be measured. Labor and equipment needs are established which include type, quantity, cost per unit and various mark-up components that factor in the cost of overhead and profit. An ultimate, all-inclusive cost is determined which can be divided by the quantity of the representing item to achieve a unit cost.

Table 8: Cost Based Estimate Example: Rip Rap Installation					
Material Cost Calculation					
Description	**Quantity**	**Unit**	**Unit Price**	**Tax @ 6%**	**Subtotals**
Geotextile	396	SY	$1.00	$0.06	$419.76
Loose Rip Rap	200	CY	$20.00	$1.20	$4,240.00
Total Materials Cost					**$4,659.76**

Equipment Cost Calculation: (Monthly Rate/Hrs per month) + Operating Cost							
Description	**Quantity**	**Monthly Rental Rate**	**Hours/Mo**	**Operating Cost**	**Cost/Hr**	**Duration (Hrs)**	**Subtotals**
Cat 330 Excavator	1	$9,560.00	176	$67.16	$121.48	30.00	$3,644.40
Case 340 End Dump, 22 CY	1	$11,290.00	176	$64.63	$128.78	20.00	$2,575.60
Cat 966G Loader	1	$6,520.00	176	$47.21	$84.26	20.00	$1,685.20
Total Equipment Cost							**$7,905.20**
The prices listed are from the Rental Blue Book using the monthly rental rates factored for a 176-hour month.							

Labor Cost Calculation							
Description	**Quantity**	**Hourly Rate**	**Straight Time Cost/Hr.**	**Burden**	**Burdened Cost/Hr.**	**Duration (Hrs)**	**Subtotals**
Foreman	1	$45.00	$45.00	20%	$54.00	10.00	$540.00
Excavator Operator	1	$31.52	$31.52	20%	$37.82	30.00	$1,134.72
Loader Operator	1	$31.52	$31.52	20%	$37.82	20.00	$756.48
Laborers	1	$23.00	$23.00	20%	$27.60	30.00	$828.00
Truck Operator	1	$26.00	$26.00	20%	$31.20	20.00	$624.00
Total Labor Cost			**$157.04**		**$188.45**		**$3,883.20**
20% labor burden (labor overhead) is used in this example							

Total Cost Summary		
Description	**Calculation**	**Subtotals**
Total Materials		$4,659.76
Total Equipment		$7,905.20
Total Labor		$3,883.20
Total Materials, Equipment & Labor	- - - - - - - -	**$16,448.16**
Overhead	10%	$1,644.82
Profit	5%	$822.41
Total Item Cost		**$18,915.38**

In this example the total cost for labor, materials and equipment is $18,915.38 and the representing work item is 200 CY of placed Rip Rap.

$$\frac{\$18{,}915.38}{200\ CY} = \$94.58\ per\ CY\ of\ Placed\ Rip\ Rap$$

7.4 Risk-Based Method

Risk-based cost estimates apply risk identification and uncertainty analysis techniques to forecast project contingency. In general, risk represents the cost associated with threats or opportunities that fall outside the "base" assumptions (what's included in the project). Risk reflects the possibility that key exclusions (what's not included in the project) ultimately come true, plus the possibility of other conditions or events surfacing which were not considered in the base estimate. In order to account for these identified uncertainties, risk-based estimates produce an expected value and a potential range of project costs. They also provide a ranking of risks to monitor during the project development process to help manage contingency and prevent cost and schedule impacts in future estimates. Risk-based estimates are typically used during the planning, scoping, and early design phases. However, risk-based estimates can be applied at any point when there is significant uncertainty in the project definition or estimating information.

The risk-based estimating approach involves simple or complex risk modeling based on inferred and probabilistic relationships among cost, schedule, and events related to the project. Risk-based estimating can employ historical data and/or cost-based estimating techniques and best judgement of subject matter experts to develop the project "base estimate" (project cost if the project proceeds as planned). Risk elements (defined as opportunities or threats) are then defined and applied to the base estimate through risk modeling to provide a probable risk contingency. As the project progresses in development, the contingency amount is expected to decrease because the project information is refined as more details become available. Correspondingly, the base estimate increases as contingency items materialize and are included in the base estimate.

Risk Identification

The risk identification process begins with the team compiling a list of the project's possible risk events. Possible risks are those events or conditions that team members determine would have a significant project cost impact. The identification process will vary depending upon the nature of the project and the risk management skills of the team members, but most identification processes begin with an examination of issues and concerns raised by the project development team. These issues and concerns can be derived from an examination of the project description, work breakdown structure, cost estimate, design and construction schedule, procurement plan, and general risk checklists. Checklists and databases can be created for recurring risks, but project team experience and subjective analysis will almost always be required to identify project-specific risks.

The team should examine and identify project events by reducing them to a level of detail that permits the team to understand the significance of any risk and identify its causes. This is a practical way of addressing the large and diverse number of potential risks that commonly occur on highway design and construction projects (see Table 9 below for common risks that occur on transportation projects). Teams must be cautious not to overlook risk or focus on solving problems during the risk identification process.

At times, the number of risks and the magnitude of the uncertainty can be overwhelming. Therefore, it is often better to focus on listing and categorizing risks during the identification stage and exploring solutions/opportunities later during the mitigation process.

Risk identification needs to be continuous, and there should be a continual search for new risks that should be included in the process. Techniques outlined in this section should support the risk identification process, but it will be the people involved who are most critical to the success of the process.

Table 9: Common Transportation Risks

Environmental Risks	External Risks
• Delay in review of environmental documentation • Challenge in appropriate environmental documentation • Defined and non-defined hazardous waste • Environmental regulation changes • Environmental impact statement (EIS) required • NEPA/404 Merger Process required • Environmental analysis on new alignments required	• Stakeholders request late changes • Influential stakeholders request additional needs to serve their own commercial purposes • Local communities pose objections • Community relations • Conformance with regulations/guidelines/design criteria • Intergovernmental agreements and jurisdiction
Third-Party Risks	**Geotechnical and Site Risks**
• Unforeseen delays due to utility owner and third-party • Encounter unexpected utilities during construction • Cost sharing with utilities not as planned • Utility integration with project not as planned • Third-party delays during construction • Coordination with other projects • Coordination with other government agencies	• Unexpected geotechnical issues • Surveys late or in error, or both • Hazardous waste site analysis incomplete or in error • Inadequate geotechnical investigations • Adverse groundwater conditions • Other general geotechnical risks
Right-of-Way/Real Estate Risks	**Design Risks**
• Railroad involvement • Objections to ROW appraisal take more time or money, or both • Excessive relocation or demolition • ROW acquisition problems and schedule • Difficult or additional condemnation • Accelerating pace of development in project corridor • Additional ROW purchase due to alignment change	• Design is incomplete/design exceptions • Scope definition is poor or incomplete • Project purpose and need are poorly defined • Communication breakdown with project team • Pressure to deliver project on an accelerated schedule • Constructability of design issues • Project complexity (scope, schedule, objectives, cost, and deliverables are not clearly understood)
Organizational Risks	**Construction Risks**
• Inexperienced staff assigned • Losing critical staff at crucial point of the project • Functional units not available or overloaded • No control over staff priorities • Lack of coordination/communication • Local agency issues • Internal red tape causes delay getting approvals, decisions • Too many projects/new priority project inserted into program	• Pressure to deliver project on an accelerated schedule • Inaccurate contract time estimates • Construction QC/QA issues • Unclear contract documents • Problem with construction sequencing/staging/phasing • Maintenance of traffic/work zone traffic control

Developing Risk-Based Estimates

Accounting for risk is critical to developing more accurate project estimates. Identifying possible 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.

Base estimates are established or predicted based on available project knowledge. For example, engineering costs are developed based on anticipated scope, past experience, and assumed delivery method while construction costs are developed based on an anticipated design, assumed quantities, unit costs and the application of markups for known factors. 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. Traditional estimating practices tend to produce “the number” for a project. However, a single number has the potential to mask 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.

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. 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 nonnumeric terms. Risks are generally ranked along the scale of low, medium, high or very high which are based on personal judgement which means the outcomes could be subjective and may not be repeatable.

Risk identification results in the generation of a risk register. Even though the risk register can be sizeable, it is necessary to evaluate and prioritize each identified risk event. Through prioritization, the Project Manager can overcome indecision by providing specific, documented risk events that the team 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 better focus project resources.

How to perform Qualitative Risk Analysis

Once a risk is identified, including a thorough description of the risk and risk triggers (events that cause the risk to occur), it can be characterized in terms of probability of occurrence and the consequence if it does occur. Below are basis steps to follow when performing a qualitative risk analysis.

1. Gather the project team and appropriate subject matter experts to discuss project risk.

   a. Since risk identification is dependent on the project team members' expertise, internal and external subject matter experts, base cost estimating lead, and risk facilitator (if needed). Accordingly, the experience level of the team should correspond to the magnitude of the project.
   b. Establish which of the qualitative risk matrices will be used and define the terms that will be used to label risk (such as Low, Medium, High or Very High).
2. Review Project Estimate and basis of estimate
   a. Collaborative effort
   b. Confirm that cost matches scope
   c. Check reasonableness of the design and overall strategy
   d. Identify and remove contingency and conservatism
3. Define the "Base" estimate
   a. The planned scope and strategy (without significant risk or opportunity). The "base" cost reflects the key assumptions for the project.
   b. Ensure the "base" includes allowances for the known items that will be required, but haven't yet been estimated in detail (i.e., guardrail typically isn't a line item in a planning-level estimate, but we need to "allow" for that cost in the estimate)
   c. Ensure the "base" includes all related soft costs such as environmental, design, right-of-way, utilities, contract admin, construction management, engineering services, etc.
   d. Organize the base estimate around work activities or bid items
   e. For each work activity or bid item, develop:
      i. Base cost (current $)
      ii. Base duration (calendar time)
      iii. Cost-escalation rate
   f. Include significant uncertainties
4. Identify risks and develop a risk register.
   a. Identify all potential events, both risks and opportunities, outside the "base" assumptions
   b. Comprehensive and non-overlapping
   c. Appropriate level of detail
   d. Include significant relationships among risks
   e. Consider possible causes and effects
   f. Identify trigger events
   g. Link identified risks to applicable work activities or bid items
5. Evaluate the likelihood of the risk occurring by asking the group "How likely is it that this risk will occur?" Record the result that the group agrees on.

Risk Probability Ranking Example	
Ranking	**Probability**
Rare	Remote (10%)
Unlikely	Unlikely (30%)
Possible	Likely (50%)
Likely	Highly Likely (70%)
Very Likely	Near Certainty (90%)

6. Evaluate the consequences if the risk does occur by asking the group "What is the degree of impact if this risk does occur?" Record the result that the group agrees on.

Risk Impact Ranking Example	
Ranking	**Cost**
Insignificant	No cost increase, or potential cost savings
Minor	< 5% cost variance
Moderate	5 - 10% cost variance
Major	10 - 15% cost variance
Very Significant	> 15% cost variance

7. Score identified risks
   a. Risks are ranked based on their impact to project cost
   b. Identify Low, Medium, High or Very High risks
8. Determine a cost impact
   a. Evaluate cost sensitivity of the base estimate
   b. Prioritize critical activities and risks
   c. Assign contingency based on risk factors only
   d. Risks factored in the cost are based on best current estimates
9. Manage Risk
   a. Identify potential risk management actions (e.g. prevention, mitigation, avoidance, etc.)
   b. Quantify likely implementation costs
   c. Quantify likely benefits
   d. Simulate net effect
   e. Implement mitigation strategy and monitor performance
   f. Assign risk owners
   g. Communicate estimate

As the project progresses, the risk register should be used to identify new risks, monitor and control existing risks, and track the status of the risk responses.

Figure3: Example Risk Register

Bid Item	Risk Assessment											
	Risk Description	Prob.	Impact	Probability/ Impact Score		Cost Impact (%)	Unit Price Impact	Item Cost Impact	Risk Owner	Response	Mitigation Plan	Monitor and Control Plan
201-005A | CLEARING & GRUBBING | ACRE						0.0%	$0.00	$0.00				
203-020A | REM OF BRIDGE | EACH	Specialized bridge removal	Very Likely	Major	VH		30.0%	$112,500.00	$112,500.00			Add contingency and find similar historic bridge removals for comparison.	
203-005A | REM OF OBSTRUCTIONS | LS	Unquantified work item	Very Likely	Very Significant	VH		20.0%	$6,000.00	$6,000.00			Itemize all obstructions that need to be removed from the project.	
203-080A | REM OF GUARDRAIL/BARRIER | FT						0.0%	$0.00	$0.00				
205-005A | EXCAVATION | CY	wrong price for large quantity	Possible	Major	M		25.0%	$1.25	$625,625.00	PM	Threat - Mitigate	Analyze excavation cost trends. Use cost-based estimate and employ an independent cost estimator.	Evaluate costs at preliminary and final design stages
205-040A | GRANULAR BORROW | CY						0.0%	$0.00	$0.00				
205-071A | EXCAVATION AND REPAIR OF SOFT SPOTS | CY	Unidentifiable soft spot quantity	Possible	Major	M		15.0%	$9.75	$29,250.00		Threat - Avoid	Possibly pay by the CA	

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 should regularly update the Project Team on the status of their risks and the progress of the response strategies.

The activity of determining a value for the probability of something occurring and its consequence to project objectives is for many a new concept and can seem strange at first. However, as it is in all disciplines, with experience, those who practice this type of analysis develop intuition and an ability to understand projects to a greater extent. This experience and intuition is extremely valuable, and is particularly evident when the Project Manager can gather reliable subject matter experts together to seriously and thoroughly discuss the project.

The aim of the process is to examine how risks can be mitigated and how cost vulnerabilities can be managed from the onset of a project. On simple projects, the degree of effort may not be warranted as compared to the comprehensive risk assessment needs of a complex project. Regardless of project complexity, risk assessments (great or small) should be applied to each estimate.

8 CONSTRUCTION ESTIMATING RESOURCES

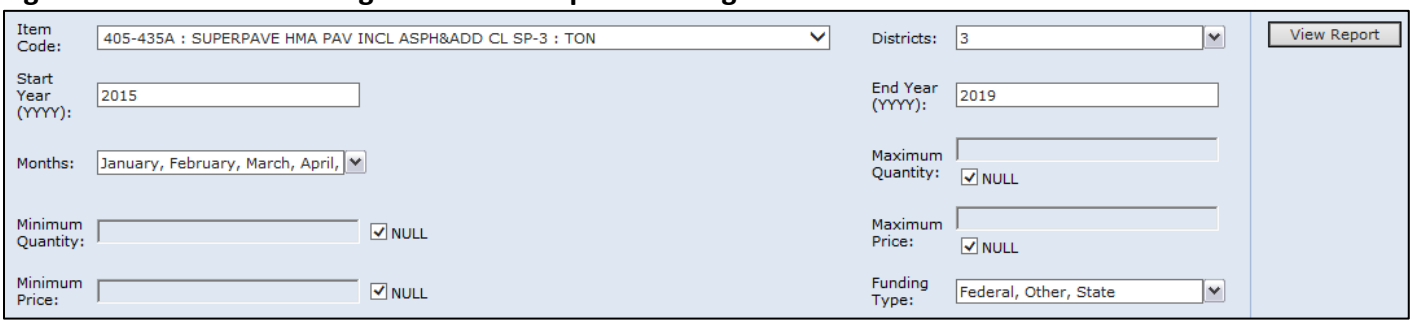
In an effort to strengthen project estimates, it is critical that the most current information and resources are used. The subsections below list a number of possible resources that can be used to prepare quality estimates.

8.1 Historical Construction Bid Data

The Department has developed a web-based automated Average Bid Item Price Report estimating tool that provides the estimator the ability to analyze historic construction bid prices received by the Department. This includes all bid information that has come

from projects that have been awarded, which means very recent data can be accessed. This information can be filtered by bid item, district, month, year, quantity, unit price, and funding source which can be applied to best fit the parameters of the project estimate. Below is a view of the filtering feature within the report.

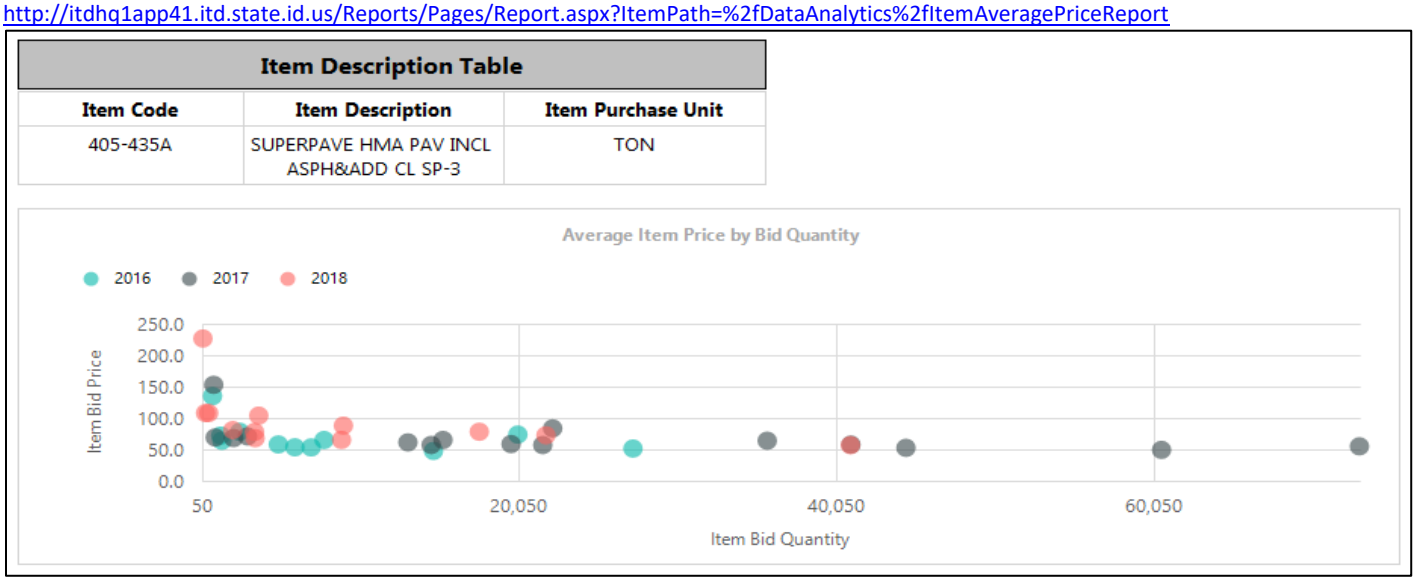
Figure 4: Automated Average Unit Price Report: Sorting Feature



Another item to highlight from the report is the scatter plot chart feature. By using the filtering feature shown above, the data can be organized in a customizable way to best reflect a desired or comparable situation. From this filtering feature, the report is able to produce charts and graphs to assist in the unit price analysis, such as the scatter plot chart below. From this chart, unit prices can be analyzed based on a correlation between past bid prices and the corresponding item quantity. The system is also able to illustrate the data by the year the project was awarded. This allows the estimator to better analyze any cost fluctuations from year to year.

Figure 5: Bid Item Price Report - Scatter Plot

http://itdhq1app41.itd.state.id.us/Reports/Pages/Report.aspx?ItemPath=%2fDataAnalytics%2fItemAveragePriceReport



Item Description Table		
Item Code	Item Description	Item Purchase Unit
405-435A	SUPERPAVE HMA PAV INCL ASPH&ADD CL SP-3	TON

8.2 RS Means

Another good resource that can be used comes from the annual publication of the RS Means catalog. There are several volumes of the catalog that are available for purchase. The most appropriate volume for highway construction is titled *Heavy Construction Costs with RSMeans data*. Each edition comes with user instructions and offer such

information as crew and equipment configurations, daily outputs, labor hour assessments, overhead and profit, etc.

8.3 Equipment Rental Blue Book

Rental Rate Blue Book (http://itdportal/Lists/UsefulLinks/DispForm.aspx?ID=26) lists daily, weekly and monthly rental rates for various pieces of equipment as well as the ownership and operating cost for the equipment. This source is very useful when performing a cost-based estimate.

Direct Link: https://app.equipmentwatch.com/search/by-manufacturer

8.4 Personal Estimating Libraries

Keeping personal estimating data is very beneficial. Not only does it keep the estimator aware of his/her own area's bidding environment it also builds on the estimator's experience. Take note of other similar projects that have gone to bid with the intent of applying lessons learned to current estimating activities.

8.5 Suppliers-Specialists-Contractors

At times, work items will be encountered that do not have historical data or a clear cost breakdown structure. In these cases, it may be appropriate to call suppliers, specialists, or contractors to get ideas about costs. These resources may be able to give a good idea about the overall scope and cost of the item, however, do not hesitate to modify their numbers to fit the project (e.g. remoteness, limitations, working days, work hours, etc.). When obtaining cost information from these resources, indicate that the price quotes will be kept confidential. Price quotes should never be shared with other suppliers and should always be kept confidential to ensure that no price negotiations take place.

9 ESTIMATING MANAGEMENT

As projects are developed, it is important to maintain proper controls over the components that effect cost. Each project development phase is inherently different from the others; therefore, they all have unique challenges to overcome during the estimating phases. This section will discuss actions that can be taken to manage an estimate.

9.1 Cost Management and Communication

Regarding cost management, consider the following criteria:

1. Implement peer reviews for each estimate and estimate update. The project team may consider a peer review involving knowledgeable and experienced individuals, including individuals from outside the project team.
2. Establish good communication practices within the team and with management about the estimate, including assumptions, uncertainty, and other issues that may influence decisions about the project.

3. Cost estimates should be saved in a place where the project team and other authorized department employees can view and use them. Include the basis of estimate and supporting documentation and be sure to carefully indicate the version of the original estimate as well as subsequent updates. As updates are made, communicate the most current total cost projection after it has been vetted through an independent review.
4. In order to foster and promote objectivity and impartiality, protect estimators from internal and external pressures that may compromise good estimating practices.
5. Estimates should not be altered to fit a predetermined budget outside of the formal estimating process. Using true and confident unit prices should always be the goal. If this causes costs to overrun, the budget should be either increased and/or the project scope should be modified.
6. Document estimate updates at each project development phase (planning, scoping, preliminary design, intermediate design, final design, PS&E and Advertisement). Updates to the base estimate are also critical during the annual ITIP update and when major scope changes occur.
7. Appropriate contingency levels should be applied to the estimate based on the maturity of the project. Contingency used early on in the planning or scoping phases that is no longer needed as the project progresses towards advertisement should not be used to increase project scope.
8. Keep district management and HQ program management informed about project changes and impacts that affect the project budget. Obtain proper approval prior to budget changes.

9.2 Basis of Estimate

Every estimate should begin with a supporting basis of estimate. The basis of estimate summarizes the information, assumptions, risks, and methodology used to develop a project cost estimate. A well-prepared basis of estimate will promote the development of the estimate, understanding, estimate updates, and helps avoid estimating errors and omissions. Each time an estimate is updated, the basis of estimate should be updated as well to document what has changed. Use best judgment to determine the appropriate level of detail in the basis of estimate. Consider the project size and complexity, the type of project, the degree of project definition (well-defined versus vague), and the number and type of estimate assumptions. The basis of estimate should include enough detail to communicate key assumptions to enable an independent review of the estimate, and to provide a basis for change management. Below are a number of considerations to be included in a basis of estimate.

- Project Name
- Estimate Date
- Current project phase
- Project Objectives

- Project Scope
- Project Location, including constraints and site issues
- Project Schedule
- Construction Contracting Strategy
- Cost Estimating Methodology and Sources of Information
- Allowances
- Assumptions (what is included in the project)
- Exclusions (what is not included in the project)
- Risks
- Estimate Reviews
- How and why the estimate has changed (with each update)
- Applicable reference documents

9.3 Independent Estimate Review

Each base cost estimate should have some level of review to increase the confidence level of the estimate. Project complexity is the most important driver of the level of estimate review and should be carefully determined 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 should be held and the results documented. The final results of the independent review and reconciliation will be left to the Project Manager.

Independent reviews should be made by experienced individuals who are familiar with the type of work inherent to the project, and who have had no involvement in the development of the project estimate to date. The independent reviewers should consult with other sources such as other design engineers, construction managers, or other subject matter experts as needed on specialty items of work. Checks performed by independent reviewers should include:

- Reviewing the estimate file and Basis of Estimate document for completeness and readability
- Ensuring that the estimating methodologies are noted for individual items 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 (cost drivers)

- Making note of comments on unit rates and quantities
- Checking for mathematical errors

9.4 Documentation and Change Management

Documentation is important in order to clearly understand what is included in the estimate, what the contingencies and allowances represent, what risks are involved, as well as the associated inflation considered. Proper documentation will also allow estimates to be easily checked, verified, and corrected.

To develop an estimate that is in line with market considerations and eventually the low bid, proper documentation of the estimate throughout the project development process is critical. This documentation is important as project team members contributing to the cost estimate are aware of the assumptions that have been made throughout the project and the assumptions that need to be resolved to further refine the cost estimate. This includes all assumptions for estimated quantities and unit prices throughout project development, and how the project specific conditions do affect quantities and unit prices for certain types of work on the project.

During project development, changes in scope or other issues that affect project cost must be documented and resolved in the estimate at various key milestones. In addition, document all estimate assumptions as well as maintain the estimate data and information that supports the quantities, prices, allowances, assumptions and contingencies. The following process presented in Table 10 illustrates the steps to be followed to help maintain proper change management controls.

Table 10: Change Management Process

Step	Description
1. Monitor project scope and project conditions	Identify any potential deviation from the current cost estimate, including: • Changes in project scope • Changes due to design development • Changes due to external conditions • The nature and description of the potential change • Impacts on the project budget and/or schedule due to a change
2. Evaluate potential impact of change	Assess potential impact of change, including: • Cost and time impact of the deviation • Assess whether to modify the project scope, budget, and/or schedule due to change
3. Adjust cost estimate	Document changes to the base estimate, including: • Appropriate approval of the deviation • Revised project scope, budget, and/or schedule • Notification of the change to project personnel
4. Obtain appropriate approvals	Obtain authorization to proceed through: • Review of current project scope and estimate basis • Securing approvals from appropriate management levels and/or stakeholders • Approval of current estimates, including any changes from previous estimates • Release estimate for its intended purpose and use

10 CONTINGENCY, INFLATION AND ESCALATION

Uncertainties due to such factors as risk and project complexity need to be acknowledged early for all projects in the project development process, starting with the Planning phase, and updated regularly in subsequent phases. Regardless of the cost estimating methodology, an element of uncertainty is inherent in any cost estimate. In order to account for as much of this uncertainty as possible, the project delivery schedule and estimate should be evaluated and assigned an appropriate reserve amount to be included in the total project cost estimate. This reserve can come in the form of contingency, inflation and/or specific escalation and will play a significant role in developing present value estimates and forecasting future value costs.

Predicting the future cost of such items as steel, cement and asphalt can be difficult since prices for these items can be influenced by many factors within our global market. This means that estimated bid prices should reflect the best judgment and experience based on known conditions and trends.

Reserves that have been set-aside in the planning or scoping phases that are not needed at the design or advertising phases should not be used to increase project scope. Rather it is most appropriate to release any unused reserves to be included in statewide balancing.

10.1 Development Contingency

Proper contingency should be applied to the cost estimate based on conditions such as design stage and project complexity. Contingency funds are typically meant to cover a variety of possible events and problems that have not yet been specifically identified or to account for a lack of project definition during the preparation of the construction cost estimate and throughout project development.

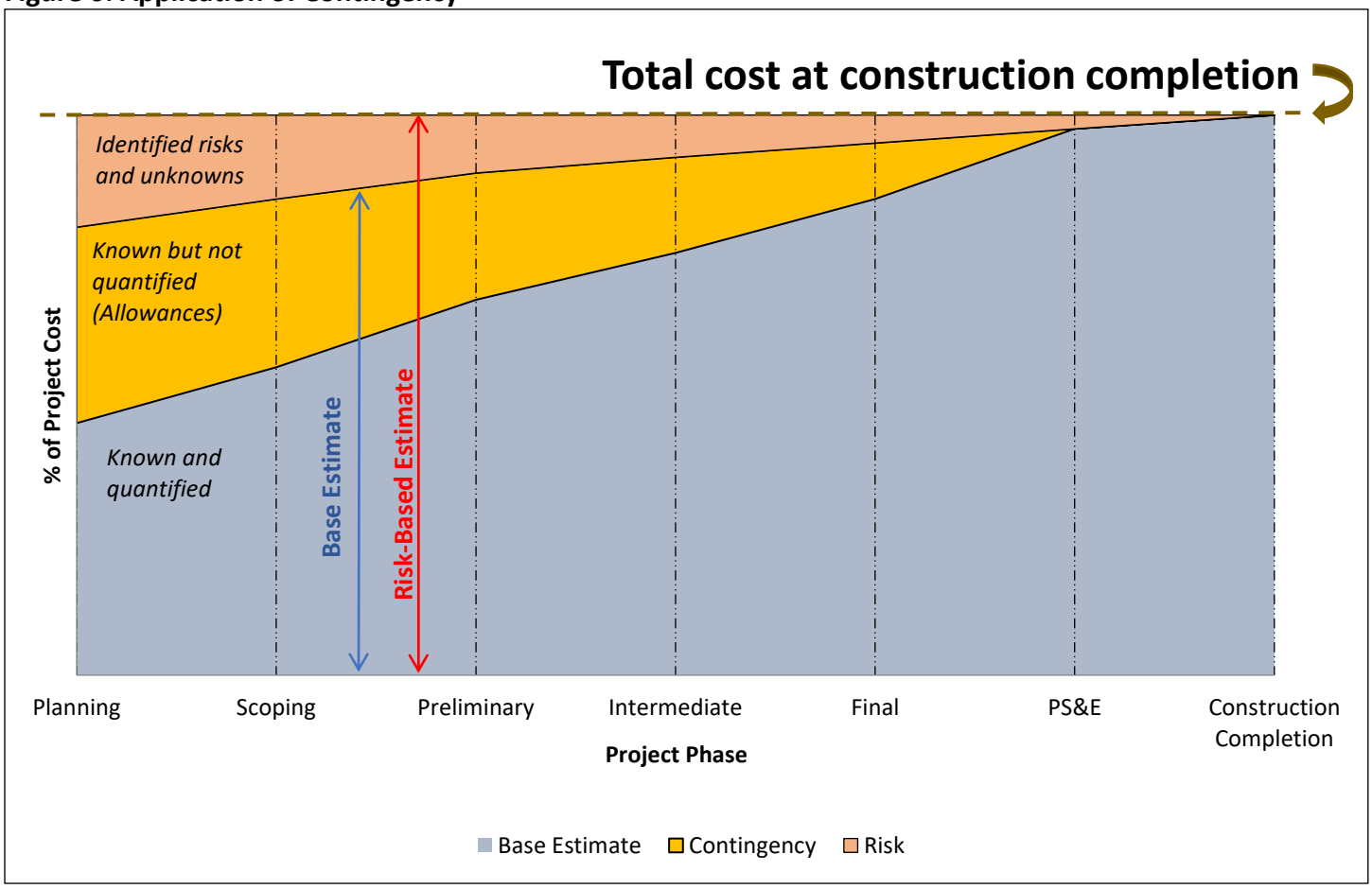
As a caution, contingency funds are not to be used to cover added scope or project cost overruns. Inconsistent application of contingency throughout the project development can cause confusion as to exactly what is included in the line items of an estimate and what is covered by contingency amounts.

As shown in Figure 6, Application of Contingency, the amount of cost uncertainty has the potential of being high during the beginning stages of a project. However, as the project design matures and project details become apparent, this uncertainty should decrease (i.e., higher contingency at the Planning and Scoping stages and lower contingency as the project reaches the PS&E stage). The cost estimate should be considered a living document. It moves up or down 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.

The ideal outcome of appropriately applied contingency is that the overall project cost (base estimate + contingency) determined at the planning and scoping phases does not increase as the project matures through development. As the project progresses throughout project development and previously anticipated risks and uncertainties

materialize (become part of the base estimate) or fail to materialize, the amount of estimated contingency and the base estimate will change accordingly.

Figure 6: Application of Contingency



The following contingency levels shown in Table 11: Contingency Matrix are provided as guidelines for determining an appropriate contingency amount for a project based on the project's level of development. However, the Project Manager must consider the project characteristics in combination with how well the project is defined at each estimating milestone in order to apply an adequate contingency percentage. For some projects, the contingency determination may deviate from the suggested rates provided below. For example, less complex projects such as a chip seal or overlay project are typically easier to define and will have fewer unknowns early in the design process and therefore require a smaller contingency. Conversely, major, complex projects typically have more unknowns early in the project development process and also contain higher risk.

Table 11: Contingency Matrix			
Project Development Phase	**Purpose of Estimate**	**Methodology**	**Suggested Contingency**
Planning	Concept screening or feasibility Idaho Transportation Improvement Program (ITIP)	Parametric Risk Based	30-50%
Scoping	Concept screening or feasibility Idaho Transportation Improvement Program (ITIP)	Parametric Risk Based	30-40%
Preliminary	Design Estimate (project control of scope, schedule & budget)	Historic Bid-Based Risk-Based	20-30%
Intermediate	Design Estimate (project control of scope, schedule & budget)	Historic Bid-Based Cost-Based Risk-Based	15-20%
Final	Design Estimate (project control of scope, schedule & budget)	Historic Bid-Based Cost-Based Risk-Based	10-15%
PS&E	Engineer's Estimate (prior to bid)	Historic Bid-Based Cost-Based Risk-Based	0-10%

Contingency that is assessed to an estimate during the development stage is to be handled separate from construction contingency which is explained below. A purpose of development contingency is to align the estimating process with project phases, scope development, confidence level and the decision making processes.

10.2 Construction Contingency

Construction contingencies are typically reserved to cover a variety of possible risks or events that are not specifically identified or quantified, such as change orders, cost overruns, or other project requirements during construction. On average, the general construction contingency factor to be used is 5%.

10.3 Inflation

Inflation is an economic term that indicates the price increase of goods and services over time that is not offset by increased productivity. Inflation causes purchasing power to reduce and it affects most everything in the financial market. It is measured and reported by various indexes and the most common index for determining the inflation

rate is called the Consumer Price Index or CPI. Monthly CPI reports are published at the U.S. Bureau of Labor Statistics website.

The estimate represents the probable cost at the time of estimate. Any time an estimate is created or updated, the unit prices must reflect the values at the time the estimate is done. This may require going back to the unit price database and get the latest pricing information.

The estimate must always be adjusted for inflation by considering the interval of time from when the estimate was performed to the project's construction year. This will allow the estimator to express the project cost estimate in year-of-construction dollars. On average, the general inflation factor to be used is 2% to 3%.

The link below provides a resource to where estimators can determine appropriate inflation for a project. Rates of inflation are calculated using the current Consumer Price Index published monthly by the Bureau of Labor Statistics.

- https://www.usinflationcalculator.com/inflation/historical-inflation-rates/

It can be assumed that inflation can be applied uniformly among all project bid items.

10.4 Escalation

Escalation can be defined as the change in price levels due to underlying economic conditions. Escalation is affected by changes in price-drivers such as technology and productivity. Changes in the market conditions such as high demand, profit margins, and labor shortages also impact escalation. Accurately representing escalation is a complicated issue because the value varies between office and field labor, equipment, and bulk materials. Escalation can also vary between regions and procurement strategies.

Cost escalation is applied differently since it has the potential to not move in direct correlation with the rate of inflation. Using this information can be very beneficial in assessing the current market behavior and determining how the market will behave in the future. Escalation can be applied to any bid item, however, increased effort should be implemented to track price trends for higher cost items such as roadway excavation, aggregates, surfacing and structures since these items usually make up the majority of a project's cost.

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. Several common cost components are typically used in the composition of overall project costs depending on the tasks involved. These factors may include:

- Asphalt
- Concrete
- Steel
- Aggregate

- Fuel
- Lumber and wood products
- Machinery and equipment
- Electrical and lighting equipment
- Right of way
- Labor

10.5 Price Indexes

Asphalt Index: An asphalt index has been established by the Department which is updated on the first Monday of each month based on the previous four week average as reported by Poten & Partners, Inc. for typical non-modified paving grades in the Boise Area.

- http://apps.itd.idaho.gov/apps/contractors/index/AsphaltIndex.pdf

The U.S. Bureau of Labor Statistics also provides a national price index for asphalt paving mixtures and asphalt paving cement. This index is updated on a monthly basis.

- https://fred.stlouisfed.org/series/PCU3241213241210131

Cement and Concrete Index: The U.S. Bureau of Labor Statistics releases a national producer price index for cement and concrete manufacturing. This index is updated on a monthly basis.

- https://fred.stlouisfed.org/series/PCU32733273

Oil Price Index: The U.S. Energy Information Administration releases crude oil spot prices on a monthly basis. Costs are reflective of the average value of crude oil per 42 gallon barrel produced. The cost of crude oil can be influenced by number of factors that fall under the categories of supply, demand and geopolitics which can stem from both national and international sources.

- https://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm

Iron and Steel: The Bureau of Labor Statistics releases various producer price indexes including one for Iron and Steel.

- https://www.bls.gov/regions/mid-atlantic/data/producerpriceindexmetals_us_table.htm
- https://fred.stlouisfed.org/series/WPU101

National Highway Construction Cost Index: On a quarterly basis, the Federal Highway Administration provides a price index that can be used to track price changes associated with highway construction costs.

- https://www.fhwa.dot.gov/policy/otps/nhcci/

APPENDIX A: FACTORS THAT INFLUENCE ESTIMATES

There are many key factors that may affect the project cost. Such factors as project goals, purpose and need, scope (what will be built), site conditions (geotechnical, environmental, hydraulics, etc.) and construction phasing play a big part in influencing project costs. In this section descriptions will be provided to illustrate some of the various contributing factors.

A.1 Geographic Considerations

Geographic considerations are powerful project characteristics that may substantially affect unit prices. The project's location, whether in an urban, suburban, or rural setting, should be considered in establishing an estimate. Some of the cost considerations relating to a project's location may be accounted for in the mobilization bid item.

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

Projects located in rural settings have factors that affect the establishment of unit bid prices different from the 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.

For 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. Again, those costs may be directly attributed to and reflected in the mobilization bid item.

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

Groundwater conditions can vary greatly and need to be investigated to determine the extent of dewatering required for foundations and other structures such as stormwater retention ponds. Varying geotechnical conditions will need to be considered in the final estimate.

Material hauling that must be accomplished by entering and exiting at designated locations only (such as interchange ramps), hauling loads uphill rather than downhill, working on the top of slopes or retaining walls, etc., is always more expensive to construct than work that is easy to accomplish on level or gentle slopes. The ease of accessibility to the work will affect the cost to do the work.

A.2 Restrictive Work Hours or Method of Work

Restricting the contractor's working hours or the method of work on a project may have major effects on prices. The prices for work that is limited to short shifts, or required to be completed in long shifts, or limited to nighttime operations should be increased to reflect the cost of premium wages required for such work and for the general inefficiencies and decreased productivity that may result. Night work for plant operations (e.g., asphalt production) can be especially expensive when small quantities are involved. Plants usually do not operate at night and may require special production runs at much higher than normal operating costs.

Restrictions could also be manifested by the time of year the contractor is permitted to perform work due to such things as irrigation or fish windows. This can have a major cost and schedule impact if work is limited to periods of cold weather.

A.3 Quantity Considerations

The quantity of a given material 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.

- On one hand, generally, the unit price for larger quantities of a given material should be less than it would be for smaller quantities. Larger quantities may give rise to efficiency by gained experience and the expertise of the contractor's personnel in completing the work.
- On the other hand, for some projects, 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, or may even tie up a region's labor resources.

Small quantities of items of work are often less cost-effective to construct and lead to higher unit prices. Suppliers charge more for smaller purchases, and in some instances the minimum amount that has to be purchased is greater than needed for the project. Smaller-quantity items may be subcontracted out; this increases a contractor's overhead and usually results in a markup being applied to those items.

A.4 Separate Operations

Separate operations will usually increase item costs, especially if the order of work or the work unit is to be constructed in scattered locations throughout the project (each requiring move-in and move-out costs). If this is the case, unit prices should be based upon the smaller unit sizes and should not be based upon the entire quantity for the total project. For example, a bridge repair project which involves several bridge locations should most likely be estimated based on the smaller individual unit sizes to account for production inefficiencies and the move-in and move-out costs.

A.5 Handwork and Inefficient Operations

Handwork and small or inefficient operations (even though equipment may be used) will have higher unit costs than work that is able to be mass produced or constructed by using techniques that result in higher production rates.

A.6 Item Availability

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. This should be considered in establishing the unit price.

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

A.7 Scheduling/Lead Time

To be efficient, a contractor needs to optimize the scheduling of resources, including labor, equipment, and materials. The ability to plan for and maximize resources allows contractors to be more competitive in bidding. Lead times need to be considered in estimating the project based upon when it is expected to be built. For example, a project that is two seasons long may have the majority of its paving in either the first or the second year.

A.8 Difficult Construction/Site Constraints

Difficult construction and site constraints will increase the cost of construction for a contractor. Examples of site constraints that should be considered include: remote location; long haul routes; placing piles under water; working near active railroads, irrigation facilities, utilities, or nearby historical buildings (possibly fragile); constructing on or near culturally important or environmentally sensitive sites; and working in areas with limited room to construct an item.

A.9 Estimating Lump Sum Items

Lump sum bid items can be more difficult to estimate, therefore, if the work to be performed can be quantified, then a payment method that includes a quantity should be used. Not to exclude lump sum items entirely, as a benefit to the Department, lump sum item can reduce administrative costs in contract administration, as well as allow a contractor a bit more freedom to be innovative with regard to work means and methods. Lump sum items also transfer the risk of performance and quantities to the contractor. Lump sum bid items may also be 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. If lump sum estimating is used, it is essential that the lump sum item be defined and detailed as feasible in order to accomplish a reasonable lump sum estimate.

An estimator should define a lump sum item in terms of its simplest, most basic components and should also consider other factors that may not be easily estimated. By

breaking out a lump sum item into smaller items of work that have historical data and applying reasonable estimated prices to those subunits, the estimator can calculate the overall lump sum item.

Using lump sum items typically transfers risk to a contractor, therefore, the contractor may adjust the price upward to take on this risk since contractors cannot necessarily rely on overruns to cover work that they did not foresee. 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 project temporary traffic control, the lump sum payment may provide the incentive to perform the work more quickly. In such situations, hourly pay items offer no incentive, and may result in the contractor remaining in the work zone for a longer period of time.

In most cases, lump sum bid items can lead to higher contractor bids. Therefore, lump sum items should only be used when the following conditions apply:

1. The lump sum item is a standard item with no appropriate alternative non-lump sum standard item available for use.
2. 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.
3. The project has complex items with many components (although the designer is encouraged to break down these work items as much as possible).
4. The lump sum payment may be justified as incentive to complete the work in a more timely or efficient manner than if other units of measure were used.
5. The lump sum item may be justified as less expensive than a Contingency Amount/Force Account item 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.

A.10 Contingency Amount/Force Account

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

The case of poorly defined items of work is the one most frequently encountered. The contractor does not usually bid on this work so there is little incentive to reduce costs or execute the work diligently. Because of this, the force account method of payment should only be used when necessary.

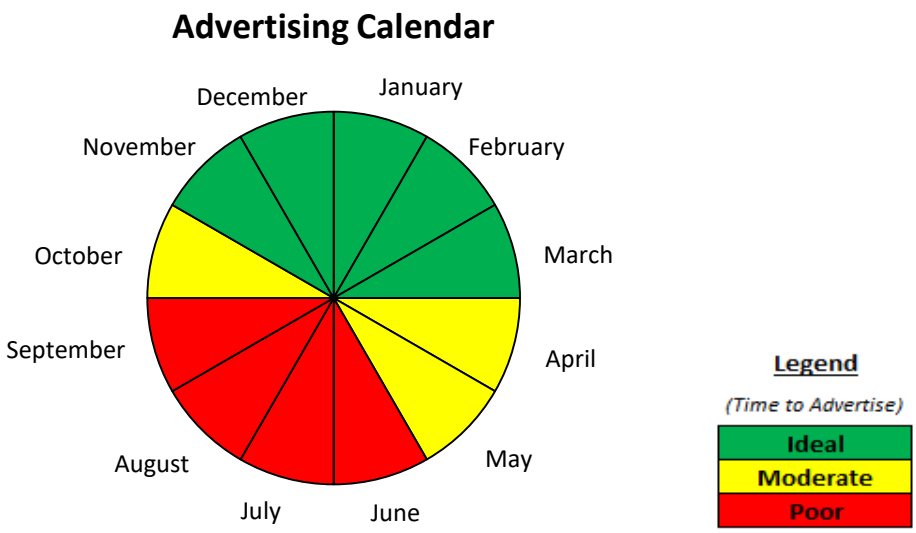
When a reasonable cost estimate for a contingency amount item is required, the estimator should try to establish the scope of work to be accomplished. Once the scope is developed, it can be compared to historical bid price data for similar items of work. If no comparable history exists, the contingency amount item should be broken out into

its anticipated core components. The estimator can then rely on historical bid data for those items and the given limitations to come up with a reasonable estimate. If no such data exists, the estimator may need to estimate the amount and costs of materials, equipment, and labor to execute the work.

Contingency Amount may also be considered as 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.

A.11 Timing of Advertisement

The timing of the project advertisement can influence bid prices. Contractors can have a time of year that is busier than others. This relates to weather and construction windows; for example, asphalt paving is not done during cold, wet weather. The appropriate timing of advertisement can also be affected by other items like fish and HMA paving windows or other outside constraints. The peak construction season for most highway projects is April through October which would lead to the most advantageous bidding period to be between November and March. During these winter months, contractors will most likely bid aggressively because they are looking to build their backlog for the following year. Additionally, with less construction in the winter, contractors will have an increased number of people available to research innovations and prepare more competitive bids.



The peak season for marine work is November through March. The best time to advertise these types of projects is several months prior to November to allow time for contract execution and for contractors to mobilize their resources in time to take advantage of the full work season.

If contractors have fully allocated resources for the upcoming season, 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 the Department to advertise a project as soon as possible prior to the peak construction season, to allow contractors time to plan, schedule, and

seek as many opportunities as possible to find efficiencies in their work plans. Hopefully, this promotes a more competitive bidding environment.

The estimator preparing the final Engineer's Estimate needs to be aware of the timing of the advertisement. The estimator should 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.

It is important to know if the work can be accomplished before winter weather causes the project to shut down. If the job cannot be finished before the end of the construction season, and the project needs to be suspended, contractors will increase their bid prices to cover their overhead during the winter and repair any damage that may occur. Even if contractors reasonably expect to finish before the winter, they may protect themselves by assuming an early winter.

When programming, consider the following tips to best execute the advertisement of a project.

- Plan ahead to take advantage of prime bidding periods of the year.
- Provide a preliminary advertising schedule so contractors can plan their bidding schedule.
- Minimize bid openings around holidays.
- Advertise winter work (structural, irrigation, etc.) in the fall because contractors tend to bid aggressively for winter backlog.
- Stagger work through the prime bidding period.
- Stagger similar types of work and geographically similar work.
- Implement flexible start dates
    - Allows contractors to determine most efficient time to start a project within a reasonable construction window.
    - More efficient scheduling of resources allows for lower costs.
    - Allows contractors to bid on more projects, resulting in lower costs.
- Work restrictions (examples)
    - HMA – Air and surface temperatures per section 405
    - Chip seal – June 15 to September 1
    - Microsurfacing – Air and surface temperatures per section 415
    - Irrigation – Verify with the impacted irrigation company
    - Migratory birds – see environmental document
    - Fish Windows – see environmental document
    - Seeding – Temperature restrictions per section 621. Generally, between March 15 and April 30 or October 15 and November 15
    - Trees, Shrubs, and groundcovers – Temperature restrictions per section 620. Generally between September 15 and May 15.

A.12 Expected Competition/Contractor Availability

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 may be bid more competitively.

Competition could be considered the most major component that influences cost. When the estimator expects just one or two bidders, then the project cost may be much higher than otherwise anticipated. On the other hand, if there are many bids, the project cost may be significantly lower than the estimate. Due to the number of bidders, there is a noticeably dramatic effect upon the value of the lowest bid. Ideally, a good bidding environment exists when three or more contractors bid on a project.

A.13 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 this does not become an influencing factor on the bids. If this cannot be prevented, then the estimate needs to reflect that multiple bids will be developed at the same time. The estimator should consider to what extent the reduction below the normal number of bidders will influence the bid amount.

The probability of the occurrence of this risk should be carefully evaluated. Common mitigation strategies include timing of the advertisement and work packaging. On the other hand, in extremely competitive bidding environments, with large numbers of contractors bidding, the bids may actually come in lower than expected.

Another factor to consider is that multiple active projects can 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 estimator must be aware of the ability of the market to support multiple projects. Other conflicts could include traffic control, labor issues, and direct coordination issues, among others. 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 regions or local agencies). There may be opportunities for collaboration and coordination that will result in more competitive bids and better maintenance of traffic.

A.14 Specialty Work

Specialty items are not necessarily new items or new construction methods. Rather, they are items that are somehow different than the majority of the work on a given project. For example, on a pavement rehabilitation project, the signal work may be classified as specialty work, although it would not be classified as such on a project that was predominantly signal and lighting work. Estimating the cost of specialty work

requires a thorough understanding of the work involved and the resources required for accomplishing it.

When estimating specialty work you are not familiar with, seek the advice of experts who can help, even contacting vendors who specialize in the particular work. This could lead to a better understanding of the associated costs as well as improve the confidence level of the estimate.

Also, consider the number of qualified contractors capable of doing projects which include specialty elements of work.

A.15 Material Shortages

Material shortages will have a major effect on prices, since prices are directly affected by supply and demand. Where a shortage is especially severe, a change in design might be considered rather than increasing prices.

A.16 Standard Items vs. Nonstandard Items

Standard items are familiar to both the Department and the contractors. These items of work typically represent a known quantity and quality and bid history tends to reflect that. When an item is changed in some way to become a nonstandard 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 a nonstandard item, the estimator should recognize that the price may differ from the historical prices.

A.17 First-Time-Use Items

On occasion, items of work are included in a project for which the Department has little or no historical data 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 with use of the item can usually help in determining a cost.

Suppliers, other state departments of transportation, RS Means Publications, and 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-use 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.

A.18 Soil Conditions

General assumptions about soil conditions may be made early in the estimating process, but they may turn out to be wrong. As the project and the estimate mature, 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 and communicated clearly within the basis of estimate. A common estimate omission is an improper allowance for shrink and swell of material. The Materials Engineer should be consulted to determine the appropriate shrink or swell factor to use. Since soil conditions can be a significant cost risk to a project, risk-based estimating techniques should be utilized to quantify geotechnical risks if they pose a significant threat or opportunity.

A.19 Permit Conditions

Throughout the stages of planning, scoping, and design, various projections of permit conditions for construction can be obtained from District or HQ environmental offices. Engaging these groups early helps to identify specific permits or conditions that can drive up construction costs and identify opportunities to avoid costly environmental conditions.

Be aware that considerable cost increases may be in order due to such items as:

- Stormwater collection and treatment
- Wetland protection and mitigation
- Hazardous materials testing
- Containment and treatment
- Removal and disposal of underground fuel tanks, creosote timbers, and contaminated soils.

A.20 Right-of-Way

Right-of-way (ROW) costs can vary widely from project to project. To assist in determining reliable ROW project costs, the HQ Right-of-Way section should be involved early in the development and estimating process. These SMEs can provide input regarding the cost of right of way and the uncertainty associated with the real estate market within the project's geographic area. Other issues to consider include zoning changes, growth management plans, and pending comprehensive plan changes. ROW estimates typically include administration, acquisition, relocation, cleanup costs, and allowances for condemnation. Costs may also include cash in-lieu of construction in cases where property owners elect to accept cash payment to build negotiated features with their own forces.

As a matter of cause and effect, while new highway construction projects may have additional costs associated with right-of-way acquisition, it may provide more efficient construction access and allow the contractor to use larger equipment. In contrast, maintenance and reconstruction projects on existing alignment may pose construction

access restriction and other costs associated with construction phasing and maintaining traffic.

APPENDIX B: CAUSES OF INACCURATE ESTIMATES

There are many factors that can undermine cost estimation. Some of the most common pitfalls are:

1. Poor raw data: Historic data is only as good as the information that is put into it. Therefore, it is important that the information the Department keeps in its data base is quantifiable and well organized.
2. Lack of experience with similar projects: Accuracy in cost estimating tends to increase as estimators, project teams, and organizations gain experience working with similar projects. Inexperienced estimators and project teams may not be familiar with the scope of a project, which may lead to inaccuracies - even with deterministic estimating techniques. At an organizational level, the use of analogous estimating techniques is typically not reliable if the organization has not conducted similar projects before.
3. Length of the planning horizon and of the project: It is important to keep in mind that estimates should not be made prematurely. Accurate estimating depends on the degree to which a project is defined. As the project matures, cost estimates need to be revised as more up-to-date information become available. For complex projects that take several years to develop, it's important to take currency value fluctuation and political climates into account.
4. Not fully understanding the work involved in completing work packages: This is sometimes a problem for inexperienced project teams who have not worked on similar projects before. In these situations, the potential of omitting necessary work increases.
5. Expecting that resources will work at maximum productivity: In a perfect world, everything would move at maximum productivity, however, this is only achieved when the ideal contractor and the ideal project come together in the ideal conditions. To best estimate and account for the variables that hinder the ideal situation, a more appropriate rule of thumb is to assume 80% productivity.
6. Failing to identify risks and to prepare adequate contingency plans and reserves: Negative risks can both raise costs and extend durations.
7. Not updating cost estimates after project scope changes: Updating cost estimates are an integral part of scope change management procedures as the project scope changes. Failing to update cost estimates when scope changes occur will misrepresent the true cost of the project.

8. Creating hasty, inaccurate estimates because of stakeholder pressure: Since project managers are held accountable for estimates, order of magnitude estimates are a much better choice than numbers pulled out of thin air.
9. Making a project fit a fixed budget amount: The scope of a project should determine its budget, not the other way around. Estimating should be approached in a way that objectively determines how much time and resources are required to carry out a piece of work to acceptable standards of performance. The reverse approach, estimating projects to fit budgets, is likely to result in projects that fail to meet requirements, deliver results, and represent actual cost.

In addition to the degree of project definition, estimate accuracy is also driven by other systemic risks such as:

- Level of non-familiar components in the project.
- Complexity of the project.
- Quality of reference cost estimating data.
- Quality of assumptions used in preparing the estimate.
- Estimating techniques employed.
- Time and level of effort budgeted to prepare the estimate.
- Unique/remote nature of project locations and the lack of reference data for these locations.

Systemic risks such as these are often the primary driver of accuracy, especially during the early stages of project definition. As project definition progresses, project-specific risks (i.e. risk events) become more prevalent and also drive the accuracy range.

APPENDIX C: REFERENCES

- AASHTO Practical Guide to Cost Estimating
- AACE International
- Washington State Department of Transportation: Cost Estimating Manual for Projects
- Pennsylvania Department of Transportation: Estimating Manual
- New Jersey Department of Transportation: Cost Estimating Guideline