Interstate 70 Mountain Corridor Traffic and Revenue Study

October 15, 2014

Prepared for

COLORADO Department of Transportation

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4.0	October 15, 2014	All	Final Version

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ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
AGS	Advanced Guideway System
BRT	Bus Rapid Transit
CDOT	Colorado Department of Transportation
CSS	Context Sensitive Solutions
DCF	Discounted Cash Flow Analysis
EJMT	Eisenhower Johnson Memorial Tunnels
FHWA	Federal Highway Administration
HPTE	High Performance Transportation Enterprise
ITF	Issue Task Force
ITS	Intelligent Transportation System
MOT	Maintenance Of Traffic
NEPA	National Environmental Policy Act
O&M	Operating and Maintenance
PEIS	Programmatic Environmental Impact Statement
PLT	Project Leadership Team
PPSL	Permanent Peak Period Shoulder Lane
RFP	Request For Proposal
RFSOI	Request For Statements Of Interest
ROD	Record Of Decision
ROW	Right-Of-Way
T&R	Traffic and Revenue
TRUE	Transportation Risk and Uncertainty Estimating
TT	Technical Team
VOT	Value Of Time

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1 PROJECT BACKGROUND

In July 2011, the Colorado High Performance Transportation Enterprise received an unsolicited proposal for a co-development plan of a phased program of multimodal transportation improvements on Interstate 70 (I-70) between C-470 and Silverthorne initially and extending to Eagle in the future. Parsons Transportation Group (Parsons), a design, engineering and construction company with a hub office in Denver, submitted the unsolicited proposal.

As per its guidelines for unsolicited proposals, the Colorado Department of Transportation and HPTE reviewed the Parsons unsolicited proposal in June 2012, sought comparable proposals by issuing a Request for Statements of Interest for qualified firms interested in submitting a co-development proposal to assist CDOT in providing a long-term solution to the congestion and mobility issues on the I-70 Mountain Corridor through a program of highway, transit and other improvements. The RFSOI included helping CDOT to secure a Public-Private Partnership for financing, designing, building, and operating the I-70 improvements through a long-term concession agreement. Four firms were selected as a result of the RFSOI and asked to respond to a Request for Proposal.

Although four firms were shortlisted to respond to the RFP issued in early July 2012, only two firms submitted proposals. The submissions were evaluated on their technical plan as well as on their cost and risk sharing proposals; as a result the Parsons proposal was deemed the best value.

However, because the proposal included some risks that had to be addressed, CDOT was not comfortable moving immediately into a selection and co-development agreement. Instead, CDOT decided to proceed with a Traffic and Revenue study as a first step to model the variations of the proposed options and/or new options to determine which alternatives are the most economically feasible and publicly acceptable. In short, the T&R study would verify the financial feasibility of the proposed option to minimize the risk to using public funds.

The T&R Study evaluated conceptual designs, preliminary cost estimates, potential revenues, and financing for the potential addition of managed lane facilities and other improvements on the I-70 Mountain corridor in Jefferson, Clear Creek, and Summit counties, Colorado. The study area included I-70 generally between C-470 and Silverthorne for a distance of approximately 53 miles.

The I-70 Mountain Corridor Team (also called Project Team), was developed by CDOT. The Project Team consisted of CDOT, FHWA, Parsons Transportation Group, Louis Berger Group, and Ernst and Young. Parsons supported the T&R effort by assisting with the facilitation and collaborative process of the I-70 Context Sensitive Solutions, providing conceptual engineering of alternatives, and providing preliminary cost estimates for those alternatives. These activities and deliverables are described further in this report. Details are provided in the appendices.

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2 LEVEL 1 METHODOLOGY

A T&R study evaluates the feasibility of tolling a corridor based on specific lane configurations and connections. The information developed by a T&R study is used by policymakers to make long-term transportation decisions. T&R studies are conducted at various levels. The initial study is called a Sketch Level Study, Level 1, or Exploratory Study. The Project Team conducted the Level 1 Study, which produced a T&R forecast and provided data on system level impacts and performance measures.

The Study consisted of the following individual tasks (generally conducted in the order listed):

- **Project Management and Mobilization**, which included scheduling, monthly progress reporting, management and administration, and management scheduling and coordination.
- **Stakeholder Involvement and Decision Making**, which applied the I-70 Mountain Corridor Context Sensitive Solution guidance, and included the following activities:
  - Initiating the 6-Step Process for Decision Making
  - Establishing a corridor wide context statement, core values and map
  - Establishing a Project Leadership Team at the beginning of the project that includes community and stakeholder representatives
  - Taking a multidisciplinary approach to all aspects of the project by establishing a Technical Team that includes representatives from all of the disciplines that may be interested in or affected by the T&R Study
- **Data Collection and Analysis**, which included Project Team gathering data for the previous design effort, existing traffic data, and other data regarding existing conditions.
- **Development and Evaluation of Performance Measures**, which were developed based on core values derived from PLT meetings. These measures addressed the broad categories of safety, mobility, constructability, engineering criteria and aesthetic guidelines, sustainability, decision-making process, community (local, regional, statewide), historic context, healthy environment, and fiscal responsibility.
- **Development of Alternatives**, which initially required the development of four alternatives (in addition to the base condition) as follows:
  - Addition of two reversible managed lanes with direct connections (two options included)
  - Addition of three reversible managed lanes with direct connections (three options included)
  - Minimum program of improvements as described in the PEIS (four options included)

- Maximum program of improvements as described in the PEIS (two options included)

As the project proceeded, the PLT added the following alternatives and options for study:

- Permanent Peak Period Shoulder Lane
- Temporary Peak Period Shoulder Lane

- **Cost Estimates for Alternatives**, which was developed for each option under every alternative. The preliminary construction cost estimates included sufficient detail to develop an enhanced project cost estimate based on work to date. The cost estimate included electronic conceptual drawings in sufficient detail so that approximate construction quantities, right-of-way requirements, utility impacts, and constructability issues were defined. A risk/opportunity cost workshop was conducted to provide a probability-based range of costs.
- **Traffic Model and Development (by Louis Berger Group)**
- **Traffic and Revenue Forecasts and Modeling (by Louis Berger Group)**
- **Financial Analysis (by Ernst and Young)**
- **Documentation**

Except for the work identified by Louis Berger Group and Ernst and Young, the results of the above activities are reported in this document. The traffic model and traffic and revenue forecasts are reported in a separate report delivered to CDOT. The report is entitled: “Sketch Level Mountain Corridor Traffic and Revenue Study,” by Louis Berger Group, dated August 8, 2014.

3 Context-Sensitive Solutions Process

3.1 The 6-Step Process

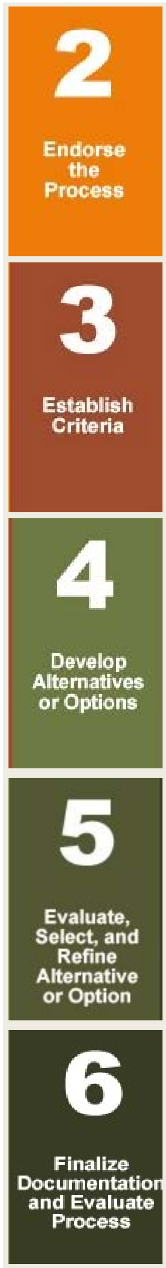
The I-70 Mountain Corridor Context Sensitive Solutions Guidance is the result of stakeholders' high level of interest and CDOT's commitment to build world-class improvements throughout Colorado's I-70 Mountain Corridor. Stakeholders from the mountain communities, business owners, and federal and state agencies have come together to ensure that all future transportation improvements fit the physical setting and preserves scenic, aesthetic, historic, and environmental resources, while maintaining safety and mobility.

The I-70 Mountain Corridor Team utilized the 6-Step Process, the principles of which are the basis for project-specific formation of the I-70 Mountain Corridor Context Statement and Core Values.

The 6-Step Process, as shown in Figure 3-1, is the starting point for all projects on the I-70 Mountain Corridor; it ensures collaboration by establishing early and continuous involvement of stakeholders in a fair and transparent decision-making process. Each phase has its own set of requirements and expectations, and the products developed at each phase provide inputs to the subsequent phases.

Figure 3-1: 6-Step Process

Step 1 uses the CSS Guidance and other relevant materials to establish the project goals and actions. It also defines the terms to be used and decisions to be made.



Step 2 establishes participants, roles, and responsibilities for each team. The process is endorsed by discussing, possibly modifying, and then finalizing with all teams the desired outcomes and actions to be taken.

Step 3 establishes the criteria that provide the basis for making decisions consistent with the desired outcomes and project goals. The criteria measure support for the Core Values for the I-70 Mountain Corridor.

In Step 4, the Project staff members work with the PLT, stakeholders, and the public to identify alternatives or options relevant to the desired outcomes, project-specific vision, and goals.

Step 5 is the process of analyzing and evaluating alternatives and applying the criteria to those alternatives or options in a way that facilitates decision making. This may be a one-step or multi-step process, depending on the complexity of the alternatives and the decision.

Documentation should be continuous throughout the process. Step 6, final documentation, will include each of the previous steps, as well as final recommendations and the process evaluation.

These steps are intended to provide a clear and repeatable process that is fair and understandable. The order of the steps is as important as the activities within each step.

The I-70 Mountain Corridor Level 1 Traffic and Revenue Study's process followed these 6 Steps, as detailed in the following subsections.

3.2 Development and Ratification of the Context Statement

The I-70 Mountain Corridor Level 1 T&R Study followed the 6-Step process as described previously, beginning with *Step 1: Define Desired Outcomes and Actions*. During this step, stakeholders worked with the Project Team to develop and ratify a project context statement.

A context statement seeks to capture in words the special qualities and attributes that define a place as unique. A context statement should capture in words that which was true 50 years ago and that which must be considered during the development of improvements in order to sustain truth in those same words for 50 years to come.

At the first Project Leadership Team meeting held on April 24, 2013, the Project Team developed a context statement for the project. The overall context statement for the I-70 Mountain Corridor was initially reviewed, as shown in Figure 3-2, to understand what the project context statement should resemble.

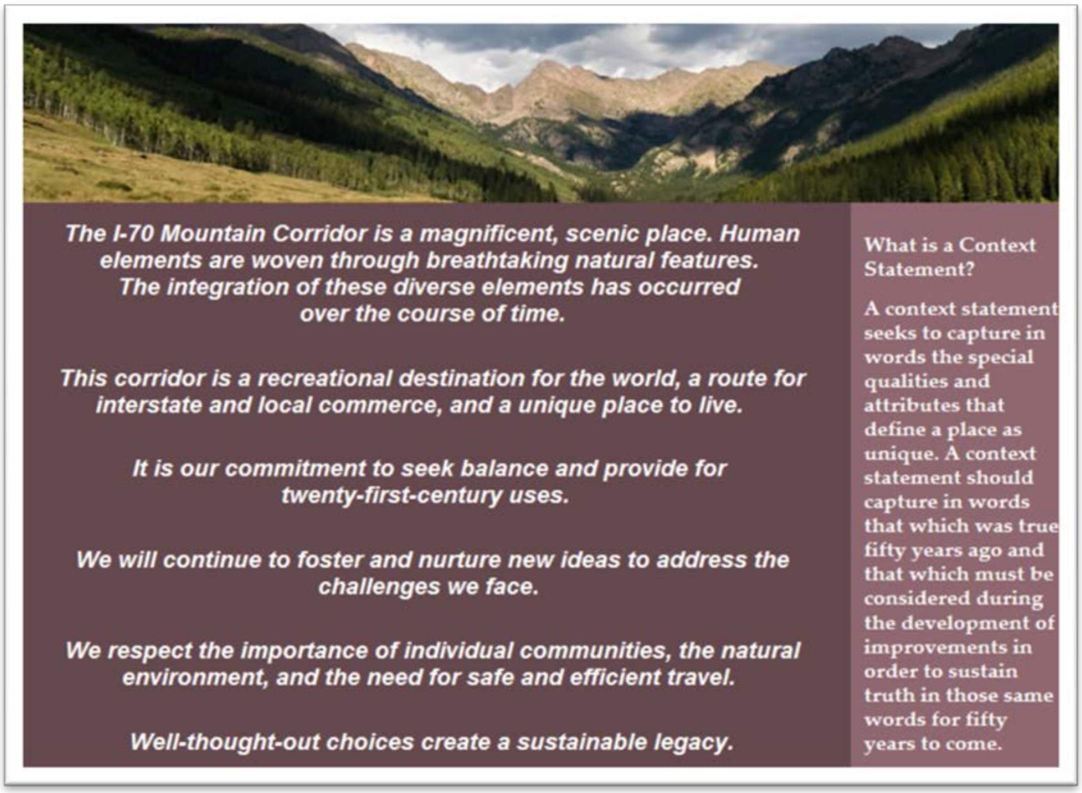


Figure 3-2: Context Statement for I-70 Mountain Corridor

A project-specific draft version of the Context Statement for the I-70 Traffic and Revenue Study was presented at the April 24, 2013, PLT meeting. Initial comments were given by meeting attendees. Additional modifications were suggested by PLT members at the May 29, 2013, PLT meeting. The Context Statement was then finalized and ratified by PLT members at the June 26, 2013, PLT meeting. The final version is as follows:

Context Statement for I-70 Mountain Corridor Level 1 Traffic and Revenue Study

The I-70 Mountain Corridor is Colorado's only east-west interstate and the primary access route from Denver to the commercial and recreational destinations of the Colorado mountains.

Current I-70 roadway geometry is constrained, with narrow shoulders and tight curves resulting in decreased safety, mobility, accessibility, and capacity for travelers.

Traditional funding sources are not adequate to construct the minimum or maximum programs identified in the I-70 Mountain Corridor PEIS Record of Decision.

To advance multimodal facilities that address transportation needs while respecting the unique communities and environmental resources of the corridor, CDOT must identify non-traditional funding programs that could include express lanes.

Sound decision-making requires the consistent application of industry standard traffic, impact, and cost data across all potential programs.

All build scenarios will impact narrow mountain valleys where the Interstate is tightly bound by topographic constraints including creeks, which support recreation and supplies drinking water to the Region, and the corridor bisects some of Colorado's oldest heritage communities. Travel through the area provides scenic vistas of the Colorado Rockies and the Continental Divide.

3.3 Development and Roles of Project Leadership Team, Technical Team, and Issue Task Forces

Next in the 6-Step process is *Step 2: Endorse the Process*. During this step, the I-70 Mountain Corridor Team established participants, roles, and responsibilities for each team, including the Project Leadership Team, the Technical Team, and the Issue Task Forces.

3.3.1 Project Leadership Team

During the first PLT meeting held on April 24, 2013, the Project Team began developing the roles and stakeholder compositions of the PLT, TT, and ITFs. The PLT had the following roles:

- PLT Role #1: Lead the project.
  - Identify all relevant materials for the project, discuss surrounding context, and establish project goals.
  - Determine the teams needed for each of the project outcomes and identify the members needed for each team.

- Assist in staffing other teams needed for the project.

- PLT Role #2: Champion the CSS process.
  - Ensure that the CSS guidance, context statement, core values, and the 6-Step Process are integrated into the project.
  - Ensure that Steps 1 and 2 of the 6-Step Process are accomplished.
  - Review and endorse required CSS elements such as the project work plan.

- PLT Role #3: Enable decision making.
  - Approve the project-specific decision-making process for the project.
  - Identify and implement the steps needed to resolve issues and make a decision.
  - Facilitate formal actions required by councils, boards, and/or commissions to keep the project moving forward.

Note: The PLT does not make the final selection or endorse the project recommendations. Rather, the PLT ensures that the recommendation is developed in an open, collaborative process.

The Project Team and stakeholders decided to invite the following 18 stakeholders to participate in the PLT:

- CDOT Division of Operations
- CDOT Division of Transit & Rail
- CDOT HPTE
- CDOT Regional and Program Staff
- City of Idaho Springs
- Clear Creek County
- Dillon
- Eagle County
- Ernst & Young
- FHWA
- Frisco
- Georgetown
- I-70 Coalition
- Silverthorne
- Jefferson County
- Louis Berger Group
- Parsons
- Silver Plume
- Summit County
- U.S. Forest Service

Over the course of the Level 1 T&R Study, the PLT met on the following dates:

- April 24, 2013
- May 29, 2013
- June 26, 2013
- August 21, 2013
- September 25, 2013
- December 5, 2013
- May 21, 2014
- June 25, 2014

Minutes from each of these PLT meetings are presented in Appendix A-1.

3.3.2 Technical Team

During the August 21, 2013, PLT meeting, the Project Team finalized the roles and responsibilities of the TT. During this meeting, PLT members also completed the list of stakeholders that would constitute the TT. The roles and responsibilities of the TT were as follows:

- Ensure that local context is integrated into the project.

- Recommend and guide methodologies involving data collection, criteria, and analysis.
- Prepare and review technical project reports.
- Support the project with technical expertise and provide insight with respect to community and agency issues and regulations.
- Assist in developing criteria.
- Assist in developing alternatives and options.
- Assist in evaluating, selecting, and refining alternatives and options.
- Coordinate and communicate with respective agencies.

The PLT decided that the TT would be composed of the following 50 stakeholder groups:

- CASTA
- CDOT Division of Operations
- CDOT Division of Transit & Rail
- HPTE
- CDOT Office of Major Project Development
- CDOT Regional and Program Staff
- City of Idaho Springs
- Clear Creek County
- Clear Creek County EMS
- Clear Creek County Sheriff
- Clear Creek Rafting Company
- Club 20
- Colorado Motor Carriers Association
- Colorado Parks and Wildlife
- Colorado Ski Country
- Colorado State Patrol
- CoPIRG
- Denver Metro Chamber of Commerce
- Dillon
- DRCOG
- Eagle County
- Eagle County Commission
- Ernst and Young
- FHWA
- Frisco
- Georgetown
- I-70 Coalition
- Idaho Springs
- Jefferson County
- Louis Berger Group
- Parsons
- Silverplume
- Silverthorne
- Summit County
- US Forest Service
- Vail Resorts
- Vail

Over the course of the Level 1 T&R Study, the TT met on the following dates:

- September 25, 2013
- December 5, 2013
- February 26, 2014
- June 25, 2014

Minutes from each of these TT meetings are presented in Appendix A-2.

3.3.3 Issue Task Forces

During the September 25, 2013, PLT meeting, the Project Team developed a list of ITFs. The key responsibilities of each task force were as follows:

- Work through the elements of the identified issue in order to reach a recommendation to be taken forward to the PLT, the TT, or the Project Team.

- Develop information and data to support estimates and recommendations.
- Develop and work from a plan that outlines the actions needed to make a recommendation within a given timeframe.
- Document the process and make recommendations.

The PLT established the following 14 ITFs:

- ALIVE
- Alternatives
- Cost Estimating
- Finance
- Historic
- Mitigation
- Permitting
- Roadway
- Structures
- SWEEP
- Traffic Modeling and Tolling
- Traffic Operations and Maintenance
- Transit
- Tunnels

Each ITF met as needed over the course of the Level 1 T&R Study. Missions, roles, and responsibilities were developed for each ITF to help guide the ITF members through the process. The missions, roles, and responsibilities for each ITF are presented in Appendix A-3[1]. Minutes from each of ITF meeting are presented in Appendix A-4.

3.4 Development and Ratification of the Core Values, Critical Issues, Critical Success Factors, and Performance Measures

Next in the 6-Step process is *Step 3: Establish Criteria*. During this step, the Project Team and stakeholders established the core values, critical issues, critical success factors, and performance measures for the project.

A core value describes something of significant importance to stakeholders; that is, something they respect and will work to protect and preserve. Core values must be honored and understood. Decisions and choices made for the I-70 Mountain Corridor should be influenced by and support the core values.

The core values are the foundation of the CSS process and help define the project goals and objectives. Draft core values and critical issues were reviewed at the June 26, 2013, PLT meeting. Initial comments were given by meeting attendees. These core values and critical issues were reviewed again and discussed in depth at the August 21, 2013, PLT meeting. The core values of the I-70 Mountain Corridor Level 1 T&R Study are as follows:

- Safety
- Mobility
- Constructability
- Decision Making Process (Local, Regional, Statewide)
- Community (Local, Regional, Statewide)

[1] Please note the Cost Estimating ITF was developed further in the process; therefore no missions, roles, and responsibilities sheet is included in Appendix A-3. Furthermore, the Traffic Modeling and Tolling ITF was combined based on the overlap of issues discussed. Two missions, roles, and responsibilities sheets are included in Appendix A-3. Finally, the Historic ITF was not convened, hence no minutes are included.

- Engineering Criteria and Aesthetic Guidelines
- Sustainability
- Historic Context
- Healthy Environment
- Fiscal Responsibility

The Project Team and stakeholders developed one to five critical issues for each core value. The critical issues were derived from each core value and were used as a basis for developing the project's performance measures.

The Project Team and stakeholders also developed critical success factors for each core value. The alternatives that advanced through the process were measured against the critical success factors to ensure that the alternatives aligned with the defined success of each core value.

Level 1 performance measures were developed by the Project Team and stakeholders for each core value. The alternatives were evaluated against these performance measures in order to determine which alternatives had the best opportunity to meet the critical success factors.

The project's core values, critical issues, critical success factors, and performance measures were ratified by PLT members at the September 25, 2013 PLT meeting. This matrix is presented in Appendix A-5.

3.5 Level 1 Screening Process

The Level 1 T&R Study was a "broad-brush" analysis, with performance measures designed deliberately to be more qualitative in nature. As discussed previously, these performance measures were derived from corridor-specific critical issues related to the core values and the critical success factors during Step 3 of the 6-Step Process.

After completing *Step 4: Develop Alternatives or Options* (discussed in Section 4 of this T&R Report), the Project Team moved on to *Step 5: Evaluate, Select, and Refine Alternative or Option*. During this step, the Project Team and stakeholders analyzed and evaluated alternatives by applying the criteria to the alternatives or options in a way that facilitated decision-making.

The Alternatives Screening Methodology was reviewed at the June 26, 2013, PLT meeting. This methodology was ratified by the PLT members on June 26, 2013. The methodology is described below and in Figure 3-3.

Alternatives Screening Methodology for the I-70 Mountain Corridor Level 1 Traffic and Revenue Study

Current options under consideration by CDOT will be evaluated in the Level 1 Study. "Broad-brush" analyses will be performed on variations of the Minimum and Maximum Program, the 2- and 3-lane reversible multimodal express lane options under consideration by CDOT, as well as new options recommended by the Project Team, in concert with the PLT. These options under consideration will be screened against the Level 1 evaluation criteria.

The Level 1 evaluation criteria will be more qualitative in nature and will be derived from corridor-specific critical issues related to the core values and the critical success factors. The I-70 Mountain Corridor has established core values, in addition to the established values. The Project Team, in concert with the PLT, may establish additional core values relative to the specific study.

Critical issues specific to the core values are problems specific to the Corridor and are related to the study objectives. After the issues are identified and agreed upon, we can measure the ability of the current options under consideration to address these issues using performance measures or measures of effectiveness related to project evaluation criteria.

The evaluation criteria and measures of effectiveness will be devised by the Project Team and the TT. Two sets of measures will be related to a singular evaluation criterion, one for use at Level 1 and one for use at Level 2. The basis for Level 1 screening decisions will be the criteria developed for this project and the measures of effectiveness selected for each of the evaluation criteria.

At Level 1, only very limited engineering and readily available data are used to address each evaluation criterion and measure of effectiveness. Only those criteria and measures that identify differences between the options are used to make screening decisions. Because this is a Traffic and Revenue Study, financial feasibility for the project to pay for itself is of paramount importance. Therefore, any option that cannot pay for itself will not be forwarded to Level 2.

After the Level 1 screening, only those options that perform best by showing advantages in meeting criteria will be analyzed in greater detail in the Level 2 Study. Results of this Level 1 Study will identify "Candidate Corridor Options" for further analysis.

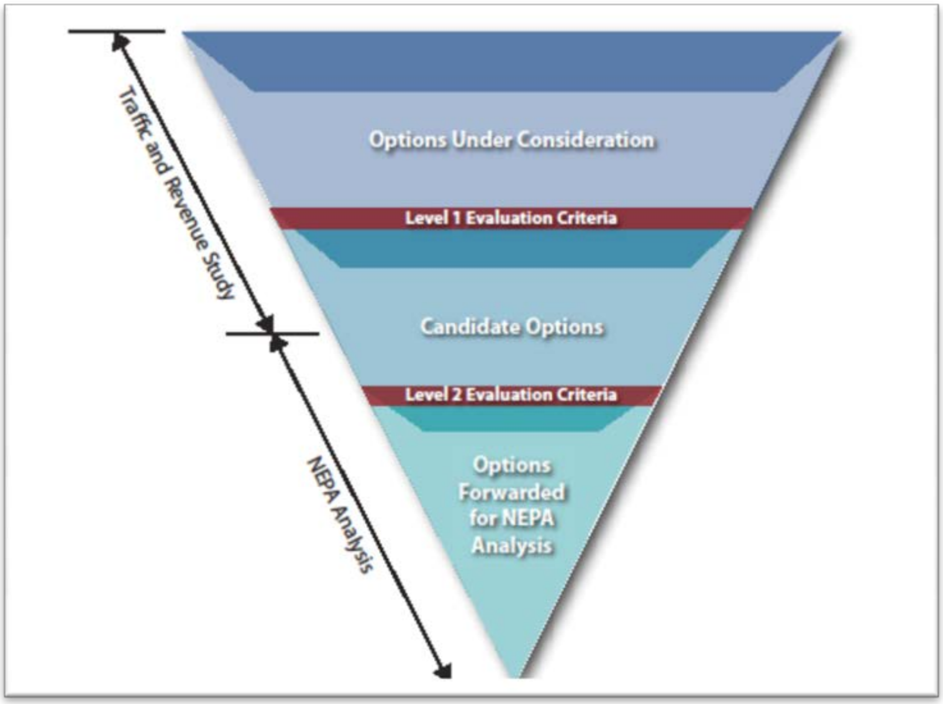


Figure 3-3: Alternatives Screening Methodology

At the June 25, 2014 PLT and TT meeting, members reviewed the draft populated screening matrix by breaking into three small working groups and rotating around three stations to facilitate discussions on each performance measure. Collaborative input from this exercise on how the six alternatives fared against the performance measures helped the Project Team complete its evaluation. The screening matrix, renamed the Level 1 Evaluation Criteria, was revised by CDOT based on the small working groups' input. CDOT then finalized and distributed the Level 1 Evaluation Criteria. This matrix is presented in Appendix A-6.

After completing this step in the CSS process, CDOT moved on to complete *Step 6: Finalize Documentation and Evaluate Process*. This Level 1 Final Report was compiled to include thorough documentation accumulated during the entire study process, as well as documentation of each of the previous five steps, final recommendations, and the process evaluation.

4 DEVELOPMENT OF ALTERNATIVES

4.1 Background

The original scope for the project included evaluation of four major design ideas, including engineering support and preliminary cost estimating for 3-D alignment model runs during Level 1. Two design ideas were based on the reversible managed lane alternatives presented in the unsolicited proposal. The additional two design ideas included minimum and maximum programs of improvements to I-70 as defined in the Programmatic Environmental Impact Statement and Record of Decision, requiring development of a draft plan and engineering for each. It was estimated four design ideas would be developed for comparative purposes.

As part of the CSS Process, during *Step 4: Develop Alternatives or Options* the Project Team, and the PLT, TT and the ITFs, met to develop the four design ideas into alternatives and make refinements to each, resulting in various options to be analyzed, based on the core values and critical success factors (criteria) that support and respect community and agency issues and regulations. The Project Team and members of the TT and ITFs ensured that local context was integrated into the project. The goals of the Alternatives ITF were to verify that each alternative selected had logical termini and that the elements were consistent with project goals, including transit components. The Alternatives ITF was also tasked with the initial development of additional alternatives and options.

Through development in these Alternative ITF team meetings, additional alternatives emerged for potential evaluation. After careful consideration, the list was narrowed down to six overall alternatives as shown in Table 4-1, with variations resulting in numerous options.

Table 4-1: Alternatives under Consideration

Alternative	Description
Base Condition	Existing roadway including eastbound temporary peak shoulder lane improvements and widening of twin tunnels. It also includes the daily CDOT bus service.
1	Two reversible, tolled managed lanes. Includes BRT.
2	Three reversible, tolled managed lanes at 65 mph. Includes BRT.
3	PEIS Minimum Program – toll at third bore EJMT (this alternative is strictly based on the PEIS description; therefore, it does not include the eastbound PPSL). Includes Advanced Guideway System (AGS).
4	PEIS Maximum Program – one nonreversible tolled lane eastbound and westbound. Includes AGS.
5	Permanent peak period shoulder lane (both directions): left side tolled, managed side lane for peak time use. Includes AGS.
6	Temporary peak period shoulder lane (both directions): narrower westbound tolled, managed lane for peak time use. Includes AGS.

In addition to the six alternatives above, a "no action" option, identified as the base condition incorporating a section of temporary peak period shoulder lane already under construction in the eastbound direction, was included for a baseline comparison.

4.2 Alternative Considerations

For each alternative, the general roadway information included the limits of construction, information on general purpose lanes, direction of improvements, required minimum design speed, and details on truck, private bus, and bus rapid transit usage. Tolling details specified the type of pricing and technology anticipated to be used. Anticipating aggressive construction durations, a preliminary schedule was identified. This schedule was needed to develop accurate project costs and projected construction start and finish because several alternatives had significantly different limits and scopes of work.

Transit information was critical to the Project Team's understanding of the approach and development of preliminary cost estimates. For two of the alternatives, a full BRT system was developed with twelve stations located strategically throughout the corridor. The alternatives accommodated an advanced guideway system in the future. For all others, a CDOT-operated bus network between Denver and Glenwood Springs with six stations was included, followed by an AGS to begin operation after 2035.

A section on special structures was developed to help eliminate confusion between the various options. Due to high cost considerations, tunnels and viaducts were clearly stated as special structures if included on each alternative.

Using the guidelines above, a table with information, typical section, and map indicating limits of construction was prepared for each of the following alternatives:

- Base Condition: Existing I-70 with eastbound peak period shoulder lane currently under construction
- Alt01_Opt01: 2 tolled reversible managed lanes, variable (55 / 65 mph) design speeds
- Alt01_Opt02: 2 tolled reversible managed lanes, 65 mph design speeds
- Alt02_Opt01: 3 tolled reversible managed lanes, variable (55 / 65 mph) design speeds
- Alt02_Opt02: 3 tolled reversible managed lanes, 65 mph design speeds
- Alt02_Opt03: 3 tolled reversible managed lanes, variable (55 / 65 mph) design speeds and longer viaduct
- Alt03_Opt01: Minimum program per the PEIS including Eisenhower Johnson Memorial Tunnels 3rd Bore, 55-mph design speed
- Alt03_Opt02: Minimum program per the PEIS including EJMT 3rd Bore, new tunnels, 65-mph design speed
- Alt03_Opt03: Minimum program per the PEIS, 55-mph design speed

- Alt03_Opt04: Minimum program per the PEIS including new tunnels, 65-mph design speed
- Alt04_Opt01: Maximum program per the PEIS including EJMT 3rd Bore, 55-mph design speed
- Alt04_Opt02: Maximum program per the PEIS including EJMT 3rd Bore, 65-mph design speed
- Alt05_Opt01: Permanent peak period shoulder lane from EJMT to Floyd Hill
- Alt06_Opt01: Temporary peak period shoulder lane in westbound direction, Empire to Floyd Hill

Development of these alternatives in conjunction with the TT led to further refinements including typical sections and construction limits. For example, it was determined that standard shoulder widths would be an appropriate assumption for a Level 1 study. Managed lane criteria were adopted from the FHWA Priced Managed Lane Guide, 2012. In future studies, the typical section may be modified in select locations to meet minimum reduced shoulder widths in order to avoid or mitigate impacts to sensitive areas, with the approval of FHWA. It is common practice to consider design variances in future life cycle phases of project development.

The above 13 options formed the basis for the preliminary cost estimates and revenue studies. After the analysis was complete, two additional refinements were requested. The Project Team revised the initial Alt05_Opt01 alternative for the permanent peak period shoulder lane to include a 2-foot buffer in each direction. An updated preliminary cost estimate including this 4-foot width was provided, although it did not undergo the same cost / risk analysis or revised revenue study. In addition, a modification of Alt05_Opt01 was performed as a sensitivity analysis. The 2-foot buffer in each direction was included, and the western terminus was reduced from EJMT to Empire, resulting in the development of Alt05_Opt02. The final alternatives developed for the Level 1 study are shown in Appendix B.

4.3 Design

4.3.1 Roadway

The Project Team established the roadway and tunnel design criteria, setting the basis for all alternative designs. (A copy of the roadway and tunnel design criteria is included in Appendix B.) A conceptual design was completed for each alternative option and included 3-D alignment and grade modeling along the I-70 mainline. For consistency, the same roadway-modeling template was applied to each option of the alternative. The template followed the proposed edge of pavement alignments, varying in width to match the appropriate section. End conditions (slopes, wall, or rock cuts) within the template were established to first follow CSS guidelines for slope criteria. If these criteria could not be met within current CDOT ROW or within critical limits such as existing roads, the next step was to follow standard criteria shown in the CDOT Roadway Design Guide, 2005, Table 4-2. If normal cut/fill slope conditions could not be met within the critical limits, a wall was designed with appropriate barrier if roadside features encroached within the clear zone. In areas with significant rock cuts, the slope was steepened to account for the mountainous terrain. If walls reached a height of 25 feet or greater, designers evaluated and proposed bridges where appropriate. There are many opportunities to optimize the design for any alternatives that progress beyond this conceptual level. After this conceptual level design was completed, the 3-D alignment model for each alternative was used to determine earthwork and wall quantities.

At this early stage, the layout of each interchange is conceptually shown in plan view only. Due to the large number of alternative options, full interchanges were not anticipated to be designed or modeled during Level 1. For subsequent T&R studies, full layout with 3-D alignment design modeling will be completed. If an interchange exists today, it is maintained in the future for all alternatives.

For access to toll or peak period lanes, weave sections were incorporated based on in the ingress/egress maneuvers shown in Figure 4-1.

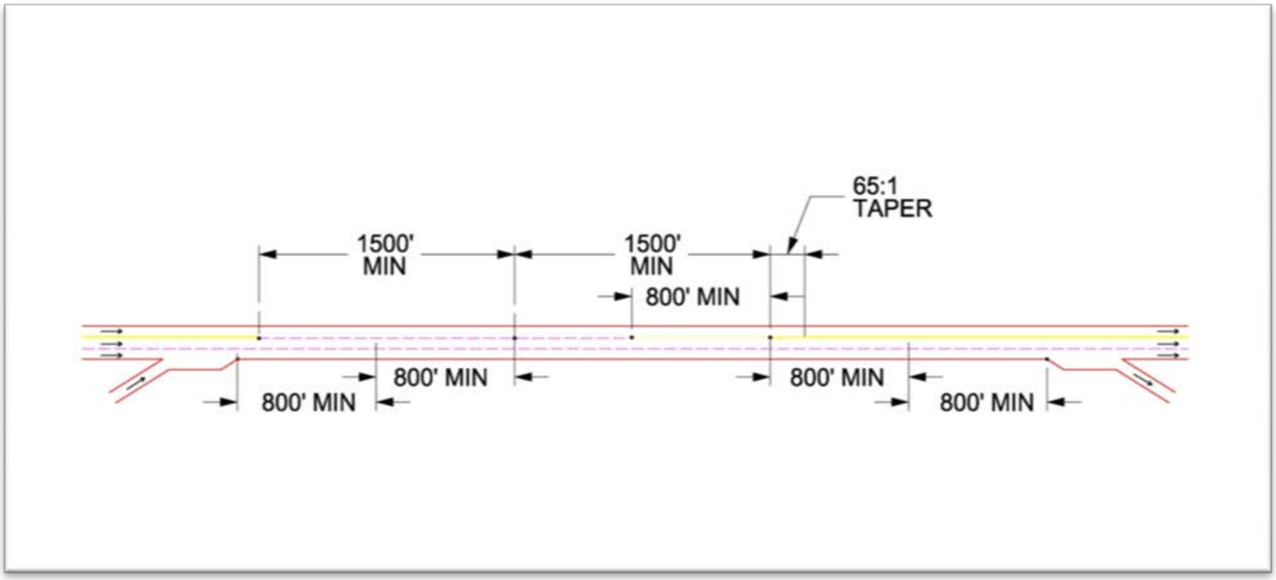


Figure 4-1: Proposed Minimum Spacing for Ingress/Egress Weaving Maneuvers

For the reversible managed lane options (Alternatives 1 and 2), connections to ramps were a more complicated process. Lower volume ramps applied the weave section shown in Figure 4-1. At interchanges currently handling larger traffic volumes, a direct connection was made with separated ramps to maximize safety in the corridor. These interchanges require complete reconstruction to accommodate managed lane ramps within the median, tying into a median separated crossing roadway incorporating roundabouts at each general purpose lane ramp terminals to direct traffic. Gates were used to prevent access in the wrong direction to the reversible lane ramps. Figure 4-2 presents an example.

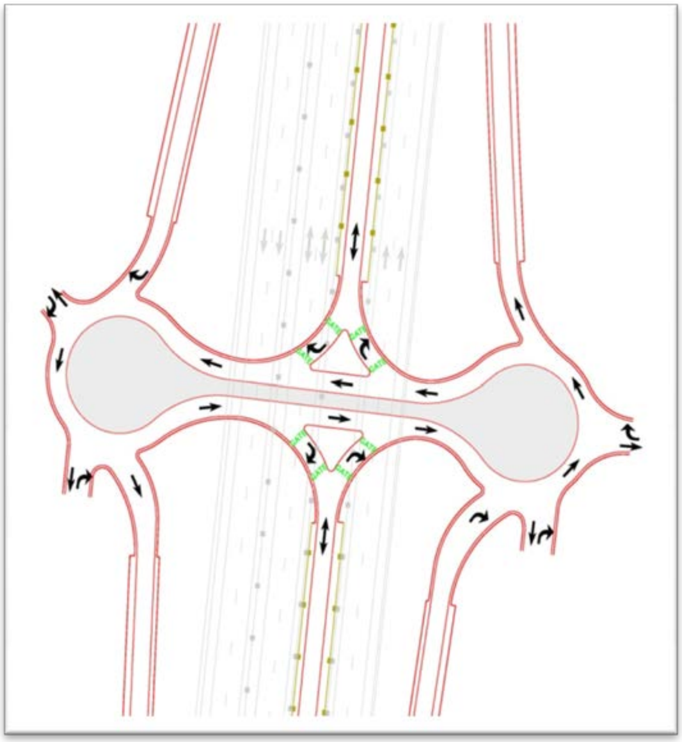


Figure 4-2: I-70 Direct Connect Ramps (Typical Layout)

Traffic analysis for the ramp connections will be completed in future studies to determine number of lanes and required storage lengths. Preliminary cost estimates were performed based on the anticipated footprints shown at this sketch level of analysis.

4.3.2 Drainage

After gathering the available data (including existing plans, reports, county data, and topographical maps), the approximate locations of major drainage crossings were determined. The data was organized in spreadsheets, using the same crossing location for each alternative and adjusting the length as necessary to accommodate the typical sections. For onsite drainage, a typical section was applied to incorporate inlets and crossing structures, which were assumed at every 500 feet when flow was adjacent to a barrier and at 1,000 feet for non-barrier locations along the corridor. Water quality basins and sediment bays were also included using a similar estimation. The Clear Creek Sediment Control Action Plan was used as a basis; this plan used a sediment bay spacing of four bays per mile. This information provided an estimate scaled to match the length and width of the alternative improvements. In areas where only widening is anticipated for Alternatives 3 and 6, culverts were assumed to be extended with water quality structures incorporated. Existing major culverts were assumed to remain, with minor additional culverts added where needed, because the roadway improvements were minimal.

4.3.3 Environmental

The ALIVE (A Landscape Level Inventory of Valued Ecosystem) ITF was convened from members of the pre-existing I-70 ALIVE group in addition to supplemental members specific for this project, to address wildlife issues. The ALIVE ITF conducted an in-depth evaluation of the corridor to determine the desired wildlife crossing locations. Spreadsheets evaluating length, width, and type of crossing for each alternative helped define and assign appropriate costs. Target species analyzed included lynx, elk, deer, moose, bear, boreal toad, aquatic species, bighorn mountain goat, mountain lion, fox, and Preble's jumping mouse. Preliminary locations and costs were developed for new or increased size of structures, in addition to fencing, escape ramps, signage, and monitoring cameras. Prioritization of locations and potential crossing type did not occur during the Level 1 analysis.

The project team also considered historic sites, wetlands, and sensitive resources in the corridor. Examples of potential sites to avoid include the following:

- Athletic fields
- Bench Trail
- Clear Creek
- Clear Creek Greenway
- Easter Seals Camp
- Exposed geologic deposits
- Fen locations
- Georgetown-Silver Plume National Historic Landmark
- Georgetown Hill Overlook
- Georgetown Loop Railroad
- Mine shafts/tunnels
- Mining roads
- Private residences
- Tailing pile runoff
- Water Wheel Park
- Eligible and/or potentially eligible resources listed on the National Register of Historic Places

Designated cultural resources, including the Georgetown-Silver Plume National Historic Landmark Districts and potentially eligible historic resources will be considered in greater detail if any of the alternatives are forwarded for additional evaluation in Level 2 or Tier 2 studies. All future efforts will comply with the Section 106 Programmatic Agreement for the I-70 Mountain Corridor.

To understand costs for sediment control, estimates for each design included native seeding, soil conditioning, and mulch. At this conceptual level, the preliminary quantities of construction items developed are based on the area of disturbance developed for each alternative by the roadway designers.

4.3.4 Intelligent Transportation Systems and Tolling

Similar to other disciplines, the intelligent transportation systems and tolling ITF's developed a spreadsheet with preliminary quantities at conceptual level based on the length, width, and complexity of the alternative. A detailed layout was not required at this stage.

4.3.5 Structures

The preliminary design of bridges involved a matrix for each alternative identifying proposed bridge layouts based on existing locations. Working closely with roadway designers, additional bridges deemed necessary in the 3-D alignment modeling process were also included in the estimate. These bridges are primarily in the wider roadway sections of Alternatives 1, 2, and 4. Viaduct bridges were quantified separately due to higher anticipated complexity.

4.3.6 Transit

Options for transit were evaluated by the Transit ITF at a conceptual level in order to determine probable costs for a BRT system. All AGS-related design was covered in CDOT's Advanced Guideway System Feasibility Study, February 2014.

4.3.7 Utilities

After gathering data from utility companies in the corridor, a preliminary memorandum with major utility information was presented to the Project Team. An impact analysis was performed to associate proposed improvements with the approximate location of major utilities. Information is based on schematic maps provided during initial outreach; no field data has been collected for this study.

4.4 Summary

Thirteen alternative options were fully developed to a conceptual level design to understand the major impacts and provide approximate quantities for cost estimating and comparison purposes. The designs are not refined or optimized at this stage, which is consistent with the effort expected for a Level 1 study. There are many opportunities to continue design refinement and better avoid, minimize or mitigate impacts throughout the corridor.

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5 COST ESTIMATING

5.1 Background

The I-70 T&R Project Team completed conceptual designs and Level 1 cost estimates for all alternative options developed by the Project Leadership Team. Appendix C presents the Level 1 Cost Estimate Report, which summarizes the costs for those alternatives. Appendix C also includes detailed, itemized cost breakdowns of all options.

5.2 Cost Estimating Methodology

The Project Team carried all alternative options developed by the PLT to a conceptual design level. Preliminary estimating included known and quantifiable costs, known but not quantifiable costs, and unknown costs. At this level of study, the ultimate cost of project alternative options cannot be predicted with 100 percent certainty because a number of variables can affect plans and estimates. These variables are as follows:

- Technical issues (design unknowns such as uncertainty over foundation conditions)
- Regulatory, political, and policy issues (e.g., changes in regulations and CDOT/FHWA policy during the design process)
- Stakeholder concerns (e.g., roadway width, roadside treatments, and access to communities)
- Limited design information (at this time designs are at a level of 5 percent or less)
- Year of construction
- State of economy

To assess these circumstances, the Project Team used the Transportation Risk and Uncertainty Estimating cost estimating process. The TRUE process provides a method for quantifying uncertainties, risks, and opportunities in costs through a systematic analysis.

The first step of the process is to generate base costs through the engineering estimating application of 2014 unit prices and quantity takeoffs. Unit costs and quantities do not include any contingencies to cover risks, opportunities, or uncertainties.

The next step is to review the base costs in a cost/risk workshop. In the cost/risk workshop, a team of subject matter experts assesses each item, assigning cost ranges and probabilities. This information is input into a predicative analysis tool that uses a Monte Carlo Simulation. A Monte Carlo Simulation is a computerized mathematical technique that relies on repeated calculations of tens of thousands of scenarios to obtain possible cost outcomes.

The scenarios are plotted on a cost distribution curve. This curve develops the possible range of costs based on the risks and opportunities assigned to the base cost items. Figure 5-1 shows an example curve. Cost distribution curves have been generated for each alternative & option, as well as each capital cost line item. For each alternative & option, the cost ranges are reported in Appendix C.

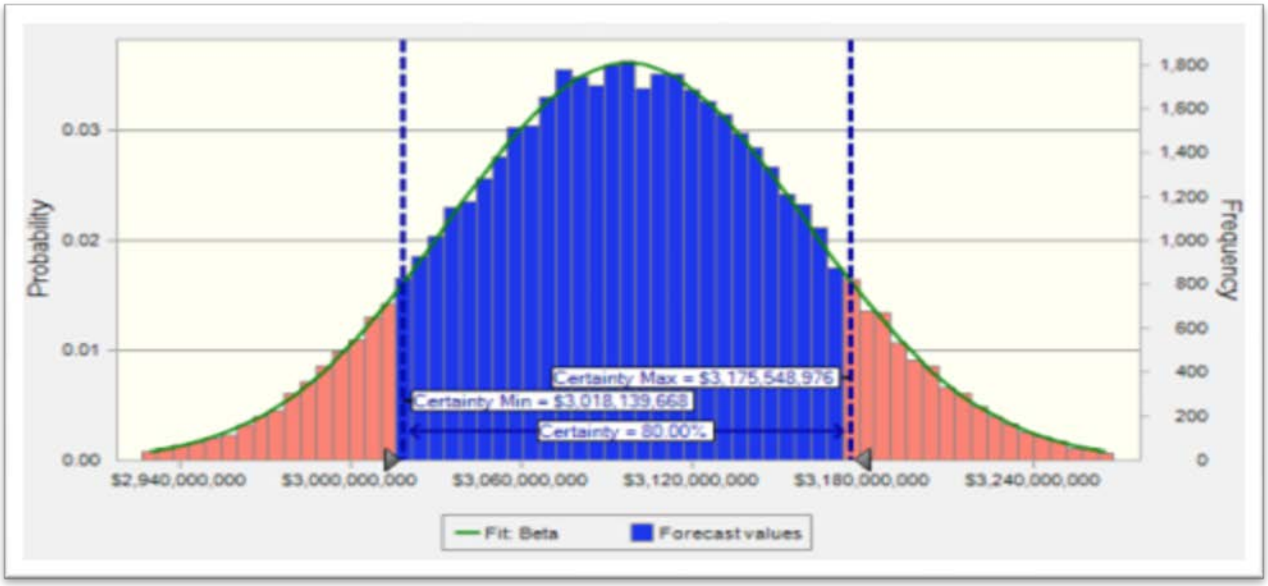

Figure 5-1: Cost Distribution Curve (Example)

For the Level 1 preliminary cost estimates, CDOT chose to apply an 80 percent confidence level for the estimates, which means that the Project Team is 80 percent confident that the reported range of costs for each alternative will be attained and 20 percent confident that the total cost for each alternative will fall outside that range.

All cost elements were taken through this cost/risk analysis <u>except</u> for the following:

- Advanced guideway system capital and operating and maintenance costs (applied directly from the 2014 AGS study).
- Roadway, structures, tunnels, and bus rapid transit operating and maintenance costs (directly from individual O&M cost worksheets)
- Design and construction engineering costs (calculated as percentages of the capital cost range)
- CSS factors provided by CDOT (applied directly to capital cost [15 percent] and design costs [19 percent]).

This report includes the summary of cost ranges based on the cost/risk workshop and the original base cost estimates for each alternative. All costs are in 2014 dollars.

5.3 Development of Quantities and Unit Pricing Assumptions

The first step of the process was to generate base costs through the application of 2014 unit prices and quantity takeoffs. Both capital and O&M costs are included in the estimate breakdown. Construction features are broken down by line items for the following components:

- Roadway and structures
- Tunnels
- Transit
- Design and Construction Engineering

Unit costs and quantities purposely do not include any contingencies to cover risks, opportunities, or uncertainties. These costs were covered in a CSS factor described in Section 5.4 below. The structure of the unit pricing was derived from the estimates performed for the I-70 Mountain Corridor PEIS. The unit pricing structure was modified to provide a more detailed breakdown of items, particularly bridge and tunnel structures. Certain items were accounted for as allowances of totals of unit construction costs. Percentage contingencies were used for those items and were consistent across the range of alternatives and options. The breakdown of items is included in each feature below.

For unit prices, CDOT cost data was used where applicable. If CDOT cost data was not applicable, unit prices were derived from the cost/risk workshop described in Section 5.5.

Quantities were developed based on the conceptual designs. All alternative options were designed to no more than a 5 percent design level, from which quantities were developed. A limited amount of structure delineation was performed to generally establish structure locations and dimensions from which structure quantities were developed.

5.4 CSS Factor

All projects in the I-70 Mountain Corridor are developed through the I-70 CSS process described in Section 3 of this report. This collaborative process requires continuous stakeholder participation and consideration of corridor specific aesthetic guidance and design criteria. To better account for costs typically associated with these types of specific design criteria, the Project Team first eliminated all of these costs from the unit price estimates. These unit price costs included architectural finishes, coloring, and rock sculpting, among others.

CDOT then conducted a process to determine multiplicative factors, named the “CSS factors” to be applied back to the total project cost to account for the unique characteristics of this corridor. Based on a sample of recent major I-70 highway improvements projects, CDOT estimated the factors to be 19 percent for design and 15 percent for construction. These factors were then applied to the total cost estimates for both design and construction. To avoid duplication of costs, the dollar amounts calculated were included as allowances in the cost estimates, as written in Section 5.6.1.

5.5 Cost and Risk Workshop

All alternatives and options developed in conjunction with the TT were carried to a conceptual design level (less than 5 percent). Preliminary estimating included known and quantifiable costs, known but not quantifiable costs, and unknown costs.

To assess these circumstances, an important element of the TRUE process is a cost/risk workshop.

The 4-day cost/risk workshop was held during the week of February 10, 2014. In the workshop, a team of subject matter experts (Parsons and subconsultants, CDOT, and FHWA; see Appendix C for attendees) assessed each item's base cost, assigning both minimum and maximum costs and probabilities for achieving the minimum, base, and maximum cost. In some cases, specific unit item prices were discussed and developed if CDOT unit pricing was not applicable. This information was input into a statistical model. This model was developed using software called Crystal Ball ™. This software is a predicative analysis tool that uses a Monte Carlo simulation, as described in Section 5.2. The full report on the cost/risk analysis of preliminary costs is included in Appendix C-2

5.6 Cost Estimate Summary and Breakdown

The cost scenarios for each alternative option are plotted on a cost distribution curve. This curve develops the possible range of costs based on the risks and opportunities assigned to the base cost items. Cost distribution curves have been generated for each alternative option, as well as for each capital cost line item. For the Level 1 cost estimates, CDOT chose an 80 percent confidence level for the estimates, i.e., 80 percent confidence that the reported range of costs for each alternative will be attained and 20 percent confidence that the total cost for each alternative will fall outside that range.

For each alternative option, the cost ranges are reported in the summary spreadsheets included in Appendix C-1. Summary details of estimating specific system elements are described in the following sections. The cost estimate breakdowns are described in detail in Appendix C.

5.6.1 Roadway

Designs for Alternatives 3 through 6 were originated based on data from the 2011 PEIS or other studies. Designs for Alternatives 1 and 2 were based on work conducted by Parsons during the development of their unsolicited proposal. Roadway designs, although conceptual, were all based on criteria meeting full American Association of State Highway and Transportation Officials and CDOT standards. It should be noted that this results in very conservative designs, consistent with a Level 1 study. Allowances were made for the known but unquantifiable items, including the above described CSS factor of 15 percent, and were added to the base costs for known and quantifiable items. Most final designs in a challenging mountain corridor environment result in design variances to both better address the context of the surroundings and to allow for better value while still maintaining safe roadway design features.

The 3-D alignment configuration models for each alternative were created in Microstation. These alignment models were used for the development of roadway quantities and were also provided to the CDOT Project Manager for use in the traffic and revenue model.

The breakdown of roadway and roadway structures costs is shown in Table 5-1. Detailed roadway backup costs are included in Appendix C-3. ITS elements and ROW Approximations are included in Appendix C-7 and C12 respectively.

5.6.2 Maintenance of Traffic

Maintenance of traffic costs are included in the line item “Traffic Control” (Construction). The logic used to estimate the MOT costs for each alternative and option of the Level 1 study for the I-70 Mountain Corridor is based on cost percentages. Detailed MOT concepts have not been developed for any of the alternative options at Level 1; therefore, MOT costs are being expressed as an assumed percentage of the total construction cost for each alternative option. These percentages are applied only to the total estimated construction costs, with a few exceptions as noted in the appropriate summaries. MOT preliminary cost detail is included in Appendix C-8

For each alternative and option, the following items are used as the basis for the MOT cost estimate and are listed accordingly:

- Primary construction operations
- An assumed general MOT concept(s)
- Construction items that will skew the MOT costs up or down and affect the percentages

In general, for all concepts with significant offline expensive work which have limited impacts to traffic and thus require less MOT (e.g., retaining walls in widened sections or new viaducts), the percentage of the construction cost will be much less than those concepts with significant MOT operations. In addition, for those options that are improving the design speed to 65 mph, the roadway must be realigned at many locations, which will require more offline work and will have a lower percentage of the construction cost for MOT.

For all alternative options, it is assumed that the east and westbound Twin Tunnels have been widened, but no other westbound roadway improvements are complete prior to this project.

Table 5-1: Roadway and Roadway Structure Cost Breakdown

Roadway and Structures	Unit
Structures – Basic	SF
Special Structures – Complex	SF
Special Structures – Fly-over	SF
Special Structures – Viaduct	SF
Interchanges	EA
Wildlife Crossings	LS
Walls – Cut	SF
Walls – Fill	SF
Excavation – Rock Cut	CY
Embankment	CY
Pavement Resurfacing	Ton
Pavement – Full Depth	Ton
Base Course	CY
Barrier – Type 7	LF
Barrier – Retaining	LF
Guardrail – Type 3	LF
ITS	LS
Transportation and Operation Center	LS
Tolling, Gates, and Controls	LS
Maintenance Equipment (Special)	LS
Roadway and Structures Allowances	**% Range or Units**
Contingency (Unallocated Items)	1 – 10
Environmental Mitigation and Basic Landscaping	LS
Utilities	LS
Drainage and Water Quality (Permanent)	LS
Water Quality (Construction)	LS
Signing and Striping (General)	1 – 5
Traffic Control (Construction)	5 – 25
Mobilization and Staging	4 – 10
Right-of-Way	LS
CSS Contingency	15
CY = cubic yard; EA = each; LF = linear foot; LS = lump sum; SF=sq. foot	

5.6.3 Roadway Structures (Bridges and Walls)

Bridge structures were generally located during the structure delineation process. Each structure was placed into one of the following categories: basic structures, special structures (three types), interchanges, and wildlife crossings. Conceptual designs for bridge length and deck width were developed to calculate deck square footage.

Bridge and wall costs were a major discussion item during the cost /risk workshop. Historic data from complex CDOT projects in mountainous terrain was dated, and therefore not applicable. To respond to this challenge, the bridge and wall pricing includes additional documentation on the derivation of unit prices as described in the following paragraphs.

Unit bridge costs were derived from their cost data information about historic costs for comparable bridge construction. Cost data books for highway construction are maintained by CDOT for projects that are completed on state facilities. The most comparable type of bridge construction (in mountain regions, for interstate highway use, heavily influenced by CSS design, etc.) in relatively recent history has been bridge construction for the I-70 corridor within or near Glenwood Canyon. The construction period for that work was from about 1980 to 1993, with most of the bridge construction performed between 1980 and 1990.

Bridge costs per square foot (of deck area) as found in the CDOT cost data books for the period of 1980 through 1990 were tabulated and compared. The identifiers for bridges in the Cost Data books include project number, unique bridge ID, terrain type at bridge location, bridge length, bridge width, total square footage, total cost, and cost per square foot. Cost data for the bridges are also separated by bridge superstructure types, such as concrete slab bridge, prestressed girder, and steel box girder.

To increase confidence in a prediction of possible bridge prices for construction in the I-70 improvements, the tabulation of bridges from CDOT data was limited to bridges in mountain terrain, which is considered to be the prevailing terrain type that will be encountered in reconstruction efforts for the proposed I-70 projects. Costs for bridges in this terrain type likely include premiums for remote (non-urban) construction, material delivery, climate challenges, and possible site restrictions. No particular superstructure types were singled out for cost comparisons, except that highway bridges described as “concrete rigid frame” types were excluded from the comparison because they are typically short, single-span, geometrically restrictive structures that may not fit the context of the corridor. Also, bridges described as pedestrian facilities (non-highway) and non-CDOT bridges (bridges without structure numbers) were not included in the tabulation. As the information from the cost data books was tabulated, the bridge descriptions were validated in CDOT’s Online Transportation Information System website by entering the structure number, reviewing the data, and viewing the photographs of the bridges.

As expected, the total and individual square footage and the superstructure types of bridges that were constructed in any reporting year varies widely, so that average costs for any given year are not especially reliable as a predictor of future costs. In some years between 1980 and 1990, very few bridges were built in mountain terrain, which skews the annual average or median values for square footage costs. Also, average or median costs are often disproportionately skewed toward costs for bridges with small areas. To compensate, a weighted average square foot cost was used, in which the total cost for the studied bridges in a certain year was divided by the total square footage of the studied bridges. Still, the weighted average varied significantly over the decade, and an upward trend was obvious; that is, the average weighted cost per square foot for bridges in mountain terrain could be seen to increase by about $5 per square foot on average over the period from 1980 to 1990. Extrapolating that increase rate to 2014 is not valid because it does not account for changes in design directions and philosophies, advances in construction materials and methods, advancements in efficiencies of bridge construction, or the state of the economy.

Retaining wall costs were based on CDOT cost data, with adjustments made for more complex uphill (walls above the roadway) walls. Retaining walls were generally located during the structure delineation process. Each structure was determined to be either a cut wall or fill wall. Conceptual designs for wall length and width were developed to calculate the square footage of wall face amounts.

Allowances were made for the known but unquantifiable items, including the CSS factor of 15 percent, and were added to the base costs for known and quantifiable items.

Detailed structure backup costs are included in Appendix C-4.

5.6.4 Tunnels

Two major tunnels are included in the alternatives, including a third bore at EJMT, and a third bore at the Twin Tunnels. Some alternatives included short tunnels in the Hidden Valley area to minimize the footprint of the facility.

No field work was performed for this tunnel cost evaluation. Rather, the existing geologic information, published reports, and project records from construction of the existing EJMT and Twin Tunnels were used to extrapolate reported ground conditions to the proposed tunnel bores. Using this available information, recommendations were made for ground support measures and tunnel final lining for the proposed construction. The study did not include an evaluation of groundwater conditions or hydrogeologic setting, geologic hazards, environmental conditions, or other engineering or geologic considerations.

Preliminary unit costs for construction were developed using unit bid prices from tunneling projects of similar size and tunnel construction methods (I-70 Twin Tunnels Widening Project [CDOT, 2013]; Devil's Slide Tunnels [Caltrans, 2006]; Caldecott Tunnel 4th Bore [Caltrans, 2009]; and Beacon Hill Transit Station [Sound Transit, 2004]). Tunnel system costs were estimated through parametric comparisons of systems costs from those projects. The unit costs are considered order-of-magnitude numbers suitable for preliminary planning purposes; they are not suitable for a detailed construction estimate.

Allowances were made for the known but unquantifiable items, including the CSS factor of 15 percent, and were added to the base costs for known and quantifiable items.

Table 5-2 shows the item cost breakdown for tunnels. Additional assumptions and details related to the basis for cost development are included in Appendix C-5.

Table 5-2: Tunnel Cost Breakdown

Tunnel Components	Unit
Twin Tunnels – New Bore	LF
Twin Tunnels – Cross Passages	LS
Twin Tunnels – New Bore Systems	LS
Hidden Valley Tunnels (1) (EB and WB)	LF
Hidden Valley Tunnels (1) Cross Passages	LS
Hidden Valley Tunnels (1) Systems	LS
Hidden Valley Tunnel (2) (WB)	LF
Hidden Valley Tunnel (2) Cross Passage	LS
Hidden Valley Tunnel (2) Systems	LS
EJMT North Bore	LF
EJMT Cross Passages	LS
EJMT Systems	LS
Tunnel Allowances	**% Range or Unit**
Contingency (Unallocated Items)	1 – 10
Environmental Mitigation and Basic Landscaping	LS
Utilities	LS
Drainage and Water Quality (Permanent)	LS
Water Quality (Construction)	LS
Signing and Striping (General)	1 – 2
Traffic Control (Construction)	1 – 2
Mobilization and Staging	5 – 15
Right-of-Way	LS
CSS Contingency	15

5.6.5 Transit

The alternative options included one of three transit components. The most basic transit component is a single daily CDOT bus operating in mixed traffic between Denver and Glenwood Springs. That cost is not included in the capital costs of the alternatives because it is considered to be an existing/committed cost. The second option is an AGS. All AGS costs originated from CDOT's AGS Feasibility Study. The third transit component that was included as part of the managed lanes alternatives is a BRT system. The BRT system for these alternatives would run in the managed lanes within mixed traffic, and the roadway cost component is included in roadway estimates. The buses would not have their own lane. The capital costs of stations and vehicles were also estimated. Allowances were made for the known but unquantifiable items, including the CSS factor of 15 percent, and were added to the base costs for known and quantifiable items. Table 5-3 shows the cost breakdown for transit with detailed backup of costs included in Appendix C-6.

Table 5-3: Transit Component Cost Breakdown

Transit Components	Unit
Vehicles	EA
Infrastructure	LS
Stations – Basic	EA
Stations – Major	EA
Maintenance Barn	EA
Transit Allowances	**% Range or Unit**
Contingency (Unallocated Items)	1 – 10
Environmental Mitigation and Basic Landscaping	LS
Utilities	LS
Drainage and Water Quality (Permanent)	LS
Water Quality (Construction)	LS
Signing and Striping (General)	1 – 5
Traffic Control (Construction)	5 – 25
Mobilization and Staging	4 – 10
Right-of-Way	LS
CSS Contingency	15

CEA = each; LF = linear foot; LS = lump sum

5.6.6 Utilities

Privately owned utilities (electric and gas transmission lines and communication trunk lines) located in an easement or fee property and utilities owned by CDOT and local jurisdictions would be relocated at project cost and would be referred to as "major utilities" for this project. To identify owners of major utilities in the project area, the Project Team conducted a search of the Utility Notification Center of Colorado database. Utility owners were contacted to confirm the presence or absence of facilities in the project area and to obtain key maps and contact information. After reviewing the key maps and verbal information from utility owners, major utilities were identified and added to a working base CADD map containing preliminary design details for each alternative option. Private utility owners were asked if their facilities were located in an easement. Although it was not apparent from key maps and follow-up conversations with Xcel, it was assumed that overhead electric transmission lines and towers were located in an easement or fee property, as this is usually the case. The Project Team performed an impact analysis by comparing the approximate location of major utilities with the proposed improvements associated with each alternative. Assumptions that were made regarding relocations and adjustments are presented in Appendix C-9.

5.6.7 Design and Construction Engineering

Cost items related to environmental clearances (National Environmental Policy Act), as well as design and construction engineering are included in this section. Backup costs for wildlife crossings are included in Appendix C-11. Depending on the construction element chosen, preliminary and final design costs ranged from 8 to 12 percent. Values for construction engineering of the above elements ranged from 4 to 8 percent. The CSS design contingency value of 19 percent is accounted for under this section. Table 5-4 shows the detailed breakdown of design and construction engineering items and values.

Table 5-4: Design and Construction Engineering Cost Breakdown

Design and Construction Engineering	% Range or Unit
National Environmental Policy Act	LS
Roadway and Structures Preliminary & Final Design	8 – 12
Tunnels Preliminary & Final Design	8 – 12
Transit Preliminary & Final Design	8 – 12
CSS Design Contingency	19
Roadway and Structures Construction Engineering	6 – 10
Tunnels Construction Engineering	6 – 10
Transit Construction Engineering	6 – 10

5.6.8 Operations and Maintenance

Preliminary operations and maintenance estimates were prepared using work breakdowns consistent with CDOT’s historical maintenance line items. Units, such as lane miles, were calculated from the conceptual designs developed for each alternative option. Other activities were calculated based on a lump sum amount. These costs are reported as totals per year. Table 5-5 shows the cost breakdown for O&M and detailed backup of costs included in Appendix C-3.

Table 5-5: O&M Cost Breakdown

Roadway and Structures O&M Costs	Unit
Snow Removal	LM
Routine Maintenance	LM
Pavement Rehabilitation	LM
ITS Operations	LS
Tolling Operations	LS
Long-Term Capital Replacement	LS
Tunnel O&M Costs	**Unit**
Routine Maintenance	LM
Pavement Rehabilitation	LM
Tunnel Systems	LS
Long-Term Capital Replacement	LS
Transit O&M Costs	**Unit**
Vehicle Operations	LS
Vehicle Maintenance	LS
Infrastructure Maintenance	LS
Long-Term Capital Replacement	LS
General and Administrative	LS

5.7 Schedule

A preliminary schedule was developed for each option of each alternative to provide an estimate of the construction start, construction duration, and anticipated first year of operation. The construction start considers the environmental (National Environmental Policy Act) process, the public process, and the procurement of documents ready for construction. Durations for the options varied based on the complexity of design and the relative controversy of the option, with the more controversial options needing more time to complete necessary processes. Construction durations were based on past experience with similar projects and the special considerations for the I-70 mountain corridor. Adding the construction duration to the anticipated construction start provides an estimate of the first year of operation. Schedule information for each alternative option is provided on the alternatives' schematics. The schedule information provided is preliminary in nature and subject to the actual durations of the environmental / public processes durations and funding levels.

5.8 Summary and Results

The cost estimating methodology used for the Level 1 Study is consistent with industry-accepted approaches for the development of costs at the early conceptual stage of design. Special attention was given to high cost project components such as the third bore of EJMT and other complex structures.

The use of the Transportation Risk and Uncertainty Estimating cost estimating process, including a facilitated cost/risk workshop, takes the estimating one step beyond what might ordinarily be done on a Sketch Level T&R Study.

The costs and contingencies reported here are conservative but appropriate for an early corridor planning effort. With continued project development and design refinement, coupled with a strong value engineering process, there are opportunities for significant cost reduction.

A summary of costs for each alternative and option is shown in Figure 5-2. Each alternative/option shown includes the minimum and maximum cost as determined in the cost/risk analysis. In Figure 5.2, "CE" refers to Construction Engineering.

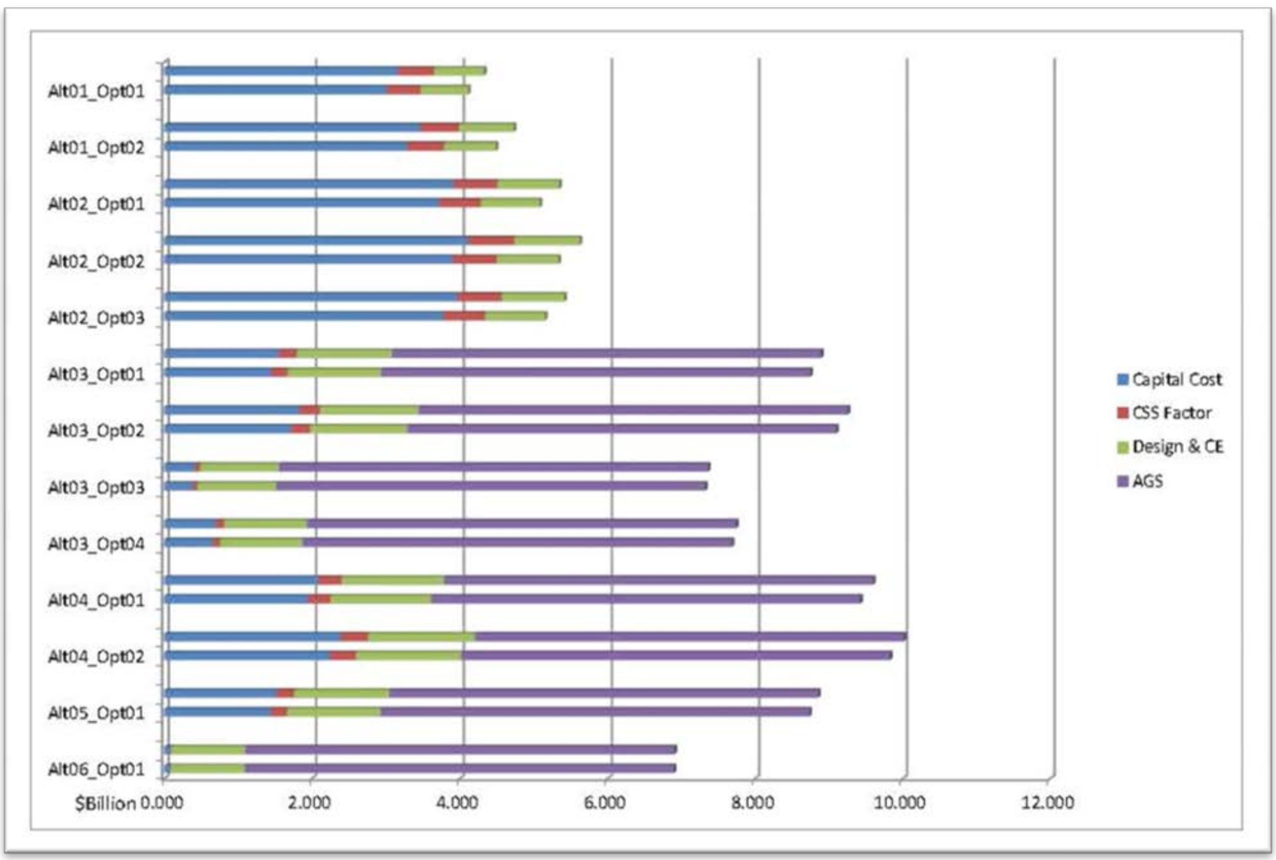

Figure 5-2: Cost Estimates Summary

The financial evaluation and revenue estimates that were compared to these costs are included in a separate report delivered to CDOT. This report is entitled: “Sketch level Mountain Corridor Traffic and Revenue Study,” by Louis Berger Group, dated August 8, 2014. Details of this Study are described in Chapter 6.

6 Modeling Details, Recommendations, and Next Steps

6.1 Introduction

This section of the report describes modeling details, recommendations, and next steps. Much of this section is taken from the “Sketch level Mountain Corridor Traffic and Revenue Study,” (referred to as the “Modeling Study”) by Louis Berger Group, dated August 8, 2014.

6.2 Modeling Details

The purpose of the Modeling Study is to evaluate a series of revenue-collecting capacity enhancement alternatives proposed for the Corridor in order to identify a financially, environmentally, and socially responsible solution to the I-70 Corridor’s current and future traffic congestion. The results from this Modeling Study allow CDOT to make an informed decision on which alternatives provide the greatest benefits in terms of safety, mobility, and environmental protection, among others, and the extent to which each alternative can pay for themselves largely through toll user fees.

This Modeling Study was conducted at a sketch level, commonly referred to as a “Level 1” analysis. As a result, this Modeling Study did not include the development of a new travel demand model and did not involve primary data collection efforts. Instead, the basis of the modeling process was the existing regional model developed in 2003 for the 2011 I-70 Mountain Corridor Programmatic Environmental

The modeling effort evaluated the PEIS model, performed updates on the model and validated its calibration. The Modeling Team carried out a series of updates on the PEIS model, followed by a verification of runs against actual counts to ensure that the model was properly calibrated. The most significant modifications included updating the demographics data to 2010 from 2000; modifying the traffic assignment capability of the model to support tolling assignments; and differentiating truck vehicle classes from standard automobiles.

For modeling and forecasting assumptions, the Modeling Study relied primarily on data from the most recent studies on the corridor; traditional data sources such as the U.S. Census and the State Demographer; or inputs from the Issue Task Force multi-stakeholder groups. In order to maintain consistency in comparison of results with the PEIS, this study directly adopted a series of assumptions from that work. The assumptions related to trip descriptors, market segments, model run parameters, traffic growth, operations, and financial assumptions. The model and the assumptions were used to develop the 2025 forecast runs.

The set of alternatives evaluated provide different levels of additional capacity for the corridor and involve different transit options - CDOT bus; Bus Rapid Transit running in mixed traffic on the managed lanes; or the Advanced Guideway System. The Modeling Team developed a detailed link-level tool in order to conduct the 50-year projections to 2075 using the 2025 modeled forecast as a base. The Corridor was organized into 19 key segments. Each segment had a representation of volumes, capacity, and speed on toll lanes and corresponding free lanes by time of day, day of week, and season, as reflected in the PEIS model. The tool provides a forecast of managed lanes usage and pricing based on congestion and value of travel time savings. The tool calculates annual revenue and traffic performance measures depending on the volume outputs and pricing at each time period, day, and season.

The specific items of the forecast development follow. Per mile dynamic tolling is based on volume to capacity ratio which determines levels of congestion along the corridor and varies the price of the tolls as needed in order to maintain a certain average speed. The model also includes fixed tunnel tolls at two locations, which vary depending on the alternative.

6.3 Traffic and Revenue Results

The Modeling Study provides traffic and revenue forecasts to 2075 for six alternatives, one sensitivity analysis, and the base condition forecasting the corridor's traffic and capacity constraints if no action is taken (e.g. no build condition).

Overall, the reversible managed lanes options (Alternatives 1 and 2) and the PEIS Maximum Program (Alternative 4) add significant capacity and present high revenue capture. The PEIS Minimum Program option (Alternative 3) provides the lowest improvements in capacity and the lowest revenue capture. The Peak Period Should Lane alternatives (Alternatives 5 and 6) provide some capacity improvement, yet have significant revenue generation. Alternative 5.1, the sensitivity analysis, has a lower revenue generation potential than Alternative 5 given that capacity improvements cover only half the distance. The base condition, which includes the Eastbound PPSL, has some revenue generation.

The inputs to the discounted cash flow analysis included the revenue forecasts for each of the alternatives and their corresponding capital and operations and maintenance costs. The cost estimates are described in Section 5 of this report. BRT farebox revenue for Alternatives 1 and 2 is included in the analysis since it contributes to the 50 year concession arrangement. Alternatives 3-6 and the sensitivity analysis 5.1 which include the AGS component do not consider AGS revenues or costs since its operations are separate from the highway capacity improvements.

Table 6-1 below illustrates which alternatives capture enough toll revenue to pay for capital and O&M costs and/or O&M costs only based on the DCF analysis. In summary, although alternatives 1 and 2 show the greatest improvements in capacity, the revenues captured are not able to cover capital and O&M expenses. Alternative 4 provides minimal improvements in time savings and therefore minimal revenue. Alternatives 4 and 5 provide considerable improvements in capacity and significant revenues. Both can cover O&M but neither can cover capital expenses. Sensitivity analysis Alternative 5.1 and Alternative 6 provide limited improvements in capacity but generate an important amount of revenues; both cover all costs.

Table 6-1: Ability to Pay for Capital and O&M Costs through Toll Revenue

Alternative	Revenue	Capital + O&M	O&M
1	$1575.38	✗	✓
2	$1517.97	✗	✓
3	$50.98	✗	✗
4	$486.60	✗	✓
5	$440.49	✗	✓
5.1 sensitivity	$256.65	✓	✓
6	$222.57	✓	✓

6.4 Next Steps

After the Level 1 modeling and cost estimating was completed, the Technical Team evaluated the results of those analyses. Based on that evaluation, CDOT reached the following conclusions.

Except for the Temporary Peak Period Shoulder Lane (Alternative 6), none of the alternatives and options considered include toll revenues to cover roadway capital costs. At this time, CDOT recommends advancing only the Temporary PPSL and doing so without a Level 2 T&R Study. If trends or events having unexpected effects on travel needs, behaviors, and patterns substantially alter the current assumptions, CDOT may reconsider or refine these alternatives. Preliminary design, cost estimates, modeling data, evaluation criteria, and performance measures produced as part of Level 1 will provide updated documentation for upcoming I-70 initiatives.

The Level 1 Study covers multiple options at a high level without developing details that would be needed in a Level 2 analysis. For example, traffic growth rates in the corridor are variable when considering recent, short-term growth and when compared to long-term growth over 25 years. Factors such as recent economic conditions and pent-up demand are affecting the recent growth trends. Weather, grades, and road curvature, and traffic incidents (among others) have a strong impact on congestion and are not fully captured in the PEIS model. In addition, the Level 1 Study used existing data from other recent projects. The lack of detailed data limits the model's ability to include the most up to date or variable assumptions on value of time, vehicle occupancy rates, trip purposes, and other critical measures. The standard activities developed in a Level 2 study, including the implementation of a microsimulation tool and the development of a stated preference survey, would address most of the issues listed above and would provide a more accurate evaluation of traffic and revenue for the proposed alternatives. These items will have potentially significant impacts on highway operations and revenue generation forecasts.

CDOT will continue its current plan to incrementally implement the Minimum Program of the I-70 Mountain Corridor PEIS using traditional public funding sources and without assistance from a private concessionaire. In addition, the following actions should be taken:

- CDOT should monitor growth rates, both of traffic and of the economy (population and employment for the Front Range and Mountain Corridor together) as indicators and direction for further consideration of T&R work in the I-70 Corridor.
- There are opportunities to better define VOT with a deeper level of study. Experience with the Peak Period Shoulder Lane will give valuable insights into actual VOT choices ("revealed preference"), which is the best indicator of how travelers trade off time, money, and congestion specific to the I-70 Corridor. Similarly US 36 Managed lanes will provide an urban corridor comparison. CDOT should consider an evaluation of these two corridors, and traveler choices in each, a year or two after opening.
- Based on the two actions above, CDOT should consider whether and/or when further stated preference survey work could be undertaken to broaden the predictive capabilities of the data and traveler choices for the I-70 Mountain Corridor.

7 LESSONS LEARNED

Step 6 of the 6-Step Context Sensitive Solutions Process is to *Finalize the Documentation and Evaluate the Process*. The process evaluation includes developing a discussion of lessons learned throughout the project duration so that future projects in the I-70 Mountain Corridor can use these lessons to be more efficient and streamlined in their processes, communications, and collaborations. Based on the scale and higher level view of this Level 1 study, CDOT thought it would be most appropriate to streamline this process and state what their views of the lessons learned were for the project.

CDOT reviewed each phase of the Level 1 T&R Study; including project development, CSS process, and development of alternatives, cost estimating, and screening. CDOT then developed the following lessons learned in the hope of contributing institutional knowledge to future projects in the corridor. These lessons learned have been grouped into four broad categories for ease of use: Administrative (A), Management (M), Stakeholder Coordination (S), and Technical (T). Lessons learned in each category are listed in the following subsections.

7.1 Administrative

- **A1:** Provide absolute accuracy of stakeholder contact information:
  - Assign an administrator early to maintain contact information.
  - Use a database (such as Microsoft Access) to store contact information.
  - Use electronic sign-in tools at meetings, if feasible.
  - Update contact information regularly.

7.2 Management

- **M1:** Indentify roles and responsibilities of all members of the Project Team through an organizational chart; distribute this information to all stakeholders for clarity.
- **M2:** Develop consistent, timely messaging in advance of stakeholder meetings to ensure that everyone (Project Team and stakeholders) understands these messages. Base the presentation content and pre-meeting outreach calls to stakeholders on this messaging.
- **M3:** Develop a strategy for working an unsolicited proposal alternative into the CSS process. Consider using a third, independent party to lead the project development, management, and evaluation processes. Consider using consultants that developed the unsolicited proposal for technical questions and answers and alternative refinement only.

7.3 Stakeholder Coordination

- **S1:** Provide advanced meeting schedule to stakeholders:
  - Send out “save the date” notices.

  - Use a single administrator to schedule meetings and invite participants.
  - Make pre-meeting outreach calls to stakeholders prior to critical meetings with key messaging/promotion.
  - To promote more meaningful dialog during meetings, provide meeting material to stakeholders in advance of meetings.

- **S2:** To disseminate information to stakeholders, use CDOT's external website rather than SharePoint. Use ProjectWise for data exchange between consultants and CDOT.
- **S3:** During meetings, ensure equal involvement of all stakeholders. Individuals become reluctant to participate when meeting attendance increases to more than 20 people. The use of small group break-out sessions and strong facilitation, even employing an independent facilitator, encourages participation and conversation.
- **S4:** Ensure a balanced and representative Project Leadership Team that is appropriately sized for the nature of the undertaking.
- **S5:** Engage all stakeholders into the Lessons Learned evaluation at the end of each project.

7.4 Technical

- **T1:** Continuously educate stakeholders on technical and financial concepts. Note the similarities between parallel, recent projects (for example the modeling effort for the AGS Feasibility Study and the modeling effort for the Level 1 T&R Study).
- **T2:** Cost estimating is a necessary step for a Level 1 T&R Study. Given the speculative nature of cost estimating, it is important to clearly state all assumptions and caveats.

APPENDIX A CSS DOCUMENTATION

The index of documents in this appendix is shown below. Due to the size of these documents, they are not included in this report.

Please go to http://www.coloradodot.info/projects/i-70mountaincorridor/trafficrevenuestudy and click on the folder "Appendices to Level 1 Report" to view/download these documents.

- Appendix A1: Project Leadership Team Meeting Minutes
- Appendix A2: Technical Team Meeting Minutes
- Appendix A3: Issue Task Force Mission Roles and Responsibilities
- Appendix A4: Issue Task Force Meeting Minutes
- Appendix A5: Core Values, Critical Issues, Critical Success Factors, Level 1 Performance Measures
- Appendix A6: Level 1 Evaluation Criteria

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APPENDIX B ALTERNATIVES

The index of documents in this appendix is shown below. Due to the size of these documents, they are not included in this report.

Please go to http://www.coloradodot.info/projects/i-70mountaincorridor/trafficrevenuestudy and click on the folder "Appendices to Level 1 Report" to view/download these documents.

- Appendix B1: 2014 I-70 Alternatives (Base Condition)
- Appendix B2: I-70 Alternative 1, Option 1
- Appendix B3: I-70 Alternative 2, Option 1
- Appendix B4: I-70 Alternative 3, Option 1
- Appendix B5: I-70 Alternative 4, Option 1
- Appendix B6: I-70 Alternative 5, Option 1
- Appendix B7: I-70 Alternative 6, Option 1

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APPENDIX C COST ESTIMATES

The index of documents in this appendix is shown below. Due to the size of these documents, they are not included in this report.

Please go to http://www.coloradodot.info/projects/i-70mountaincorridor/trafficrevenuestudy and click on the folder "Appendices to Level 1 Report" to view/download these documents.

- Appendix C1: Cost Summaries and Build Ups
- Appendix C2: Cost Risk Analysis
- Appendix C3: Roadway Cost Estimates
- Appendix C4: Structure Cost Estimates
- Appendix C5: Tunnel Cost Estimates
- Appendix C6: Transit Cost Estimates
- Appendix C7: ITS Cost Estimates
- Appendix C8: Traffic Control Estimates
- Appendix C9: Utility Cost Estimates
- Appendix C10: Drainage Cost Estimates
- Appendix C11: Environmental Cost Estimates
- Appendix C12: Right-of-Way Approximations

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APPENDIX D ARCHIVING DETAILS

The index of documents in this appendix is shown below. Due to the size of these documents, they are not included in this report.

Please go to http://www.coloradodot.info/projects/i-70mountaincorridor/trafficrevenuestudy and click on the folder "Appendices to Level 1 Report" to view/download these documents.

- Appendix D1: I-70 File Naming Convention

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APPENDIX E DIGITAL DESIGN DATA

The documents in this appendix are not included in this report.

As of October 15, 2014, all digital design data will be provided to the CDOT project manager, Benjamin Acimovic, on a portable hard drive.

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APPENDIX F AGENCY COMMENTS

The index of documents in this appendix is shown below. Due to the size of these documents, they are not included in this report.

Please go to http://www.coloradodot.info/projects/i-70mountaincorridor/trafficrevenuestudy and click on the folder "Appendices to Level 1 Report" to view/download these documents.

- Appendix F1: Clear Creek County Study Letter, August 26, 2014
- Appendix F2: USFS Comment on Level 1 Evaluation, August 21, 2014
- Appendix F3: Clear Creek County Comment Form, September 26, 2014

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