C-470 Express Lanes Feasibility Study
Final Report

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ACRONYMS AND ABBREVIATIONS

A	
AADT	Average Annual Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
ADT	Average Daily Traffic
AVI	Automated Vehicle Identification
C	
CDOT	Colorado Department of Transportation
CDOW	Colorado Division of Wildlife
CIP	Capital Improvement Plan
CTC	Colorado Transportation Commission
CTE	Colorado Tolling Enterprise
D	
DMS	Dynamic Message Sign
DOT	Department of Transportation
DRCOG	Denver Regional Council of Governments
DTC	Denver Tech Center
E	
EA	Environmental Assessment
EIS	Environmental Impact Statement
EL	Express Lane
ELFS	Express Lane Feasibility Study
EPA	U.S. Environmental Protection Agency
ETL	Express Toll Lane
EWG	Executive Working Group
F	
FHWA	Federal Highway Administration
FONSI	Finding of No Significant Impact
FTA	Federal Transit Administration
G	
GPL	General Purpose Lane
H	
HCM	Highway Capacity Manual
HCS	Highway Capacity Software
HOA	Home Owners Association
I	
ITS	Intelligent Transportation System
LOS	Level of Service
M	
MPH	Miles Per Hour
N	
NEPA	National Environmental Policy Act

O

O&M	Operation and Maintenance

P

PMT	Project Management Team

R

ROW	Right-of-Way
RTD	Regional Transportation District
RTP	Regional Transportation Plan

S

SH	State Highway
STIP	Statewide Transportation Improvement Program

T

T&R	Traffic and Revenue
TABOR	Tax Payers Bill Of Rights
TAZ	Traffic Analysis Zone
TEA-21	Transportation Equity Act for the 21st Century
TMC	Traffic Management Center
TWG	Technical Working Group
TxDOT	Texas Department of Transportation

U

USACE	United States Army Corps of Engineers
USBOC	U.S. Census Bureau
USFWS	United States Fish and Wildlife Service

V

V/C	Volume to Capacity Ratio
VE	Value Engineering
VMT	Vehicle Miles Traveled
VPPP	Value Pricing Pilot Program

ES.0 EXECUTIVE SUMMARY

ES.1 BACKGROUND

Population and employment growth in the south Denver Metro area have contributed to increased traffic on C-470, the 26-mile beltway around southwest Denver. As traffic volumes increase, congestion, delay, and unreliable travel times have resulted. To evaluate possible solutions to these problems, the Colorado Department of Transportation (CDOT) was awarded a Value Pricing Pilot Program (VPPP) grant from the Federal Highway Administration (FHWA) to study the potential development of managed lanes as a way to alleviate congestion on the corridor.

This C-470 Express Lanes Feasibility Study (ELFS) evaluated the financial and operational feasibility of adding tolled express lanes to C-470 from I-70 to I-25 to the middle of the free general purpose lanes. The C-470 express lanes would charge a variable toll to control the facility volume to maintain reliable, free-flow traffic conditions. The study sought to determine whether traffic demand and willingness to pay tolls might be sufficient to produce a financially viable solution to relieve the congestion. The results of this analysis were then used to formulate recommendations on the appropriate implementation steps.

The ELFS was conducted in parallel with the C-470 Environmental Assessment (EA), which evaluated potential solutions to congestion and reliability problems on the corridor between South Kipling Parkway and I-25. Both studies used 2025 as the planning horizon year. The purpose of the ELFS was to determine whether a tolled express lane alternative was financially and operationally feasible and whether it should be considered as a potential alternative in the EA. As a new concept to the Denver area, tolled express lanes required more evaluation to characterize the alternative and determine its potential viability as an alternative in the EA. The VPPP grant provided the means with which to perform the preliminary financial feasibility of express lanes on C-470.

ES.2 STUDY PROCESS

After development and calibration of regional travel demand and micro-simulation models, a sequential screening process was performed to eliminate unsatisfactory alternatives and to identify those that were viable.

The first step in the ELFS screening process was to perform a cursory capacity assessment of the entire 26-mile C-470 corridor as an initial indication of demand for express lanes. Those sections that did not show a high potential demand were then subjected to a best-case scenario financial feasibility assessment before being dropped from further consideration. Those sections that indicated a higher potential demand were more rigorously screened to determine their feasibility. The second and third levels of screening evaluated and narrowed down potential access locations. The final step in the process was to identify final access locations and types. After the screening process, the preferred alternative express lane configuration was thoroughly evaluated to optimize T&R and to assess its financial feasibility.

Conceptual design was performed on the preferred alternative, producing horizontal and vertical geometry to be used for the micro-simulation and to develop project cost estimates.

Based on the traffic, revenue, and costs produced, a present value analysis of projected revenue over a 40-year bond retirement period was performed to establish a measure of financial feasibility for the preferred alternative.

The study also investigated potential implementation plans and phasing schemes for the recommended alternative.

ES. 3 SCREENING ANALYSIS

The first level of screening sought to determine which corridor segments would be over capacity in 2025 and therefore would have a demand for express lanes. The segment between Kipling Parkway and I-70 (western segment) showed lower volumes and fewer segments that exceeded capacity; this is because the western segment consists of six lanes from Morrison Road to I-70, and thus can handle the majority of the demand placed on it. The segment between Morrison Road and Bowles Avenue did exhibit demand that exceeded capacity; however, this segment is situated in the center of the corridor and thus presents difficulty in implementing a continuous toll facility. As a result, it was initially determined that the western segment had limited potential for tolling. Upon verifying this initial finding with a cursory revenue analysis, it was determined that the western segment was not feasible in the timeframe of the study's planning horizon, and it was eliminated from further consideration. This conclusion was based on land use and traffic growth assumptions from the adopted 2025 Denver Regional Council of Governments (DRCOG) travel model, and the existing laneage. This approach is a conservative assessment of the financial viability of the western segment; other assumptions, if adequately verified, such as increasing the traffic growth rate or hypothetically changing the existing capacity, could improve the viability of implementing tolls in this segment.

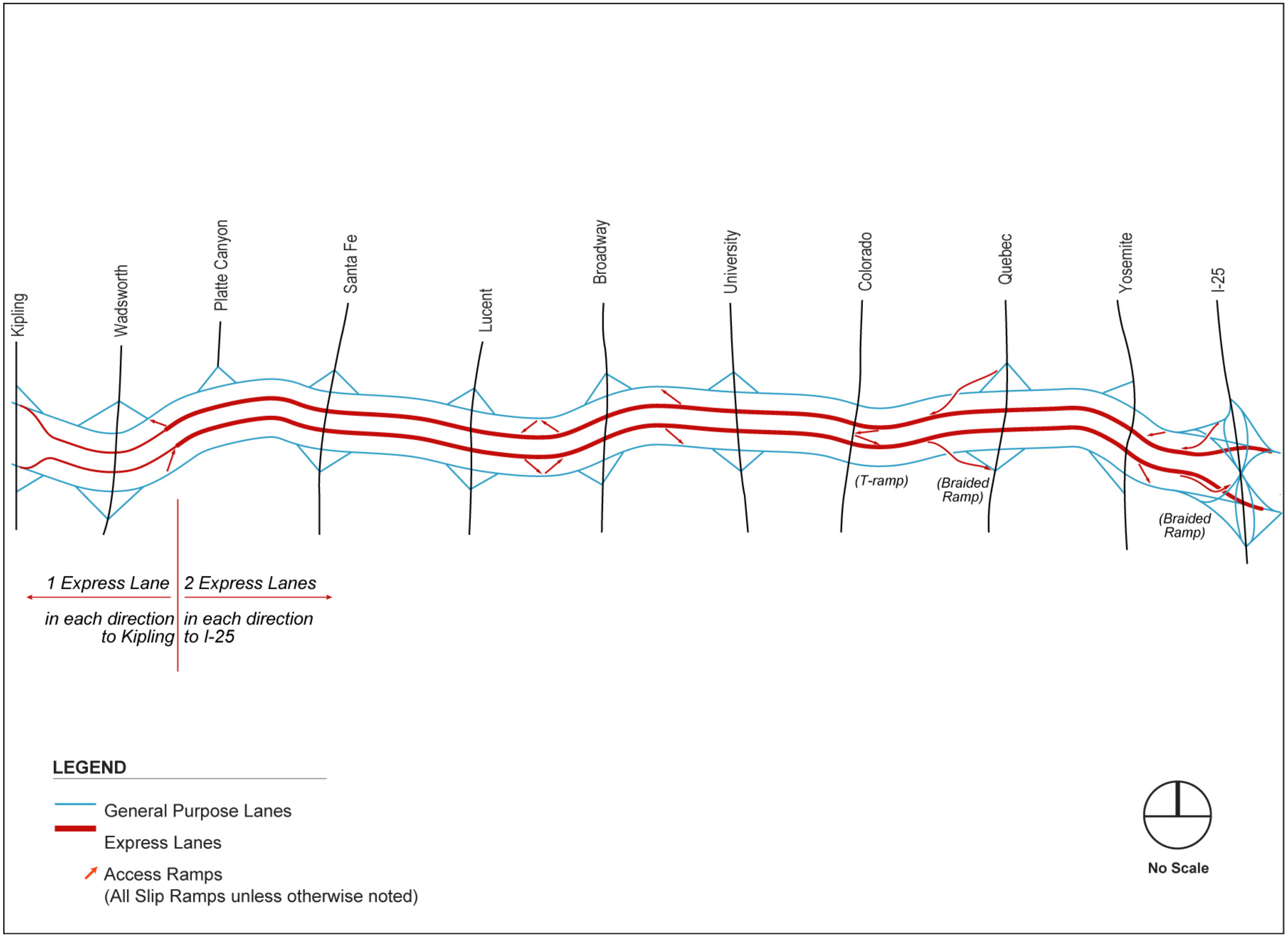
The segment between Kipling Parkway and I-25 (eastern segment) showed the highest volumes and number of segments over capacity, and thus the most potential for express lane usage. This eastern segment was then advanced through the screening process to define and evaluate its feasibility. The second and third levels of screening sought to determine potential access locations for this eastern segment.

Based on interchange locations that showed the highest projected volumes and therefore the highest demand for express lanes, the potential access locations were narrowed to Wadsworth Boulevard, Santa Fe Drive, the University Boulevard/Broadway/Lucent Boulevard area, Colorado Boulevard, Quebec Street, and Yosemite Street/I-25.

The fourth and final level of screening involved a detailed analysis of access locations, operations, and design considerations. At this level, an accurate determination of express lane use was conducted using the MINUTP and AIMSUN travel demand and micro-simulation models. The analysis determined the final access locations to be Wadsworth Boulevard, Broadway/Lucent Boulevard, Colorado Boulevard to and from the east, Quebec Street to and from the west, and Yosemite Street/I-25.

After the screening process, the final express lane configuration was refined to optimize traffic operations and revenue projections. This refinement sought to produce the alternative with the highest financial feasibility and best overall operations. The final alternative, shown in Figure ES.1, proposes a 12.5-mile, four-lane, barrier-separated express lane facility constructed inside the general purpose lane facility from Kipling Parkway to I-25, with the following access points: western terminus at Kipling Parkway, access at Wadsworth Boulevard, Lucent Boulevard/Broadway, Broadway/University Boulevard, Quebec Street, Yosemite Street, and the eastern terminus at I-25.

Figure ES.1
Proposed Access Configuration



ES.4 CONCLUSIONS

The refinement process sought to optimize T&R and establish a measure of the financial feasibility of the C-470 express lanes concept. Due to the preliminary nature of this feasibility study, and the variability of factors for a bond issuance, the revenue analysis was conducted to characterize a range of potential feasibility outcomes. A sensitivity analysis was conducted on the coverage rates and interest rate of the bonds. The projected cost of the C-470 express lanes (Phase 1 – Kipling Parkway to I-25) would be $335 million. Using a Senior Lien Coverage Rate of 1.75, and varying the Junior Lien Coverage Rate from 2.19 to 2.99, a composite coverage rate of 1.3 to 1.4 was produced. Using a bond interest rate of 5.5 percent and 6.0 percent, it is estimated that the express lanes could support a bond issuance of approximately 68 to 80 percent of the initial capital construction cost after accounting for annual financing, operations and maintenance, and capital reserve. This would require between $65.6 million and $108.5 million in supplemental funding from as-yet undetermined sources. Several potential strategies to reduce the funding gap have been discussed with the Colorado Tolling Enterprise (CTE). As a result, the CTE has determined that an acceptable funding plan can be developed that would cover the entire project cost and allow the project to advance. Table ES.1 summarizes the results of the preliminary financial feasibility analysis.

Table ES.1
Summary of Preliminary Financial Feasibility Analysis

Scenario	Present Value Net Revenue ($)	Capital Costs ($)	Feasibility Factor
1.75 Senior Lien/2.19 Subordinate Lien and 5.5% Bonding Rate	269,708,624	335,267,740	0.80
1.75 Senior Lien/2.19 Subordinate Lien and 6.0% Bonding Rate	243,319,829	335,267,740	0.70
1.75 Senior Lien/2.99Subordiante Lien and 5.5% Bonding Rate	251,299,736	335,267,740	0.75
1.75 Senior Lien/2.99 Subordinate Lien and 6.0% Bonding Rate	226,712,101	335,267,740	0.68

Note: All values are in 2006 Dollars

PHASED IMPLEMENTATION PLAN

Based on the conclusion that the eastern segment from Kipling Parkway to I-25 was the most financially feasible section of the corridor, it is proposed that this segment be implemented as Phase 1. The steps required to advance Phase 1 are described below:

- Carry express lanes alternative forward into the C-470 Corridor EA for consideration with other alternatives.
- Should the express lanes alternative be selected as the preferred alternative in the EA, pursue the following steps;

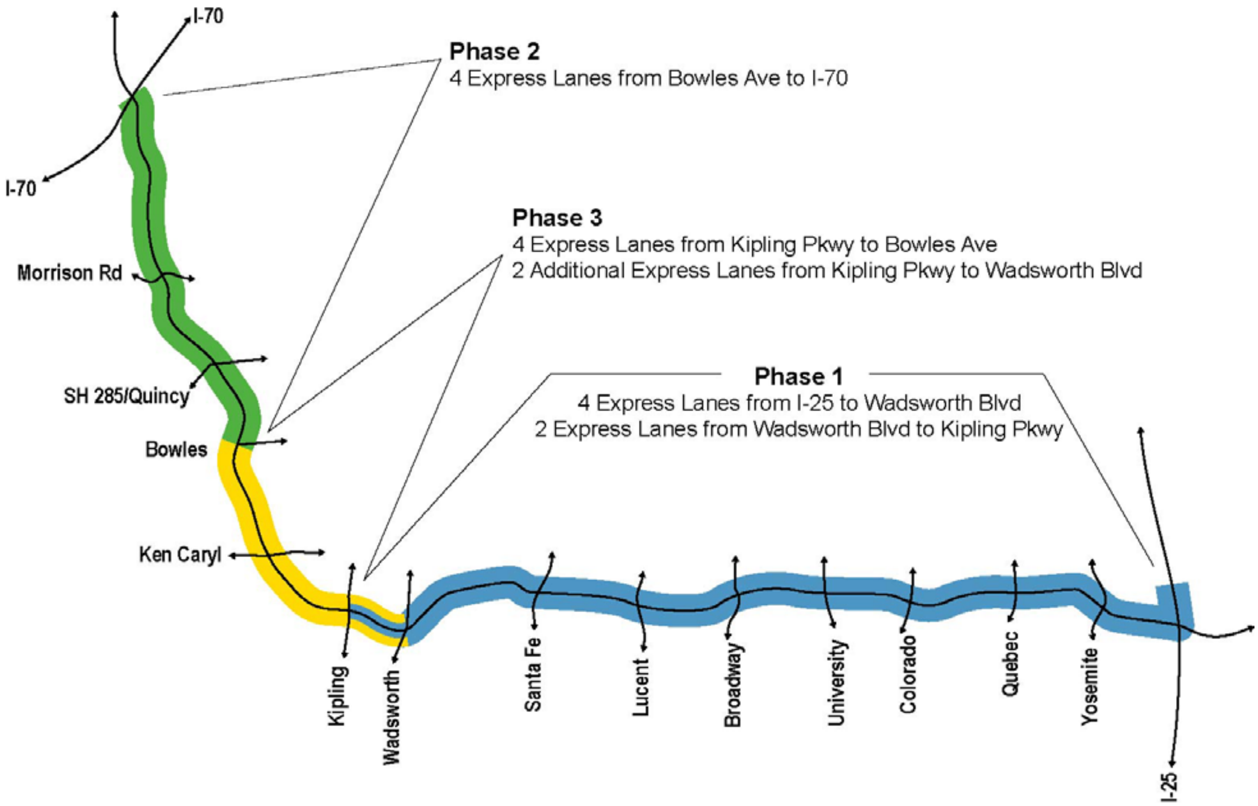
- Identify and solidify a funding plan to cover the entire project cost. Specifically, identify strategies and supplemental funding sources needed to make up the remaining 20 to 30 percent of capital construction costs. Seek amendment to the DRCOG Regional Transportation Plan (RTP) to add the express lanes to the Plan.
- FHWA would issue a decision document for the EA. If a Finding of No Significant Impact (FONSI) is issued, the express lanes would advance. If an Environmental Impact Statement (EIS) is required, that process would begin.
- CDOT would execute a design-build contract to construct the facility.
- Either CTE or the design-build contractor would administer an investment grade T&R study.
- CTE would complete a detailed financial plan, bond rating, and bond sale.
- Design-build contractor would begin the design and construction.

Although determined to be beyond the planning horizon of this study (2025), it is projected that Phase 2 of the implementation would be the segment from I-70 to Bowles Avenue. This would be the next logical segment, based on existing traffic volumes and projected growth. It is estimated that by 2030, adequate demand could occur to warrant construction of express lanes in this segment. This assumption is based on the CTE's desire for a four-lane segment and six lanes from I-70 to Morrison Road. In a hypothetical situation in which only four lanes were present in this segment, or if the CTE considers a two-lane express lane facility, the express lanes could then be feasible as early as 2020.

Phase 3 of the implementation of express lanes on C-470 is thought to be the extreme southwest segment from Bowles Avenue to Kipling Parkway. Based on current growth rates, it is expected that this final phase would not be warranted until beyond 2050.

Figure ES.2 illustrates the potential phasing plan.

Figure ES.2
Potential Phasing Plan



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1.0 INTRODUCTION

The intent of the C-470 ELFS was to evaluate the design, operational and financial feasibility, and expected public acceptance of express lanes on the 26-mile C-470 beltway in the southwest Denver Metro area. The study was conducted concurrently with the C-470 Corridor Environmental Assessment (EA), which investigated possible solutions to congestion and studied reliability problems from Kipling Parkway to I-25. Alternatives developed in the ELFS would be carried forward into the EA for evaluation against other non-tolled alternatives.

C-470 is a four-lane beltway with 18 interchanges between I-70 and I-25. The western segment of the corridor typically carries travelers from the southwestern suburbs to the Denver Technology Center (DTC), to downtown Denver and the northern suburbs, to the Golden/Boulder area, and to the Rocky Mountains to the west. Commuters in the eastern corridor segment are typically traveling to DTC and adjacent offices (a regional employment hub with over 100,000 employees) from residential areas in the southwestern part of the metro area. As the corridor approaches full build-out, other smaller employment centers are being developed, resulting in less directional split during the peak hours. The segments that do not currently have severe congestion are projected to have such conditions by 2020. Future projected traffic volumes indicate that a phased implementation of express lanes may be viable. The concept being studied is to provide express toll lanes to the inside of free general purpose lanes. The express lane volumes would be managed by charging a variable toll to ensure reliable, free-flowing traffic conditions.

1.1 C-470 CORRIDOR HISTORY

C-470 was constructed in segments in the mid 1980s and early 1990s. Auxiliary lanes were added between the interchanges of I-70 and Morrison Road, and between Quebec Street and I-25. In the early 2000s, C-470 was extended from I-70 to US 6/SH 93, providing a direct connection to the US 6/SH 93 corridor through Golden.

The eastern segment of the regional beltway system is composed of the E-470 Expressway, a private tollway. The northwest segment is composed of the 11-mile-long Northwest Parkway, also a private tollway that connects I-25 with US 36. The remaining portion of the yet-to-be-completed northwest quadrant from US 36 to C-470 is currently being studied in the Northwest Corridor EIS. A vicinity map of the area is provided in Figure 1.1.

Figure 1.1
Vicinity Map

1.2 C-470 CORRIDOR NEEDS

Due to high traffic volumes, high ramp merging volumes, and lack of auxiliary lanes, heavy congestion occurs regularly throughout the corridor. Auxiliary lane widening and ramp metering installations have mitigated some of these problems; however, level of service (LOS) E/F are typical on most segments during the AM and PM peak hours. Overall, the congestion levels and reliability problems are more prevalent in the eastern segment from Wadsworth Boulevard to I-25. The C-470 Corridor EA has defined its purpose and need statement as solving congestion, delay, and reliability problems on the corridor between Kipling Parkway and I-25.

Since its completion in 1990, C-470 has served the transportation needs of communities throughout the southwest Denver metropolitan area. Currently C-470 carry's a total of 80,000 to 100,000 vehicles per day in the busiest sections. Existing peak hour volumes on C-470 range from 5,800 to 9,100 vehicles in both directions. Existing peak hour LOS on C-470 ranges from LOS C to LOS F. Existing peak hour delay on C-470 between Kipling Parkway and I-25 is estimated at approximately 11-18 minutes per vehicle.

By 2025, peak hour volumes on C-470 will increase 35 to 40 percent. Mainline C-470 will operate at approximately 30 percent over capacity relative to CDOT's acceptable LOS, which is 8,000 vehicles per hour in both directions. Nearly every link on C-470 will operate at LOS F during the peak hour. The peak hour delay between Kipling Parkway and I-25 will exceed 22 minutes per vehicle.

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2.0 METHODOLOGY

This chapter summarizes the project study area limits and the goals and objectives of the project. The study approach, including the screening process is also summarized in this chapter.

2.1 C-470 STUDY AREA

The study area is bounded by I-70 to the north and I-25 to the east. Naturally, traffic analysis zones (TAZs) used in the travel demand model extended outside of this area, but for the purposes of using a micro-simulation model and determining potential impacts to the area, the limits noted above were used. All surface streets paralleling C-470, including Dry Creek Road/Mineral Avenue/Ken Caryl Avenue, County Line Road, Plaza Drive, Town Center Drive, Highlands Ranch Parkway, Lincoln Avenue, and Dad Clark Drive were included in the study area limits. On the western portion of C-470 where the alignment is orientated more north/south, Kipling Parkway, Bear Creek Boulevard, and Simms Street were included in the evaluation of the parallel surface street facilities. All streets with existing interchanges along C-470, in addition to locations where future interchanges has been proposed, were included in the study area. The locations where future interchanges have been discussed include Alameda Parkway, Yale Avenue, and Colorado Boulevard. A map of the project study area is shown in Figure 2.1.

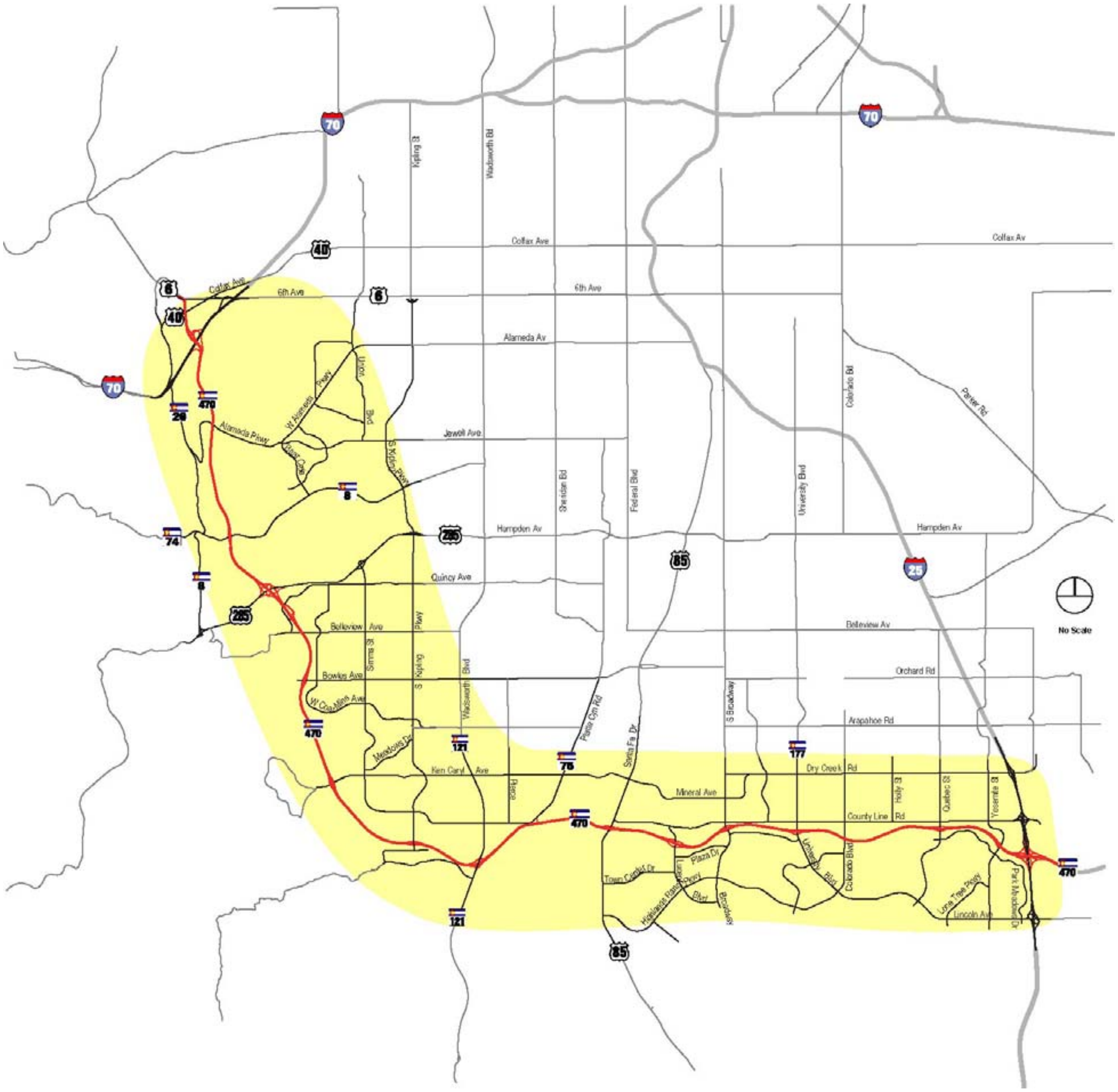
2.2 STUDY GOALS AND OBJECTIVES

The ELFS had two primary objectives. First, it was intended to confirm the initial findings of the statewide feasibility study which concluded that C-470 had good potential as a candidate toll corridor. Second, it was intended to determine if express lanes could be a viable alternative in the C-470 Corridor EA. It would assess the design, operation, financial feasibility, and public acceptance of implementing potential value pricing options as part of potential solutions to congestion, delay, and reliability along the corridor. The planning horizon used for the study was 2025. Travel demand forecasts were obtained using the regional travel demand model developed by DRCOG, with appropriate land use refinements as discussed with the various local government planning departments. The roadway network used in the travel demand model consisted of the existing network plus committed projects.

2.3 STUDY APPROACH

The ELFS began with traffic data collection along the corridor to assess existing and projected future conditions. A detailed screening process was performed to determine which corridor segments had demand for express lanes, the ultimate access locations, and access types along the corridor. The first level of screening consisted of using the travel demand model to assess existing and projected 2025 volumes to determine which segments were over capacity, and thus had demand for express lanes. The locations that showed little demand for express lanes were studied at a very cursory level. The segments that showed a higher demand were thoroughly evaluated throughout the remaining screening process.

Figure 2.1
Study Area



The second and third levels of screening evaluated the existing and projected volumes at existing and proposed interchange locations to determine which locations had high enough demand to warrant a potential express lane access. The TP+ model, an extension of the DRCOG travel demand model, was used to provide a realistic view of an express lane facility and a refined look at access locations. The fourth level of screening used the AIMSUN micro-simulation model to provide a detailed look at operations along the corridor to finalize access locations and types.

Concurrent with the AIMSUN model development, a stated preference survey was administered to corridor users to assess their value of time during their typical commute. This value of time was used in the AIMSUN model to develop the toll rate a driver would be willing to pay for a particular time savings. The output from the AIMSUN model generated the number of express lane users, toll rates, hours in which the toll rate would be applied, and the types of access and laneage required to accommodate the vehicles.

After the screening of access locations and types was completed, the final express lane configuration was refined to optimize traffic volumes, operations, and revenue. A conceptual design on the final alternative was completed to develop project cost estimates and potential environmental impacts. Using the T&R forecasts and the cost estimate, a present value analysis of projected net revenue was completed to assess the project's financial feasibility.

After a financially feasible alternative was established, the alternative was carried forward into the EA to be compared against other alternatives. The study also developed a potential implementation plan for the segments that were not deemed feasible within the 2025 design year.

2.3.1 C-470 Corridor Environmental Assessment

The National Environmental Policy Act (NEPA) requires that the FHWA identify and avoid potential impacts to the social and natural environment when considering approval of proposed transportation projects. The FHWA NEPA project development process is an approach to balanced transportation decision making that considers the potential impacts on the human and natural environment and the public's need for safe, efficient transportation.

NEPA requires that federal agencies disclose the results of their analysis and the effects of project implementation on the environment and solicit comments on the proposals from interested and affected parties. The purpose of documenting the NEPA process is to provide complete disclosure to the public; allow others an opportunity to provide input and comment on proposals, alternatives, and environmental impacts; and provide the appropriate information for the decision maker to make a reasoned choice among alternatives.

CDOT and the FHWA identified the need for improvements along the C-470 Corridor and thus initiated the C-470 Corridor EA to determine potential effects of various alternative transportation solutions. The purpose of the EA was to address congestion, reduce traveler delay, and improve reliability from Kipling Parkway to I-25. The EA sought to select an implementable transportation alternative that provided reliability, maintained travel times, and provided reliable travel choices to accommodate an expected increase in the intensity and duration of congestion forecasted for the design year of 2025.

2.3.2 Value Engineering (VE) Study

In association with the EA, a VE Study was completed in September 2004 to refine alternatives, identify potential new alternatives, and suggest strategies that would reduce the overall construction cost. Supplemental recommendations were also developed by the VE team to be considered for further study by the project team. The VE team developed 14 proposals and 29 supplemental recommendations for the consideration. The project team reviewed each proposal and accepted three of them for implementation, declined eight, and recommended three for further study. The complete list of suggested proposals and supplemental recommendations is in the *Preliminary Report - VE Study, CDOT Region 6 C-470 EA, Solutions Engineering & Facilitating, Inc., (2004).*

3.0 BACKGROUND

This chapter provides background into the development of the Colorado Tolling Enterprise (CTE) and the selection of C-470 as one of the final candidate corridors in the statewide screening of candidate tolling corridors. The theory behind managed lanes and existing corridors that use the managed lane operating strategies is also discussed in this chapter.

3.1 COLORADO TOLLING ENTERPRISE

During its 2002 session, the Colorado State Legislature created the CTE as a division of CDOT under House Bill 1310 (C.R.S. 43-4-801), which authorized the State Transportation Commission to create a Statewide Tolling Enterprise allowed to finance, construct, operate, and maintain toll facilities on highways in Colorado. CTE facilities can be constructed either in existing corridors or in new corridors, so long as the tolls are charged on new roadway capacity only. The non-profit CTE is governed by a board elected by the Colorado Transportation Commission (CTC).

Soon after its formation, the CTE screened of candidate toll corridors around the state. Initially, 79 corridors were identified as having potential to be tolled. Cursory evaluation by the CTE resulted in 39 corridors being selected for further study in the Statewide Tolling Feasibility Study.

The CTE then contracted with a consulting engineering firm to conduct a Statewide Feasibility Study to further evaluate the 39 candidate corridors and recommend those with the highest potential for financial feasibility. The study was conducted in two phases. Phase I narrowed corridors to 14, and Phase II further narrowed the list to 7. The DRCOG regional travel demand model, detailed capital costs, and operation and maintenance (O&M) costs were all used in evaluating the financial feasibility of the projects. C-470 was one of the seven final candidate corridors showing the most promise to be financially feasible.

The evaluation included several scenarios using various growth rates. All scenarios assumed the C-470 express lanes would be composed of two express lanes in each direction separated by a concrete barrier. Scenarios 1 and 1A extended from Wadsworth Boulevard to I-25. Scenario 1 assumed the land use and traffic growth projections in DRCOG's 2025 regional travel demand model, which equated to an approximate 1 percent annual growth. Scenario 1A was a hypothetical variation of Scenario 1 in which the traffic growth rate was arbitrarily doubled to determine the sensitivity of the feasibility to traffic growth rates. Scenarios 2 and 2A extended from I-70 to I-25. Again, Scenario 2 assumed the DRCOG land use and traffic growth rates, and Scenario 2A was a hypothetical case with doubled growth rates. The other notable characteristic of Scenarios 2 and 2A is that they both assumed a hypothetical situation of only four free lanes as opposed to the existing six-lane segment between I-70 and Morrison Road. The

Statewide Tolling Feasibility Study concluded that the eastern segment was approximately 70 percent feasible with the alternative growth rate (Scenario 1A), while the same segment with the adopted DRCOG growth rate (Scenario 1) was not feasible. The study further concluded that the entire corridor alternatives (Scenarios 2 and 2A) were also approximately 70 percent feasible when connected to the eastern segment and given the hypothetical assumption of only four free lanes. The criteria used to determine feasibility in the Statewide Feasibility Study is as follows. A Senior Lien Coverage Rate of 1.75 was used in combination with a 10% state and local contribution and a 20% Federal contribution. If this combination could cover 70% of the capital cost, the project was deemed feasible.

Though the CTE Statewide Tolling Feasibility Study was performed independent of the ELFS, both study teams collaborated throughout the process and exchanged assumptions and approaches on financing, cost estimates, construction, traffic volumes, and toll structure. This collaboration ensured that both studies were using the same basis for their evaluations. Ultimately, it was found that the two studies yielded similar findings. As described later in this report, this ELFS produced consistent results with the Statewide Tolling Feasibility Study, considering the slightly differing assumptions of each study. The ELFS found that the western segment was not feasible, given the existing traffic growth rate of 1.5 percent annually and the capacity associated with the current six-lane section. This is consistent with the Study's finding that express lanes are only feasible given the assumptions of a higher traffic growth rate, constrained capacity to four free lanes, and a contiguous facility throughout the corridor length. Both studies concluded that the eastern segment was approximately 70 percent feasible. The ELFS had a somewhat different method of determining the feasibility – its target was to achieve 70% coverage of the initial capital cost solely through issuing bonds. The combination of senior lien and subordinated debt should amount to at least 70% of the capital cost.

3.2 MANAGED LANES

The theory behind managed lanes is to set aside certain freeway lanes and use a variety of operating strategies to move traffic more efficiently in those lanes. Managed lanes maximize existing capacity, manage demand, offer choices, improve safety, and generate revenue. Implementation strategies include time-of-day restrictions, vehicle type restriction, value pricing, and occupancy requirements. Benefits of managed lanes include a built-in funding source, improved safety, and improved air quality. Value pricing is managed lane strategy being considered for an evaluation along the C-470 corridor, as described below.

3.2.1 Value Pricing Lanes

The concept of value pricing, also known as congestion pricing and peak-period pricing, is a way to harness the power of the market and reduce the waste associated with congestion. While the concept may be relatively new to the toll road market, the general idea has been applied to other sectors of the economy for centuries. It is the same concept of assessing higher prices to respond to peak-use demands. This concept is commonly applied in the airline industry, where a ticket costs more during peak travel times. The concept is applied when one attends a matinee movie at a reduced fee compared to prime time. As applied to toll roads, value pricing means that as the demand for the facility increases, so too does the toll price. As congestion eases and there is lane demand lessens, the toll price would decrease accordingly.

Value pricing is a technique used to manage the volume in a facility. It has been estimated on some corridors across the country that approximately 25 percent of vehicles on the road during peak hours are not commuters. By varying the toll rate based on the level of congestion, drivers are provided incentives to shift some trips to off-peak times, less-congested routes, or alternative modes.

3.2.2 Value Pricing Pilot Program (VPPP)

In 1991, the United States Congress mandated the VPPP as part of the Transportation Equity Act for the 21st Century (TEA-21). Congress's goal for the experimental program was to study the different value pricing approaches to reducing congestion. The grant program supports efforts by state and local governments or other public authorities to establish, monitor, and evaluate value pricing projects and to report on their effects. With the goal of assessing the design, operation, financial feasibility, and public acceptance of implementing potential value pricing options on C-470, CDOT submitted a proposal to FHWA's VPPP in April 2001 and was awarded a grant to study the C-470 Corridor. Currently, 15 states are participating in the VPPP, evaluating value pricing strategies that include:

- Converting high-occupancy vehicles (HOV) lanes to high-occupancy toll (HOT) Lanes
- Cordon tolls
- Fast and intertwined regular lanes (FAIR)
- Priced new lanes
- Pricing on existing toll facilities
- Usage-based vehicle charges
- "Cash-out" strategies
- Regional pricing initiatives

In addition to the C-470 ELFS, the CDOT is also participating in a VPPP to convert the existing I-25 north HOV lanes into HOT lanes from downtown Denver to the US 36 interchange. The conversion is scheduled for 2005.

3.2.3 Value Pricing Corridors Currently in Operation around the Country

Several facilities across the United States use peak-period pricing as a congestion management tool. These corridors fall into two types: HOT lanes and variable pricing on existing tolled facilities. The section below describes how value pricing corridors currently operate.

SR-91, Orange County, California

The State Route 91 (SR-91) express lanes facility opened in 1995 as the first privately financed toll road in the United States in more than 50 years. It was the world's first fully automated toll facility and was also the first application of value pricing in America. Tolls are collected via automated vehicle identification (AVI) transponders and vary by time of day and vehicle occupancy. All automobiles and motorcycles equipped with a transponder and a pre-paid account are eligible to use the lanes. Although the AVI transponder does not require a deposit, a minimum balance of $40 is necessary to establish an account. Interoperability agreements are established between all California toll facilities offering electronic/AVI toll payment options under the single brand, "FasTrak." Vehicles with three or more occupants can travel toll-free on express lanes. The current toll rate to travel the 10-mile roadway varies from $1.05 to $7.00, depending on the time of day and congestion levels.

I-15, San Diego, California

The I-15 express lanes are two reversible lanes, located in the freeway median, that flow southbound in the morning and reverse in the afternoon. The lanes were initially opened as an HOV facility in January 1988 but did not fill to capacity. In an effort to overcome these constraints, the San Diego Association of Governments Board passed a resolution and applied for a grant under the VPPP that would allow the conversion of the HOV lanes into HOT lanes. Since March 1998, users of the express lanes have been charged tolls that vary dynamically with the level of congestion. Several dynamic messages signs identifying the toll rate in effect are posted in the areas prior to the express lanes entrance. These signs indicate the highest toll users should expect to be charged, with tolls ranging from 50 cents to $4 per one-way trip under regular conditions, and sometimes as high as $8. Traffic flow is monitored in the express lanes to ensure that service on the HOV lanes is maintained at free-flow conditions (LOS C). Media response thus far has generally been positive. Some of the program's revenue is being used to fund a new express bus service.

US 290, Houston, Texas

HOT lanes were implemented on US 290 in November 2000. The reversible HOT lanes restricted to vehicles with three or more persons during peak hours of peak periods. The pricing program allows a limited number of two-person carpools to buy into the lanes during peak hours. Participating two-person carpool vehicles pay a $2.00 per trip toll, while vehicles with more occupants continue to travel free. Single-occupant vehicles are not allowed to use the HOT lanes. The QuickRide toll collection system is automated, and no cash transactions are conducted on the facility.

I-10 (Katy Freeway), Houston, Texas

In January 1998, the Texas Department of Transportation (TxDOT), Houston Metro, and FHWA funded a feasibility study of an HOT on the Katy Freeway, which resulted in a value pricing demonstration called QuickRide. By allowing HOV-2 vehicles to buy in to the HOV-3+ lane, QuickRide provided a way to utilize the excess capacity during peak periods without degrading the quality of the lanes.

Cape Coral Bridges, Lee County, Florida

In August 1998, Lee County began a value pricing pilot project on the Cape Coral and Midpoint bridges, two of the four bridges that connect Cape Coral and Fort Meyers. This demonstration was intended to be a proactive measure to examine the effects of pricing on existing congestion, as well as to install the technical infrastructure needed for future congestion management projects. Electronic toll collection (ETC) equipment was installed on the bridges, allowing for a variable pricing tolling structure and extensive data collection. By varying the toll structure, the project uses pricing mechanisms to induce patrons who usually travel during peak periods to change their time of travel. The variable toll structure offers a 50 percent discount during the shoulder periods (6:30 to 7:00 a.m., 9:00 to 11:00 a.m., 2:00 to 4:00 p.m., and 6:30 to 7:00 p.m.) just before and after the peak traffic period. Only ETC customers are eligible for variable discounts, and patrons are required to obtain a transponder and an account. Transponders either automatically debit a credit card or draw on prepaid toll accounts as patrons use the facilities.

Port Authority of New York and New Jersey

The Port Authority of New York and New Jersey oversees the maintenance and construction of several bridges and tunnels connecting New Jersey to New York. Bridges and tunnels priced for peak and off-peak periods by type of vehicle are the George Washington Bridge, Lincoln Tunnel, Holland Tunnel, Goethals Bridge, Outerbridge Crossing, and Bayonne Bridge. Commuters who use the EZPass electronic toll collection system are given discounts.

I-394, Minneapolis, Minnesota

In the spring of 2005, the Minnesota Department of Transportation (DOT) is scheduled to implement MnPass, which converts the I-394 HOV lanes into pay-per-use HOT lanes from I-94 to State Highway (SH) 101.

3.3 PUBLIC PRIVATE INITIATIVE

In 1995, the Colorado State Legislature realized that the state would be unable to keep pace with the State's future transportation needs and thus enacted the Public-Private Initiatives (PPI) Program Act. This Act allows private entities to propose alternative means of providing transportation improvements that benefit the state.

Fluor Daniel and HBG Flatiron, Inc. (d.b.a. F&F Infrastructure) submitted an unsolicited proposal to CDOT to develop, finance, design, and construct tolled express lanes along C-470 between I-70 and I-25 on a phased implementation basis. CDOT was then required to conduct an open solicitation for additional competing proposals. Ultimately, the PPI from F&F Infrastructure was chosen, and a pre-development agreement was executed between CDOT and F&F giving them the first right of refusal if the express lane alternative is chosen as the preferred alternative in the EA.

4.0 EXISTING CONDITIONS

The existing conditions analysis included extensive data collection of current highway geometry, traffic conditions, safety concerns, and planned transportation improvements. The analysis was the basis for identifying problem areas along the corridor and developing recommendations for improvements.

4.1 HIGHWAY GEOMETRIC FEATURES

Analysis of existing roadway geometrics involved identifying areas were deficiencies existed based on applicable design standards. The review included typical sections, horizontal and vertical alignment, interchange and ramp configurations, and pavement conditions, each of which is described below.

4.1.1 Typical Section

The existing C-470 roadway typical section is comprised of 10-foot outside shoulders, two 12-foot travel lanes, and 4-foot inside shoulders in both directions. The existing median is 34 feet wide and was designed to accommodate widening for an additional 12-foot travel lane with an 8-foot inside shoulder in each direction and a 2-foot center barrier. The segment between I-70 and Morrison Road was widened in 2001 to provide a third lane in each direction to accommodate auxiliary lanes. Auxiliary lanes were also added to the segment between Quebec Street and I-25, creating a three-lane cross section in each direction.

4.1.2 Horizontal Alignment

At four locations along the corridor, the tangent length between horizontal curves is deficient based on current American Association of State Highways and Transportation Officials (AASHTO) design standards for a 70 mile per hour (mph) design speed. These locations include tangents:

- Across the South Platte River
- Between the Lucent and Broadway interchanges
- Directly west of the Colorado Boulevard overpass
- Within the Yosemite Street Interchange

4.1.3 Vertical Alignment

The C-470 corridor lies within rolling terrain with maximum grades of approximately 4 percent. One exception is the approximately 7 percent grade from Santa Fe Drive (US 85) to just west of Lucent Boulevard. The Highline Canal and Trail crosses under C-470 just west of the crest vertical curve between Lucent Boulevard and Santa Fe Drive, reducing the potential of flattening the grade in this location. Crest and sag vertical curves meet design standards for 70 mph along the corridor, with the exception of the areas around Santa Fe Drive and Kipling Parkway.

For a design speed of 70 mph, a K value of 247 is required. The curve west of Santa Fe Drive has a K value of 175, which is adequate only for 60 mph design speed. The curve at Kipling Parkway has a K value of 241, which is adequate only for a design speed of 65 mph.

In addition to the substandard vertical curves, the gradient immediately east of Santa Fe Drive does not meet AASHTO criteria. The current desirable design criteria for gradients is 4 percent. The existing gradient greatly exceeds this, at 7 percent.

An additional safety concern relates to the sight distance for westbound traffic approaching the Santa Fe Drive Interchange, which is obstructed by the Union Pacific Railroad freight rail bridges crossing over C-470. This obstruction reduces the stopping sight distance for the sag vertical curve and reduces the visibility of the westbound on-ramp merge. Because this merge point is frequently the site of merge turbulence and queuing, the lack of sight distance causes most drivers to approach the interchange cautiously, creating queuing on the westbound mainline through the interchange area. The need for improved sight distance for the westbound direction is evident based on these considerations.

4.1.4 Interchange and Ramp Configurations

Interchange ramp configurations vary throughout the corridor. The C-470 Interchanges with I-70 and I-25 exclusively use directional ramps for all movements. The C-470/US 285 Interchange uses a cloverleaf design. The Morrison Road Interchange is a single point urban interchange. The Platte Canyon Road access is a right-in/right-out for westbound traffic. The remainder of corridor interchanges have diamond interchanges with C-470 crossing either over or under the surface streets. The interchange with Santa Fe Drive (US 85) is being evaluated as part of the C-470 EA to determine whether a reconfigured interchange with possible directional ramps for high-volume movements is needed.

4.1.5 Pavement Conditions

The pavement type varies throughout the corridor. Originally, the entire corridor was constructed with a concrete wearing surface. Over time, the concrete has deteriorated and cracked due to the expansive soils and natural aging of the roadway. To extend the lifespan of the roadway, portions were overlayed. The segment from I-25 to Santa Fe Drive is concrete pavement. From Santa Fe Drive to Morrison Road asphalt pavement is used, and from Morrison Road to I-70, concrete pavement is used. All the bridge decks on C-470 have also been overlayed with asphalt pavement. Most notably, in the southwest corner of C-470 from Wadsworth Boulevard to Ken Caryl Avenue, sections of pavement are “pumping” due to the expansive soils resulting in uneven pavement. Sections of concrete pavement from Lucent Boulevard to I-25 have extensive cracking.

Most of the aggregate in the concrete pavement is showing on the wearing surface, leading to a rougher and louder than normal pavement.

4.1.6 Structure Conditions

Most of the structures on the C-470 corridor are in generally good condition. Sufficiency ratings for bridges vary from the high 70s to 100, with no major bridge structure deficiencies. The Santa Fe Drive bridge over C-470 was recently rehabilitated to raise its sufficiency rating. The C-470 bridge over the Platte River does not have a current sufficiency rating; and it has been identified as having hydraulic capacity problems. Both locations are described below.

4.1.7 Santa Fe Drive over C-470

Santa Fe Drive is carried over C-470 by means of a two-span cast-in-place box girder bridge. The bridge, originally constructed in 1970, is approximately 232 feet 8 inches long and 86 feet 6 inches wide. The skew between the control lines of C-470 and Santa Fe Drive is about 70 degrees. The cross slope on the bridge is approximately 4.1 percent and drops to the west. The width accommodates six traffic lanes; two through-lanes in each direction and two shared left-turn lanes. In November 1996, CDOT rehabilitated this bridge, which now carries a sufficiency rating of 97.1

4.1.8 C-470 over the Platte River

This is one of the few structures on the four-lane parkway facility that predates C-470. A sufficiency rating on this structure is yet to be obtained. Discussions at the early environmental scoping meeting suggested that the hydraulic capacity of the structure is inadequate for handling certain flood flows. These flows are currently handled by a low-profile section of C-470 that would be inundated during flood events. It is likely that this bridge would need to be replaced to accommodate additional travel lanes on C-470.

4.1.9 Planned Transportation Improvements

With the exception of the Santa Fe Drive/C-470 Interchange reconstruction and the proposed interchanges at Yale and Alameda, no planned transportation improvements are in DRCOG's RTP that would have a direct impact on the operations of the C-470 corridor. However, various improvements along many adjacent arterial streets within the study area have been identified in local city, county, and agency plans. The improvements shown below were included in the regional travel demand model as committed projects. Also shown are the agencies responsible for implementing the improvements.

Douglas County Capital Improvement Plan (CIP)

1. Quebec Street and C-470
   a. Widen Quebec Street to provide for two left-turn lanes in both directions at ramp terminals.
2. University Boulevard and C-470
   a. Widen University Boulevard to provide for two left-turn lanes in both directions at ramp terminals.
3. Broadway and C-470
   a. Widen Broadway to provide for two left-turn lanes in both directions at ramp terminals.

Douglas County 2020 Transportation Plan Improvements

1. Blakeland Drive Extension – four-lane road between Santa Fe Drive and Plaza Drive.
2. Plaza Drive Extension – four-lane road to County Line Road.
3. County Line Road – Santa Fe Drive to Broadway/S. Park Lane improve from two to four lanes. City of Littleton will require two-lanes in each direction for this section as development occurs.
4. Colorado Boulevard – County Line Road to University Boulevard - improve from two to four lanes.
5. Yosemite Street – County Line Road to C-470 - improve from four to six lanes
6. Lincoln Avenue – I-25 to Quebec Street - improve from four to six lanes.

DRCOG 2025 RTP

1. Santa Fe Drive – Mineral Avenue to Highlands Ranch Parkway, improve from four to six lanes.
2. I-25 – North of C-470, improve from either six or eight lanes to ten lanes.
3. I-25 – South of C-470, improve from six lanes to eight lanes.
4. Broadway – C-470 to Highlands Ranch Parkway, widen to six-lanes.

US 85 Access Management Plan (2001)

1. Santa Fe Drive and Town Center Drive
   a. Southbound Santa Fe Drive will have two left-turn lanes and an exclusive right-turn lane.
   b. Northbound Santa Fe Drive will have one left-turn lane and an exclusive right-turn lane.
2. Santa Fe Drive and Highlands Ranch Parkway
   a. Southbound Santa Fe Drive will have two left-turn lanes.
   b. Northbound Santa Fe Drive will have one left-turn lane and an exclusive right-turn lane.

County Line Road EA I-25 to Santa Fe Drive (1998)

1. Broadway and County Line Road
    a. All approaches will have two left-turn lanes.
    b. All approaches, except Southbound Broadway, will have exclusive right-turn lanes.
2. University Boulevard and County Line Road
    a. All approaches will have two left-turn lanes
    b. All approaches, except Southbound University Boulevard, will have exclusive right-turn lanes.
3. Colorado Boulevard and County Line Road
    a. Eastbound and Westbound approaches will have two left-turn lanes and exclusive right-turn lanes.
    b. Northbound and Southbound approaches will have exclusive right-turn lanes.
4. Holly and County Line Road
    a. Eastbound & Southbound approaches will have two left-turn lanes.
    b. All approaches, except Eastbound County Line Road, will have exclusive right-turn lanes.
5. Quebec Street and County Line Road
    a. All approaches will have two left-turn lanes.
    b. All approaches, except Southbound Quebec Street, will have exclusive right-turn lanes.

Jefferson County Countywide Transportation Plan

1. Chatfield Avenue – Ken Caryl Avenue to Platte Canyon Road, widen to four-lanes.

4.2 EXISTING TRAFFIC CONDITIONS

The analysis of existing traffic conditions identified current traffic problems and generated a basis from which a future traffic model could be developed. Areas where traffic problems were identified were used to calibrate the model. Model calibration ensured existing conditions were replicated before introducing projected traffic volumes and planned transportation improvements into the network. The analysis included evaluating historical trends, peak hour and average daily traffic volumes, vehicle classifications, travel times, levels of service, speeds, queuing, and safety. The traffic conditions analyzed are described below.

4.2.1 Existing Average Daily Traffic Volumes

The average daily traffic (ADT) volumes were collected along C-470 and the major arterial streets. Figures 4.1 and 4.2 show ADT volumes collected in 2003. The ADT volumes in both directions along C-470 in the vicinity of I-70, Platte Canyon Road, and Yosemite Street are 73,000, 71,000, and 104,000 vehicles, respectively. These figures show that the eastern segment of the corridor carries approximately 30,000 more vehicles daily than the western segment.

Figure 4.1
Existing Freeway Volume (View 1)

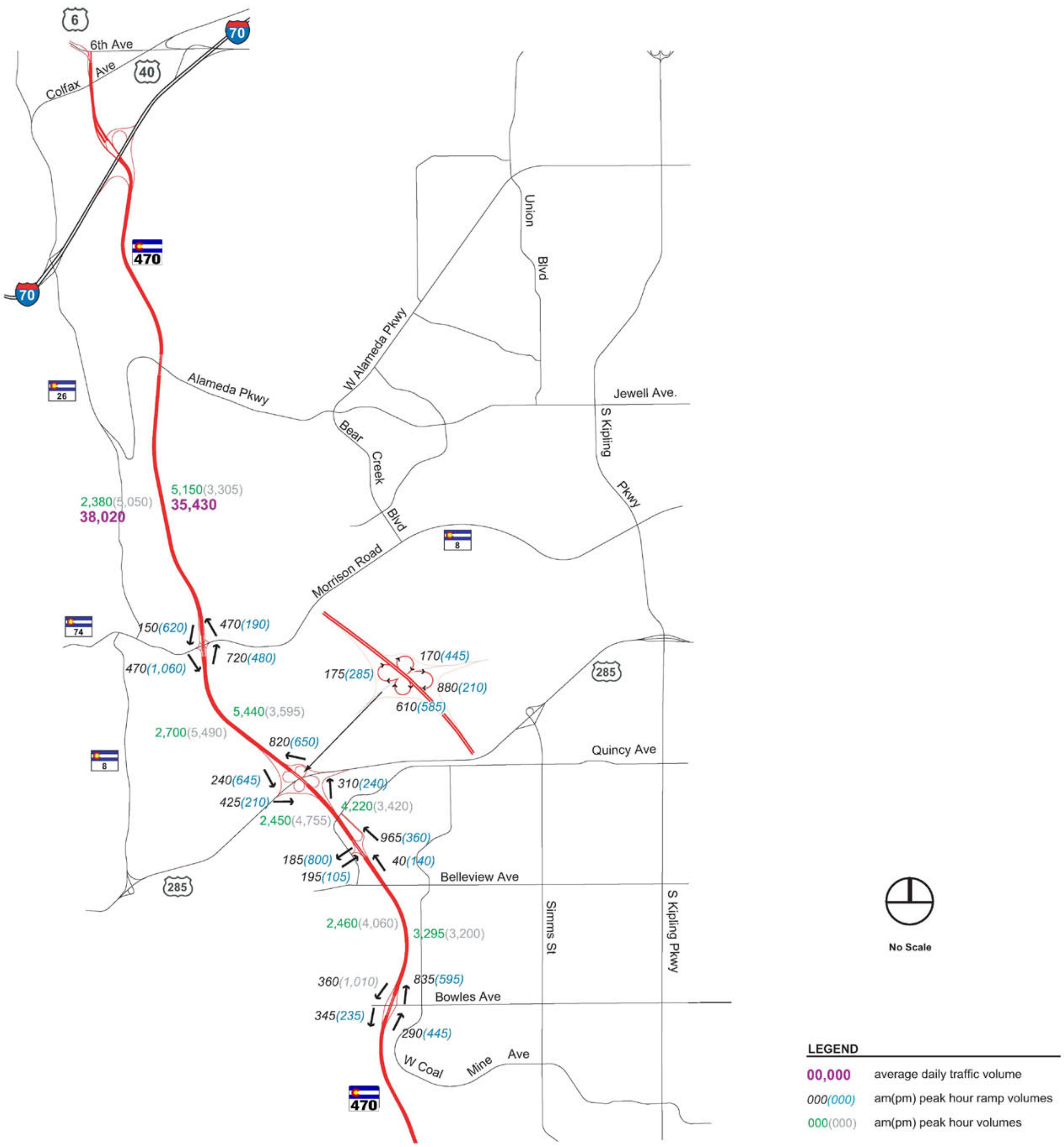
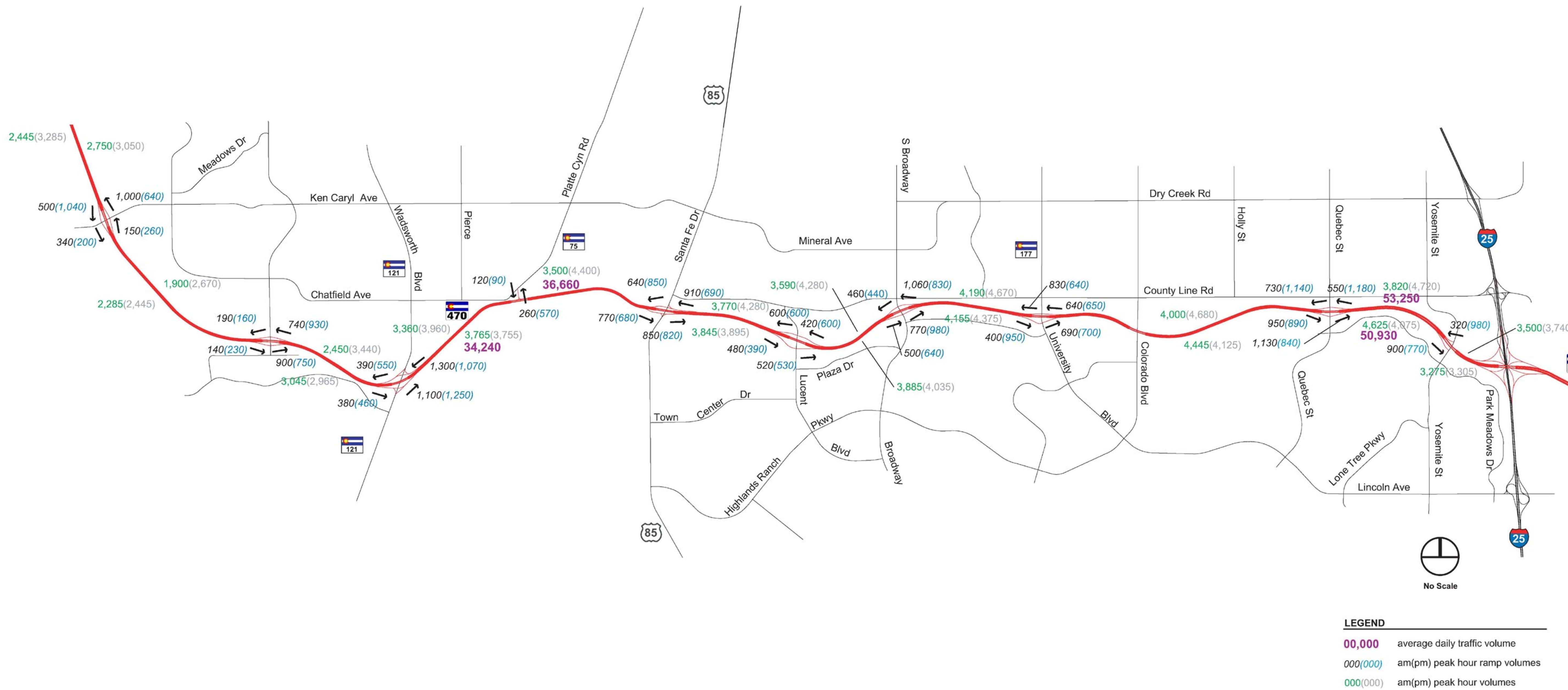


Figure 4.2
Existing Freeway Volume (View 2)



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4.2.2 Hourly Distribution

The hourly distribution is used to determine what periods have the highest volumes, and thus to define peak and off-peak hours. Table 4.1 shows the existing hourly distribution for the eastern and western segments of C-470. Table shows that the AM and PM peak hours last approximately 1.5 and 3 hours, respectively.

Table 4.1
Existing Hourly Distribution

Hour	EB	WB	AM Peak Percents		PM Peak Percents		Peak Periods
			EB	WB	EB	WB	
6:00 AM	5,401	6001	82.5	83.9			
7:00 AM	6,545	7154	100.0	100.0			AM Peak
8:00 AM	5,353	5946	81.8	83.1			
9:00 AM	3,916	4755	59.8	66.5			
10:00 AM	3,824	4533	58.4	6.4			
11:00 AM	4,079	4838	62.3	67.6			
12:00 PM	3,896	4875	59.5	68.1			
1:00 PM	3,937	5103			60.7	64.8	
2:00 PM	4,446	5743			68.6	73.0	
3:00 PM	4,929	7187			76.0	91.3	PM Peak
4:00 PM	5,932	7871			91.5	100.0	PM Peak
5:00 PM	6,485	7305			100.0	92.8	PM Peak
6:00 PM	4,839	6083			74.6	77.3	
7:00 PM	3,281	3877			50.6	49.3	

4.2.3 Vehicle Classification

To determine the percentages of cars and trucks along the corridor, vehicle classification data were collected along C-470. The classification counts, conducted in three locations along the corridor in June 2003, indicate that a maximum volume of 92 trucks travel the corridor during the AM peak hours 7:00 a.m. to 9:00 a.m. and 50 travel during the PM peak hours 5:00 p.m. to 7:00 p.m. Truck volumes in the three locations are shown in Table 4.2.

Table 4.2
Heavy Vehicle Volumes along C-470

Truck Volumes	AM			PM		
	South of Hampden	North of Hampden	East of Santa Fe	South of Hampden	North of Hampden	East of Santa Fe
Dir 1- WB/NB	70	78	61	50	49	25
Dir 2 – EB/SB	86	92	54	20	27	40

4.2.4 Travel Time Observations

Manual and automated travel time observations from I-25 to I-70 were completed as part of this study. Manual travel time observations consisted of a driver beginning at one end of the corridor and recording the time required to reach each subsequent interchange during the AM and PM peak hours. The average travel speed, number of stops, and total delay for each section were also recorded. Two runs in each direction during each peak hour on different days were performed to provide a sample representation of average conditions. The second type of travel time observation was completed with the aid of strategically mounted antennas similar to those used at electronic toll collection zones. Each antenna records arrival times of drivers with Express Toll transponders, allowing the calculation of an overall trip time. With the exception of one run, the average travel time in each direction ranged from 9 to 13 minutes, with an overall speed of around 60 mph. The AM and PM peak hour travel time observations are noted in Table 4.3.

Table 4.3
Summary of AM Travel Time Observations (sec)

Node Name	Length (feet)	Run #1 AM WB	Run #2 AM WB	Run #1 AM EB	Run #2 AM EB
I-25	0	0	0	0	0
Yosemite Street	1584	20	20	36	35
Quebec Street	7498	83	85	155	148
Colorado Boulevard	10718	122	125	216	211
University Boulevard	5333	80	82	103	98
Broadway	7603	112	117	161	156
Lucent Boulevard	6389	90	95	93	91
Santa Fe Drive	7392	111	116	131	126
Platte Canyon Road	16315	124	128	187	181
Wadsworth Boulevard	8026	123	130	187	180
Kipling Parkway	7762	107	108	163	160
Ken Caryl Avenue	11880	172	179	127	121
Bowles Avenue	12038	178	180	131	128
Belleview Avenue	5280	161	163	76	74
US 285	5861	73	75	79	76
Morrison Road	7656	99	101	84	81
I-70	20909	289	297	216	206
Total (Minutes)		32	33	36	35

Table 4.4
Summary of PM Travel Time Observations (sec)

Node Name	Length (feet)	Run #1 PM WB	Run #2 PM WB	Run #1 PM EB	Run #2 PM EB
I-25	0	0	0	0	0
Yosemite Street	1584	18	18	20	21
Quebec Street	7498	427	404	102	109
Colorado Boulevard	10718	444	432	152	160
University Boulevard	5333	99	96	77	82
Broadway	7603	90	86	109	115
Lucent Boulevard	6389	76	72	90	95
Santa Fe Drive	7392	318	329	103	110
Platte Canyon Road	16315	181	189	116	122
Wadsworth Boulevard	8026	86	84	118	123
Kipling Parkway	7762	82	83	103	108
Ken Caryl Avenue	11880	126	122	164	172
Bowles Avenue	12038	128	127	135	140
Belleview Avenue	5280	98	64	95	102
US 285	5861	101	79	98	105
Morrison Road	7656	108	104	106	113
I-70	20909	246	245	434	465
Total (Minutes)		44	42	34	36

4.2.5 Levels of Service/Densities

Current LOS and densities along C-470 were calculated using Highway Capacity Software (HCS). Based on the analysis, the segment of C-470 between Quebec Street and Platte Canyon Road has the lowest LOS (E-F) and highest densities for both the AM and PM peak hour in the east- and westbound direction. Table 4.4 summarizes the HCS analysis.

Table 4.5
AM/PM Peak Hour C-470 Freeway Segment LOS/Density Summary

		WB C-470 Freeway Segments		EB-470 Freeway Segments	
From	To	LOS	Density (sec)	LOS	Density (sec)
I-25	Yosemite Street	C/C	21.6/21.6	C/C	21.9/19.1
Yosemite Street	Quebec Street	C/C	23.4/27.7	D/C	27.5/23.5
Quebec Street	University Boulevard	F/F	-/-	F/E	-/43.2
University Boulevard	Broadway	F/F	-/-	F/F	-/-
Broadway	Lucent Boulevard	E/F	37.0/-	E/E	39.6/40.9
Lucent Boulevard	Santa Fe Drive	E/F	40.7/-	F/E	-/43.2
Santa Fe Drive	Platte Canyon Road	E/F	35.4/-	E/E	38.6/36.4
Platte Canyon Road	Wadsworth Boulevard	D/E	33.2/39.8	E/E	38.6/36.4
Wadsworth Boulevard	Kipling Parkway	C/D	23.3/31.1	D/D	27.9/26.1
Kipling Parkway	Ken Caryl Avenue	C/C	18.5/23.2	C/C	20.8/21.4
Ken Caryl Avenue	Bowles Avenue	C/D	26.0/26.7	C/D	22.2/29.5
Bowles Avenue	Quincy Avenue	D/D	32.3/27.3	C/E	22.0/39.3
Quincy Avenue	US 285	F/D	-/28.9	C/F	22.5/-
US 285	Morrison Road	D/C	35.0/20.8	B/D	16.1/31.2
Morrison Road	I-70	D/C	31.0/18.6	B/D	14.0/26.1

4.2.6 Congestion/Queue Observations

To identify areas where the volume to capacity ratio (V/C) was close to 1.0, or where the intersection was oversaturated, a Synchro model was developed for the arterial street network. The intersections identified in the Synchro analysis were then visited during the AM and PM peak hours to field verify queue lengths. The field-measured queue lengths were later used to calibrate the micro-simulation model.

4.2.7 Speed Profiles

Travel speed measurements were collected in both directions during the AM and PM peak hour between I-25 and I-70. The travel speed ranged from 45 mph to 63 mph. Table 4.5 summarizes the recorded travel speed for each segment.

Table 4.6
Summary of AM Average Speed (mph)

Node Name	Length (feet)	Run #1 AM WB	Run #2 AM WB	Run #1 AM EB	Run #2 AM EB
I-25	0	0	0	0	0
Yosemite Street	1584	60.1	58.9	`	31.1
Quebec Street	7498	61.1	59.9	33	34.6
Colorado Boulevard	10718	59.4	57.8	33.8	34.6
University Boulevard	5333	59.8	58.1	35.3	37.1
Broadway	7603	60.3	57.9	32.2	33.1
Lucent Boulevard	6389	60.8	57.5	46.9	47.9
Santa Fe Drive	7392	58.1	55.7	38.5	40.1
Platte Canyon Road	16315	58.2	56.3	59.5	61.6
Wadsworth Boulevard	8026	59.1	55.8	29.3	30.5
Kipling Parkway	7762	60.3	59.5	32.5	33.2
Ken Caryl Avenue	11880	60.4	58.1	63.8	66.7
Bowles Avenue	12038	59.7	59	62.7	64.3
Belleview Avenue	5280	50.5	49.8	47.4	48.5
US 285	5861	48.4	46.8	50.6	52.4
Morrison Road	7656	54.1	52.9	62.2	64.2
I-70	20909	58.7	57.2	66	65.1

Table 4.7
Summary of PM Average Speed (mph)

Node Name	Length (feet)	Run #1 PM WB	Run #2 PM WB	Run #1 PM EB	Run #2 PM EB
I-25	0	0	0	0	0
Yosemite Street	1584	60	60	54	51.5
Quebec Street	7498	12	12.7	50.1	46.9
Colorado Boulevard	10718	16.5	16.9	48.1	45.7
University Boulevard	5333	36.7	37.9	47.2	44.4
Broadway	7603	57.6	60.3	47.6	45.1
Lucent Boulevard	6389	57.3	60.5	48.4	45.9
Santa Fe Drive	7392	15.9	15.3	49	45.8
Platte Canyon Road	16315	61.5	58.9	63.2	61.5
Wadsworth Boulevard	8026	63.7	65.2	46.4	44.5
Kipling Parkway	7762	64.6	63.8	51.4	49
Ken Caryl Avenue	11880	64.3	66.4	49.4	47.1
Bowles Avenue	12038	64.2	64.7	60.8	58.7
Belleview Avenue	5280	36.8	56.3	37.9	35.3
US 285	5861	39.6	50.6	40.8	38.1
Morrison Road	7656	48.4	50.2	49.3	46.2
I-70	20909	58	58.2	32.9	30.7

4.2.8 Safety

Compared to other similar roadways around the state, the C-470 corridor from Kipling Parkway to I-25 is a relatively safe, four-lane urban freeway Based on an analysis conducted by CDOT Region 6 in February 2005, this segment of C-470 had lower than expected accident rates. The CDOT study (Draft Traffic Safety Chapter, For the C-470 Corridor EA, February 2005) looked at an accident history for the 3-year period from January 1, 2000, through December 31, 2002, and analyzed 1,565 mainline accidents. Of these, 1,140 were property damage only 417 were injury accidents, and eight were fatal accidents. The accident rates on this segment of C-470 were found to be very near or below average, compared with similar four-lane urban freeways in Colorado. However, the accident rate in the section around the Santa Fe Drive Interchange was noticeably above average. Over the 3-year period, accidents occurred in this section at about 30 accidents per mile per year. A similar four-lane urban freeway with similar volumes would typically have 18 accidents per mile per year (APMPY).

The area around the Santa Fe Interchange also had a high accident rate during the study period. The study indicates this segment of C-470 has a high proportion of rear-end accidents. Among the rear-end accidents is a disproportionately higher number that occurred in the westbound direction, particularly during the PM peak period.

Two design features and two operational characteristics are believed to be major contributing factors to the high accident rate at the Santa Fe Drive Interchange. The westbound portion of roadway has a steep downhill grade east of the Santa Fe Drive Interchange. Further, the westbound entrance ramp from Santa Fe Drive is on the inside of a curve, obstructing drivers' vision and making the merge maneuver more difficult. Operationally, this area is congested in the PM peak period, and the high traffic volumes entering and exiting at Santa Fe Drive increases congestion. The combination of congestion, vehicles slowing to enter/exit Santa Fe Drive, the difficult merge, and the downhill grade results in a high accident location with a high proportion of rear-end accidents.

The overall accident rate on the remainder of the corridor suggests that the facility is safe when compared to similar facilities. The pattern of accident types indicates that approximately half of the accidents are rear-end accidents, one quarter involve fixed objects, and the remaining fall into a multitude of categories. Rear-end accidents are often associated with congestion, where rapidly slowing vehicles encounter one another. Any congestion-relieving improvements made to C-470 would likely reduce the number of rear-end accidents. The Draft Traffic Safety Chapter from the C-470 Corridor EA is contained in Appendix A.

5.0 PUBLIC INVOLVEMENT

The study area stakeholders and public members were engaged throughout the study. The project team distributed information and solicited feedback through regular meetings and open houses. C-470 corridor users were also surveyed to determine the their perception of the existing problems along C-470, their opinion on installing express lanes along the corridor, and their current value of time. Their value of time was later used to determine the driver's propensity to use the express lanes over the general purpose lanes and also develop the projected toll rates for the corridor.

5.1 OVERVIEW

The public involvement process for the C-470 ELFS was designed to provide timely project updates and progress results with stakeholders and to encourage public comment and participation. With both the EA and ELFS occurring concurrently, the public involvement process for both was combined to minimize the number of required meetings and to avoid repetition. The public involvement process was part of an overall communications program that included agency involvement, community relations, media relations, and public relations. Public outreach efforts included open houses, small group meetings, one-on-one meetings, direct mailings, press releases, a Web site and email address, project phone number and mailing address, and focus groups. In addition monthly and quarterly meetings with stakeholders via standing meetings of the Project Management Team (PMT), Technical Working Group (TWG), and the Executive Working Group (EWG) were held. Due to the public's lack of familiarity with the express lane concept, an extensive educational outreach program was developed to educate the public on express lanes theories, history, and operations.

5.1.1 PMT

The PMT consisted of project personnel from FHWA, CDOT, Wilson & Company, and PBS&J. Subcontractors Ordonez and Vogelsang, Hartwig and Associates, and others attended the meetings as needed. The team met monthly to coordinate resources and continue project planning. Minutes and action items were prepared for each meeting.

5.1.2 TWG

The TWG met monthly throughout the project. The TWG consisted of project personnel from FHWA, CDOT, Wilson & Company, and PBS&J. Subcontractors attended as needed. Representatives of the three counties (Arapahoe, Douglas, and Jefferson) and eight cities (Littleton, Centennial, Greenwood Village, Highlands Ranch, Lakewood, Lone Tree, Golden, and Morrison) along the corridor also served on the TWG. A monthly meeting was held to present ongoing project reports and to discuss issues. Minutes and action items were prepared for each meeting.

5.1.3 EWG

The EWG met quarterly throughout the project. This policy-level group consisted of administrators from FHWA and CDOT, and project team members from Wilson & Company and PBS&J. Elected officials from Jefferson, Douglas, and Arapahoe counties and from the cities of Littleton, Lone Tree, Highlands Ranch, Golden, Morrison, Lakewood, Centennial, and Greenwood Village were invited to attend. Regional agencies were also represented including the Regional Transportation District (RTD), the DRCOG, the United States Environmental Protection Agency (EPA), the Federal Transit Association (FTA), Shea Homes, and the South Metro Chamber of Commerce. Colorado Transportation Commissioners also attended.

5.1.4 Open Houses/Workshops

The project team hosted four public open houses in October 2003, February 2004, June 2004, and December 2004. Both print and broadcast media were used to advertise the events, as well as the project Website and notices to local officials and public information officers. The total attendance for all four open houses was approximately 560 persons.

In addition to the open houses, three workshops specific to the ELFS were held on May 11, 12, and 13, 2004. Approximately 48 members of the public attended the three open houses, which served to educate the public on the express lane concept. Topics discussed included how express lanes operate, what they look like, and typical design features. Animated presentations showed typical express lane configurations and access types.

5.1.5 Newsletters

Four newsletters were produced and distributed at key project milestones. The newsletters provided updates, summarized public comments, and extended invitations to project open houses. A contact database of nearly 18,000 was maintained and consisted of property owners along the corridor, elected officials, media, Home Owners Associations (HOAs), civic groups, and individuals who requested to be included on the mailing list. In addition, a list of business owners along the corridor, plus businesses and residents along Santa Fe Drive, was rented as needed, expanding the mailing list to over 22,000.

5.1.6 Small Group Meetings

Small group meetings encouraged dialogues with communities along the corridor. Targeted groups included business, civic, and HOAs. The Speakers Bureau was promoted in the project newsletters, on the Web site, and via direct mailings to the groups in August 2003 and August 2004. The 43 meetings held from August 2003 to December 2004 were attended by nearly 1,000 members of the public. Actions were documented in a Small Group Meeting Report, which noted the times, dates, and locations and issues discussed.

5.1.7 Project Website

The project Website (www.c470.info) was launched in July 2003 and was promoted via project business cards, a news release, and newsletters. The site provided project information, schedules, frequently asked questions, meeting announcements, and related resources. The site also provided a means for commenting on the project and accessing project staff. Displays and handouts from each open house were posted to the site to allow the public greater access to information. From July 2003 to December 2004, the site had more than 100,000 requests for information.

5.1.8 Agency Coordination/Project Stakeholders

The project team met with all concerned federal, state, and local agencies to obtain input from all jurisdictions was considered in the shaping of the project.

The agencies included:

- FHWA
- EPA
- United States Fish and Wildlife Service (USFWS)
- Colorado Division of Wildlife (CDOW)
- United States Army Corp of Engineers (USACE)
- CDOT
- RTD
- DRCOG
- FTA
- Arapahoe County
- Douglas County
- Jefferson County
- City of Centennial
- City of Golden
- City of Greenwood Village
- City of Lakewood
- City of Lone Tree
- City of Morrison
- Highlands Ranch Metro District

5.1.9 Public Acceptance

During the public involvement process, members of the public and stakeholders had the opportunity to comment on the express lane alternative. Comments received were used to identify key concerns of the public and ultimately shape the recommended alternative. Throughout the process, similar issues were identified including noise, trails, access, highway capacity, future transit, and the environment.

Many people living in the residential communities adjacent to the corridor were worried about the potential for increased noise along C-470 with additional lanes. Many community members requested that noise walls be installed to mitigate noise.

Concerns were also voiced over the existing number of at-grade crossings along the adjacent C-470 trail and the increased safety risk of crossing several busy arterial intersections. The Public requested all trail crossings be grade separated and the C-470 trail be relocated as far from the travelway as possible.

Potential access locations to the express lanes received many comments throughout the process. The proposed access location, particularly at Colorado Boulevard, created concerns over potential increased traffic. Due to the increased efficiency of accessing the C-470 express lanes while others opposed it due to the potential of increased cut-through traffic, some public members supported the proposed access at Colorado Boulevard.

Most of all the comments recognized the need for capacity improvements along C-470, and most favored enhanced capacity through the addition of either express lanes or general purpose lanes.

Many stakeholders were concerned that the widening of C-470 to accommodate additional travel lanes would preclude the potential for a future light rail line along C-470. Members of the public were also concerned about the potential impacts to wildlife along their habitat. Concerns over air quality impacts were also identified.

5.2 C-470 FOCUS GROUPS

In June 2003, two qualitative research groups were formed consisting of individuals who live near the C-470 corridor and travel C-470 at least several times a week. The goal of the focus groups was to qualitatively assess drivers' responses to transportation problems on C-470 and to assess the potential for implementing express lanes. Depending upon which portion of the corridor members typically drive in, with Wadsworth Boulevard serving as the dividing line. Generally, drivers from the western segment were more accepting of using tolls as a way to fund additional capacity improvements, while drivers from the eastern segment noted that CDOT should not force toll roads on them as the only means to have the additional capacity. The executive summary of the C-470 Focus Groups Report is in Appendix B; key findings of the report are shown below.

- On an average day, drivers from the western and eastern segment would be willing to pay $0.98 and $1.14, respectively.
- During the heaviest traffic, drivers from the western and eastern segment would be willing to pay $3.72 and $2.72, respectively.
- Drivers perceive that once the bonds are paid off, the tolls will go away.
- Drivers believe the word "value" should be removed from the express lanes title.
- Overall, 10 out of 18 drivers somewhat favored or strongly favor the idea of express lanes.
- Overall, 8 out of 18 drivers from the focus groups somewhat opposed or strongly opposed express lanes.

5.3 STATED PREFERENCE SURVEY

A Stated Preference Survey was conducted in April 2004 to assess market demand for express toll lanes on C-470. During the study, a commuter intercept survey and phone survey of more than 2,000 C-470 commuters was conducted. The commuter intercept survey targeted a random sampling of persons who used C-470 during rush hour. The main purpose of the commuter intercept survey was to determine what commuters were willing to pay to use express toll lanes, based on a given time savings. In addition to assessing the demand for express toll lanes, other information was gathered including:

- Travel characteristics of persons who commute in the C-470 corridor
- Awareness of the express toll lane concept
- Where commuters currently enter and exit C-470
- Reasons commuters avoid travel on C-470
- Support for developing express toll lanes on C-470

The toll amount based on a particular time savings was used to develop price sensitivity curves to estimate the demand for express toll lanes as a function of two variables: (1) the amount time that a person can save by using express toll lanes, and (2) the fee that is charged to use express toll lanes. These toll sensitivity curves correlate to a driver's value of time. This value of time was then used in the micro-simulation traffic model to determine at what level of time savings and what toll rate a driver will enter the express lanes instead of waiting in the congested general purpose lanes. The Stated Preference Survey Executive Summary is contained in Appendix C; key findings are summarized below:

- 67 percent of the commuters surveyed thought it was an excellent, good, or an okay idea to develop express toll lanes on C-470; 31 percent thought it was a bad idea, and 2% had no opinion.

- 70 percent of the commuters surveyed indicated they would consider using the express lanes if the general purpose lanes were congested.
- 82 percent of the commuters surveyed indicated they had used toll highways, such as E-470, in other parts of the Denver metropolitan area,
- 11 percent of the commuters surveyed indicated that they already had a transponder for toll highways in the Denver area; 43 percent indicated that they did not currently have a transponder, but they would be very or somewhat likely to get one if express toll lanes were developed on C-470; 31 percent indicated they were not likely to get a transponder; and 15 percent had no opinion.
- 81 percent of the commuters surveyed indicated they would pay 20 to 30 cents per mile to use express toll lanes on C-470 in an emergency or if they were late for an appointment.

5.3.1 Toll Sensitivity Curves

The analysis of the stated preference survey involved developing models that could predict the rate commuters would be willing to pay to use Express Toll Lanes (ETLs) when C-470 was congested. The analyses capitalized on the unique qualities of the survey data collected and the comprehensive commuter intercept sample.

Surveys asked what cost the commuters would be willing to pay, based upon distance and time savings resulting from using express lanes. Two analyses were conducted to predict the rate commuters would be willing to pay to use express lanes. The first analysis focused on cost as a function of time savings; that is, what is the price commuters would pay to use express lanes for every minute saved in driving time. The second analysis focused on time savings as a function of cost; that is, how many minutes saved in travel time is a dollar worth. Simple regression procedures were used to examine the relationship between cost and time savings. To predict the rate commuters would be willing to pay for the use of express lanes, variables were created that computed cost per mile and minutes of time savings per mile. The regression equation for predicting the relationship between two (or more) variables is:

$$Y = a + bX$$

In this equation Y is the dependent variable, X is the independent variable, b is the slope (i.e., regression coefficient), and a is the intercept. When the equation is translated to compute cost per mile as a function of time savings, the regression equation is:

cost per mile = intercept + slope * time savings per mile

Conversely, when computing time savings per mile as a function of cost per mile, the regression equation is:

time savings per mile = intercept + slope * cost per mile

This model was applied to the survey data to predict both cost as a function of time savings and time savings as a function of cost. Analyses were also conducted with a zero intercept. In these analyses, the time savings variable is recoded to zero if the respondent indicated that they would not pay to travel in the express toll lanes.

It is important to note that some commuters would be willing to pay to use the express toll lanes when there is no time savings. Simply avoiding heavy traffic may be reason enough for some of the population. The zero intercept graphs below will not accurately illustrate this group of commuters due to the nature of the model.

Figures 5.1 and 5.2 represent the toll sensitivity curves used to develop drivers' willingness to pay a toll based on a particular time savings.

Figure 5.1
Time Saved Per Mile as Function of Cost Per Mile

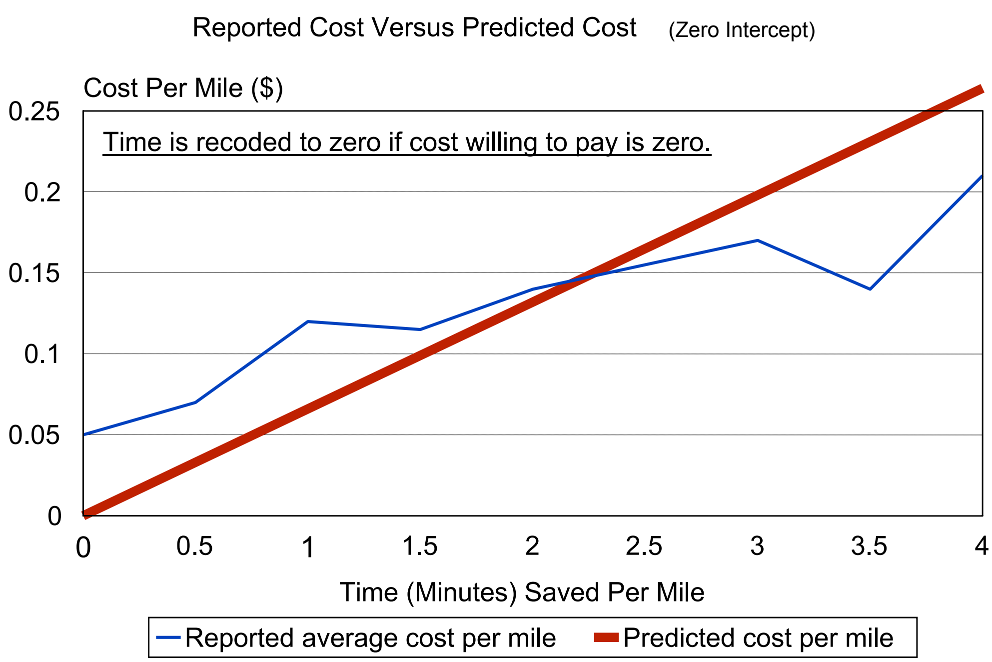
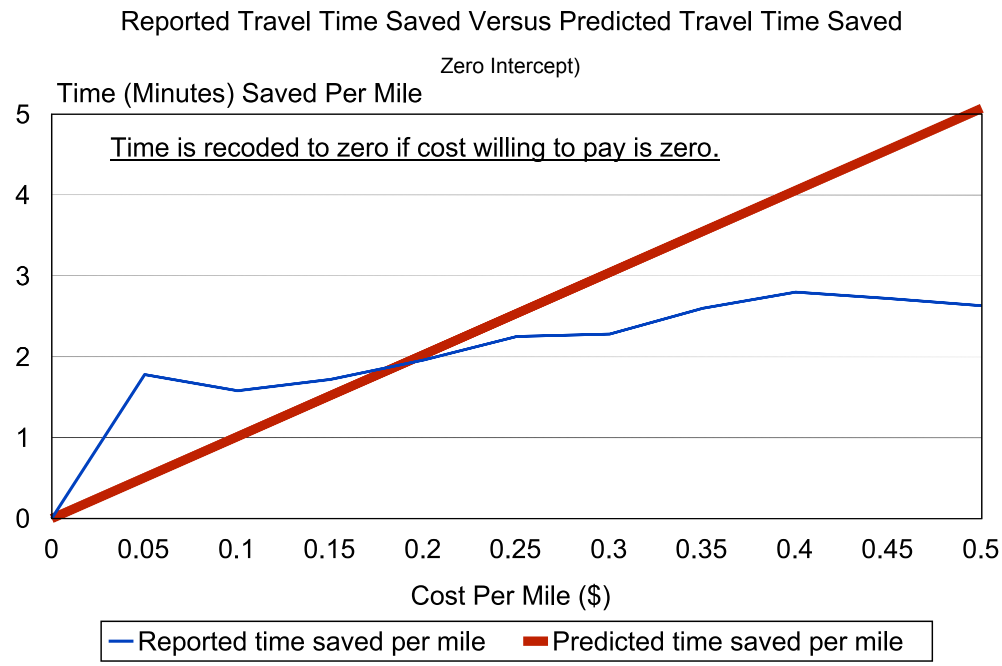


Figure 5.2
Cost Per Mile as Function of Time Saved Per Mile



5.3.2 Value of Time Calculations

One of the key input values in the micro-simulation model is drivers' estimated value of time. In the initial model runs, the value of time was taken directly from the stated preference survey, which calculated corridor users' value of time as being approximately $6.00 per hour. This value was calculated by developing a linear regression equation that best fit drivers' responses to what they would be willing to pay based on given time savings. Based on documented results from a similar survey completed for SR-91 in Orange County, California, drivers surveyed on that corridor placed their value of total travel time as being $8.50 per hour. The total travel time value assumes congested conditions are present only during a small portion of the commute. All values are in 2004 dollars. This would tend to resemble what drivers of the C-470 corridor are experiencing, based on current-day congestion levels. As traffic volumes along the corridor continue to grow, the degree and period of time during which congestion occurs will continue to increase, as will drivers' value of time.

A National Cooperation Highway Research Programs (NCHRP) report (Report 431, Valuation of Travel Time Savings and Predictability in Congested Conditions for Highway User-Cost Estimation) indicates that an adjustment factor needs to be applied to account for travel during highly congested travel conditions. The report noted that drivers' value of time increases by a factor of 2.5 during periods of highly congested travel conditions. The AASHTO User Benefit Analysis for Highways recommended applying a 2.0 factor during highly congested periods. Using the results from the C-470 User Survey and a $6 per hour value of time, the C-470 corridor's user value of time during highly congested periods would increase to between $12 to $15 per hour. All values are in 2004 dollars.

The sensitivity analysis also looked at researching other methods that past studies have used to calculate drivers' value of time during congested conditions. Five sources had computed drivers' value of time based on various input values that could be applied as nationwide averages. The studies used in the analysis, and their respective values of time, are shown in the Table 5.1. The value of times were adjusted to reflect the current dollar value based on the Consumer Price Index (CPI) for the year the study was completed.

Table 5.1
Value of Time Summary Table

Study	Based on Data from Year	Value of Time Rates ($/hr)	CPI (Study Year)	CPI (2004)	2004 Value of Time Rates ($/hr)
AASHTO User Benefit Analysis for Highways	2000	10.96	174.0	189.4	11.93
NCHRP Report 431, Valuation of Travel Time Savings and Predictability in Congested Conditions for Highway User-Cost Estimation	1999	13.25	168.3	189.4	14.91
Measure the Economic Costs of Urban Traffic Congestions	2002	14.30	180.9	189.4	14.97
Uncovering the Distribution of Motorist Preferences for Travel Time and Reliability: Implications for Road Pricing	2002	14.83	180.9	189.4	15.53
Value of Time Savings	1999	11.38	168.3	189.4	12.81
				Average	**14.03**

The AASHTO User Benefit Analysis for Highways noted that a rough calculation typically used to derive a driver's value of time is to take 50 percent of their hourly income level. To derive this value, 2000 U.S. census data for the block groups surrounding the corridor were compiled to determine the average household income

for typical corridor users. Based on the data obtained, the average income for households surrounding the corridor is $85,881 in 2004 dollars.
The next step in calculating the value of time was to determine the average number of wage earners per household who would typically commute during normal peak hours. The calculation assumed that the wage earners in the household would commute during typical AM and PM peak hours. Based on data taken from the 1997 DRCOG Household Survey for the Metro Denver Area, 1.37 persons on average make up the overall household income.

This assumption considers all household income levels found throughout the metro area, which averages approximately $37,787. Based on the higher average household income level of $85,881 for the C-470 corridor, it could be determined that drivers have higher paying jobs and that more people per household earn wages. This assumption was confirmed in reviewing a survey that was completed in 2003 by the United States Bureau of Labor Statistics and the United States Census Bureau (USBOC). That survey showed that for households with average income levels of approximately $85,000, the factor of wage earners per household was 1.90; therefore, for a comparative analysis, the 1.37 and 1.90 factors were used to compute the average income levels for a peak hour commuters along C-470. Table 5.2 summarizes the results from calculating average hourly wage rates for drivers along the corridor. It shows that by using the 1.37 and 1.90 factors, the average annual income is $62,687 and $45,200, respectively. Using the methodology that a driver's value of time under normal commuting conditions is approximately 50 percent of a driver's hourly wage, the 1.37 and 1.90 factors result in a $15.07 per hour and $10.87 per hour average value of time. Taking the average of these two values results in an overall value of time of $12.97 per hour.

Based on the documented values of time in previous studies, and the results from the stated preference survey, it is shown that an $11 to $15 per hour value could be used for a driver's value of time during highly congested periods. During off peak and shoulder peaks, where congestion levels are much lower, a driver's value of time would be closer to a value of $6 per hour. Therefore, $15 per hour was used in the analysis for this study. All values are in 2004 dollars.

Table 5.2
Value of Time Calculation for Corridor Users

Arapahoe/Douglas/ Jefferson County Average in 2000	Arapahoe/Douglas/ Jefferson County Average in 2004	Mean Number of Earners per Household in 2003		Average Annual Income of Commuters		Average Hourly Wage of Commuters ($/hr)		Average Value of Time ($/hr)	
$78,898	$85,881	1.37	1.9	$62,687	$45,200	$30	$22	$15	$11
Taken from U.S. 2000 census data for areas within the C-470 corridor study area	Inflated to 2004 dollars based on CPI Index	Assumes 1.37 people in household would commute during peak hours (taken from DRCOG 1997 household survey)	Assumes 1.9 people in household would commute during peak hours (taken from National CPS Annual Demographic Survey for income levels around three-county average in 2003)	DRCOG	CPS (Bureau of Labor Statistics and Bureau of the Census	Assumes 40-hour work week for 52 weeks a year		Assumes commuters value of time is equal to 50% of hourly wage	

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6.0 FUTURE TRAFFIC CONDITIONS

To obtain an accurate representation of projected future traffic volumes and travel patterns, a thorough analysis of land use plans within the study area was conducted. Analysis of the study area land use data included confirming existing conditions, reviewing land use plans and information from all local agencies, and developing land use data for future conditions to assess differences. A consideration with this approach was that the potential land use values presented in the DRCOG's conformed datasets were not constrained.

Specifically, the DRCOG datasets for 2001, 2010, and 2025 that use the 1,530 zone TAZ system was used as a basis. Due to the rapid pace of change in some corridor areas between 2001 and today, it was necessary to update the existing land use data to accurately reflect current conditions; this was done by comparing the DRCOG 2001 dataset with the existing conditions in the area of influence. This comparison allowed the travel demand model to be accurately calibrated to land use inputs and provided a higher level of correlation between land use and traffic data.

Meetings with local agencies in the study area were then held to gather their land use plans, ideas for change, and other information relevant to potential land use changes. The information included not only the magnitude of developments but also the potential timeframe of build out of the developments. The data were then used to develop land use scenarios for 2010 and 2025; included was existing development and all development slated to occur by those timeframes. The study included inspecting of every TAZ in the area of influence for both 2010 and 2025 to determine the amount of development in each. These new datasets were then compared to DRCOG's conformed datasets for 2010 and 2025 to assess differences. It was determined that the developed datasets were generally similar to the DRCOG conformed datasets, except in the southern portion of the area of influence, south of C-470 in Douglas and Arapahoe counties.

The land use adjustments were then shared with local agencies to obtain concurrence with the process used and the results for their areas of jurisdiction. At the conclusion of this process, it was agreed that the developed datasets more accurately reflected current and planned development in the area of influence than the DRCOG conformed datasets. DRCOG planners were also consulted on the refinements made to the model; the planners concurred with, and approved, said refinements. The developed datasets were then used for travel demand modeling for the project.

6.1.1 Average Annual Daily Traffic

The travel demand model was used to generate projected average annual daily traffic (AADT) volumes for the 2025 design year for C-470 and major arterial roadways. The projected 2025 volumes show the highest volumes being on the eastern segment of the corridor. The bi-directional ADT volumes along C-470 in the vicinity of Platte Canyon Road and Yosemite Street are approximately 120,000 and 150,000 vehicles, respectively. These figures show that the eastern segment of the corridor carries approximately 25 percent more vehicles daily than the western portion. The peak directional to non-peak directional distribution of traffic is predicted to be approximately 51 percent to 53 percent to 49 percent to 47 percent for future traffic conditions.

6.1.2 Peak Hours

The projected 2025 AM and PM peak hour volumes were generated by applying the projected growth rate for each TAZ to existing turning movement counts. Existing peak period patterns and durations were maintained without any peak spreading for the future conditions to enable a conservative analysis of the express lane ridership. These volumes are shown in Figures 6.1 and 6.2.

6.1.3 Travel Time Observations

Travel times along the C-470 corridor were obtained from the calibrated micro-simulation model for future conditions. Travel time data were collected for each segment between interchanges and later summed to obtain the total peak hour travel time along C-470 in both directions. This analysis indicated that the travel time on the express lanes from Kipling Parkway to I-25 is approximately 13 minutes, and travel time along the general purpose lane for the same stretch is approximately 27 to 34 minutes in the peak volume direction. The PM peak hour travel time observations are shown in Figure 6.3.

6.1.4 Levels of Service/Densities

A LOS analysis was conducted to assess the operations of the intersections, ramps, and freeway segments in the study area. LOS analysis was based on Highway Capacity Manual (HCM) prescribed procedures. The LOS analysis indicated that the express lanes operate at LOS D or better, while the non-toll or general purpose lanes operate at LOS E or F. Analysis of signalized intersections showed that 17 out of the total 67 intersections operate at LOS E or worse. Tables 6.1, 6.2, and 6.3 summarize the HCS analysis completed for the intersections and freeway segments for the AM and PM peak hours.

Figure 6.1
Projected AM Peak Hour Volumes

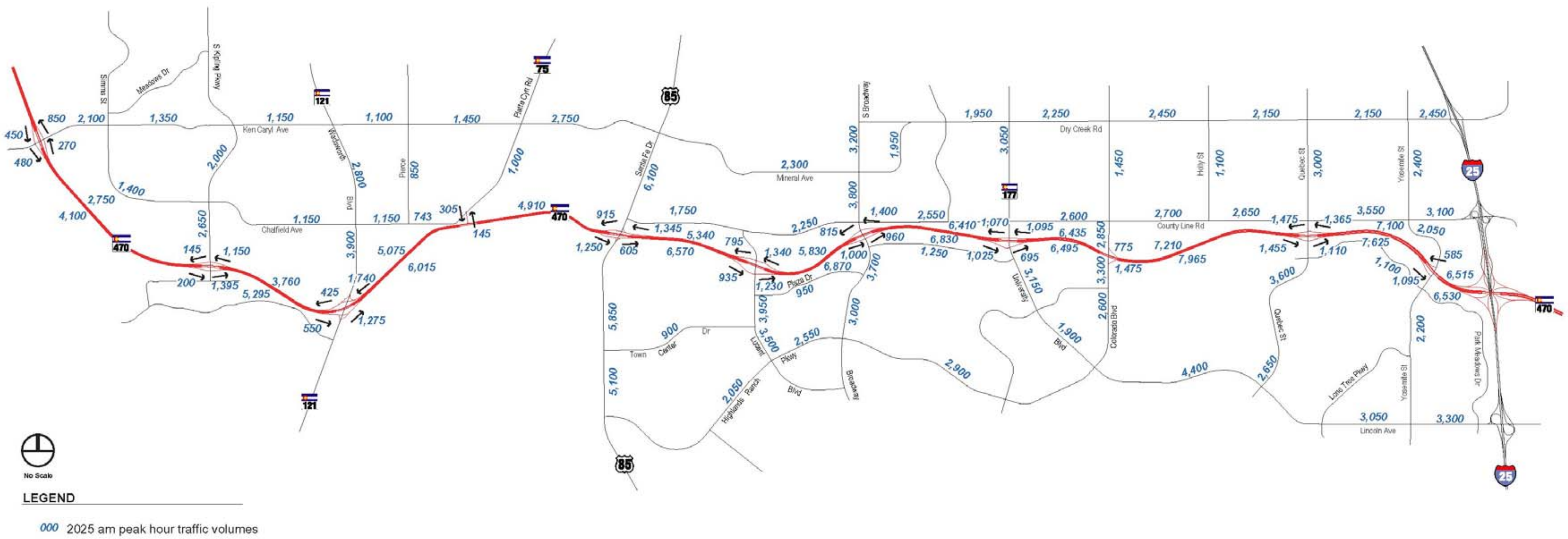


Figure 6.2
Projected PM Peak Hour Volumes

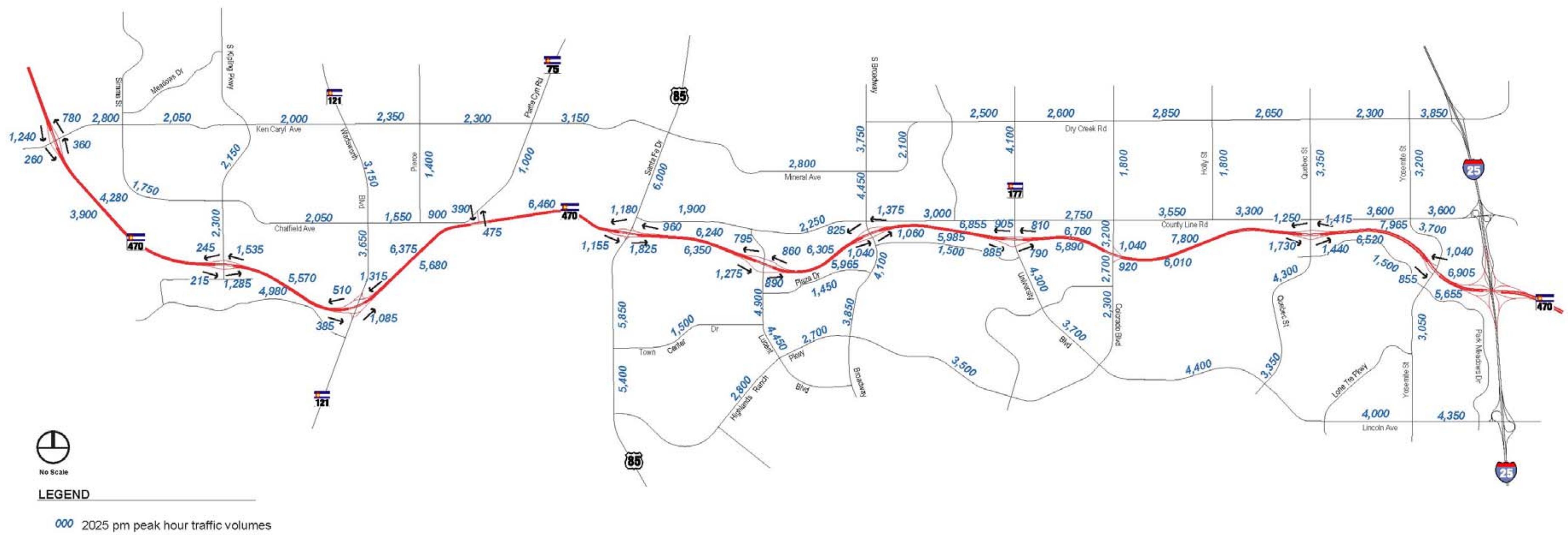
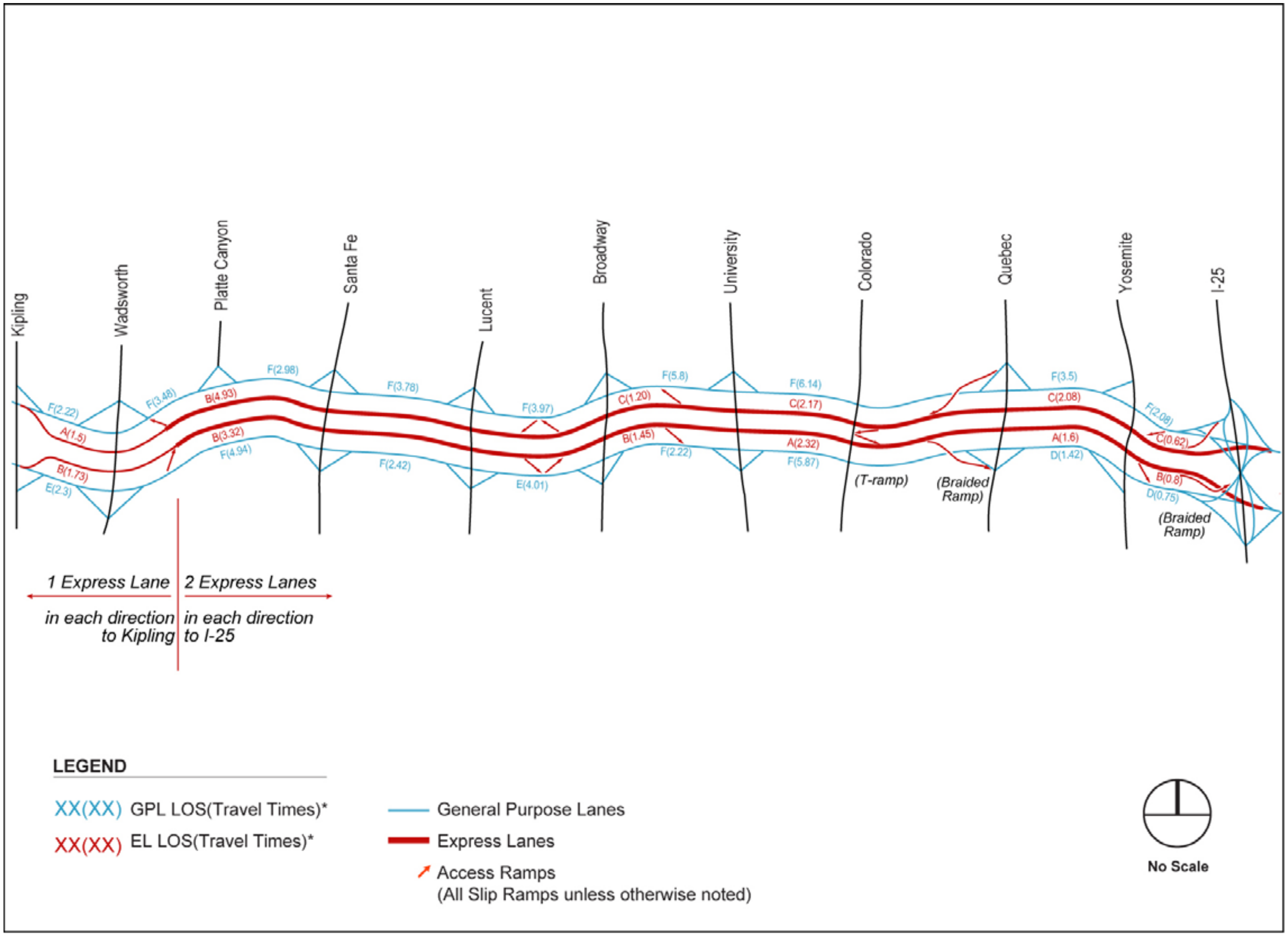


Figure 6.3
PM Peak Hour Travel Times



* Travel Time in minutes

Table 6.1
AM/PM Peak Hour Intersection Delay and Levels of Service

Intersection	AM Average Delay (seconds)	AM LOS	PM Average Delay (seconds)	PM LOS
Ken Caryl Avenue/West Ramps	17.13	B	17.79	B
Ken Caryl Avenue/East Ramps	6.47	A	15.51	B
Ken Caryl Avenue/Simms Street	26.90	C	36.11	D
Ken Caryl Avenue/Simms Street	41.90	D	35.63	D
Chatfield Avenue/Kipling Parkway	37.56	D	46.81	D
Kipling Parkway/North Ramps	17.07	B	13.96	B
Kipling Parkway/South Ramps	32.74	C	36.48	D
Ken Caryl Avenue/Wadsworth Boulevard	30.79	C	45.04	D
Chatfield Avenue/Wadsworth Boulevard	37.39	D	50.89	D
Wadsworth Boulevard/North Ramps	16.35	B	20.49	C
Wadsworth Boulevard/South Ramps	39.53	D	47.15	D
Ken Caryl Avenue/Pierce Street	34.41	C	38.82	D
Chatfield Avenue/Pierce Street	9.53	A	12.87	B
Ken Caryl Avenue/Platte Canyon Drive	51.77	D	27.23	C
Chatfield Avenue/Platte Canyon Drive	49.37	D	>100.00	F
Santa Fe Drive/Mineral Avenue	52.79	D	62.57	E
Santa Fe Drive/County Line Road	41.86	D	24.80	C
Santa Fe Drive/North Ramps	32.44	C	36.72	D
Santa Fe Drive/South Ramps	45.45	D	32.35	C
Santa Fe Drive/Blakeland Drive	27.11	C	32.97	C
Santa Fe Drive/Town Center Drive	22.74	C	12.77	B
Santa Fe Drive/Highlands Ranch Parkway	55.79	E	64.77	E
Lucent Boulevard/County Line Road	14.55	B	34.53	C
Lucent Boulevard/North Ramps	23.34	C	33.02	C
Lucent Boulevard/South Ramps	6.77	A	16.98	B
Lucent Boulevard/Plaza Drive	30.32	C	34.02	C
Lucent Boulevard/Town Center Drive	19.46	B	12.12	B
Lucent Boulevard/Highlands Ranch Parkway	34.78	C	35.77	D
Broadway/Dry Creek Road	25.99	C	27.38	C

Intersection	AM	AM	PM	PM
	Average Delay (seconds)	LOS	Average Delay (seconds)	LOS
Broadway/Mineral Avenue	47.38	D	75.73	E
Broadway/County Line Road	84.63	F	91.72	F
Broadway/North Ramps	33.19	C	30.34	C
Broadway/South Ramps	22.95	C	21.37	C
Broadway/Dad Clark Drive	52.49	D	51.21	D
Broadway/Plaza Drive	48.62	D	31.89	C
Broadway/Highlands Ranch Parkway	>100.00	F	67.90	E
Mineral Avenue/Dry Creek Road	11.76	B	24.42	C
University Boulevard/Dry Creek Road	50.54	D	66.24	E
University Boulevard/County Line Road	85.69	F	>100.00	F
University Boulevard/North Ramps	28.33	C	10.76	B
University Boulevard/South Ramps	19.59	B	10.94	B
University Boulevard/Dad Clark Drive	26.71	C	25.78	C
University Boulevard/Highlands Ranch Parkway	42.89	D	85.04	F
Colorado Boulevard/T-Ramps	50.08	D	20.10	C
Colorado Boulevard/Dry Creek Road	35.59	D	54.00	D
Colorado Boulevard/County Line Road	66.75	E	69.13	E
Holly Street/Dry Creek Road	70.66	E	>100.00	F
Holly Street/County Line Road	25.91	C	30.28	C
Quebec Street/Dry Creek Road	77.58	E	>100.00	F
Quebec Street/County Line Road	70.27	E	>100.00	F
Quebec Street/North Ramps	18.01	B	20.42	C
Quebec Street/South Ramps	34.93	C	26.55	C
Quebec Street/Park Meadows Drive	>100.00	F	71.89	E
Quebec Street/University Boulevard	54.55	D	57.89	E
Yosemite Street/Dry Creek Road	49.23	D	>100.00	F
Yosemite Street/County Line Road	53.56	D	>100.00	F
Yosemite Street/South Ramps	15.73	B	29.77	C
Yosemite Street/North Ramps	20.46	C	59.14	E
Yosemite Street/Park Meadows Drive	20.07	C	77.17	E
Yosemite Street/Lincoln Avenue	34.06	C	42.65	D

Table 6.2
AM Peak Hour Freeway Levels of Service/Density

Express Lanes - Eastbound			
From	To	Density	LOS
Kipling	Wadsworth	19.18	C
Wadsworth	Lucent	19.37	C
Lucent	Broadway	17.05	B
Broadway	Colorado	16.10	B
Colorado	Quebec	33.67	D
Quebec	Yosemite	26.55	D
Yosemite	I-25	25.10	C
General Purpose Lanes - Eastbound			
From	To	Density	LOS
Ken Caryl Ramps		23.00	C
Ken Caryl	Kipling	39.66	E
Kipling Ramps		32.79	D
Kipling	Wadsworth	39.51	E
Wadsworth Ramps		105.51	F
Wadsworth	Santa Fe	52.55	F
Santa Fe Ramps		23.03	C
Santa Fe	Lucent	94.55	F
Lucent Ramps		52.91	F
Lucent	Broadway	69.25	F
Broadway Ramps		84.37	F
Broadway	University	67.79	F
University Ramps		36.79	E
University	Quebec	41.58	E
Quebec Ramps		24.42	C
Quebec	Yosemite	33.83	D
Yosemite	I-25	55.29	F

Express Lanes - Westbound			
From	To	Density	LOS
I-25	Yosemite	9.74	A
Yosemite	Quebec	11.03	B
Quebec	Colorado	23.15	C
Colorado	Broadway	12.93	B
Broadway	Lucent	8.58	A
Lucent	Wadsworth	4.76	A
Wadsworth	Kipling	4.50	A
General Purpose Lanes - Westbound			
From	To	Density	LOS
I-25	Yosemite	9.74	A
Yosemite Ramps		0.00	-
Yosemite	Quebec	23.46	C
Quebec Ramps		53.55	F
Quebec	University	44.79	E
University Ramps		62.24	F
University	Broadway	73.23	F
Broadway Ramps		99.14	F
Broadway	Lucent	61.64	F
Lucent Ramps		44.40	E
Lucent	Santa Fe	64.23	F
Santa Fe Ramps		18.09	C
Santa Fe	Platte Canyon	0.00	A
Platte Canyon Ramps		0.00	-
Platte Canyon	Wadsworth	26.02	D
Wadsworth Ramps		16.08	B
Wadsworth	Kipling	27.49	D
Kipling Ramps		13.54	B
Kipling	Ken Caryl	19.18	C
Ken Caryl Ramps		12.94	B

Table 6.3
PM Peak Hour Freeway Levels of Service/Density

Express Lanes - Eastbound			
From	To	Density	LOS
Kipling	Wadsworth	17.31	B
Wadsworth	Lucent	8.62	A
Lucent	Broadway	9.72	A
Broadway	Colorado	7.26	A
Colorado	Quebec	13.84	B
Quebec	Yosemite	9.50	A
Yosemite	I-25	11.15	B
General Purpose Lanes - Eastbound			
From	To	Density	LOS
Ken Caryl Ramps		26.13	D
Ken Caryl	Kipling	48.60	F
Kipling Ramps		70.58	F
Kipling	Wadsworth	97.20	F
Wadsworth Ramps		98.73	F
Wadsworth	Santa Fe	53.71	F
Santa Fe Ramps		19.89	C
Santa Fe	Lucent	31.51	D
Lucent Ramps		59.10	F
Lucent	Broadway	58.53	F
Broadway Ramps		50.18	F
Broadway	University	70.63	F
University Ramps		20.35	C
University	Quebec	39.32	E
Quebec Ramps		20.66	C
Quebec	Yosemite	27.42	D
Yosemite	I-25	25.80	C

Express Lanes - Westbound			
From	To	density	LOS
I-25	Yosemite	20.01	C
Yosemite	Quebec	27.85	D
Quebec	Colorado	32.56	D
Colorado	Broadway	20.47	C
Broadway	Lucent	18.86	C
Lucent	Wadsworth	14.09	B
Wadsworth	Kipling	28.82	D
General Purpose Lanes - Westbound			
From	To	Density	LOS
I-25	Yosemite	20.01	C
Yosemite Ramps		0.00	-
Yosemite	Quebec	50.19	F
Quebec Ramps		52.79	F
Quebec	University	73.02	F
University Ramps		76.25	F
University	Broadway	73.26	F
Broadway Ramps		112.46	F
Broadway	Lucent	67.07	F
Lucent Ramps		56.55	F
Lucent	Santa Fe	55.12	F
Santa Fe Ramps		21.12	C
Santa Fe	Platte Canyon	68.87	F
Platte Canyon Ramps		0.00	-
Platte Canyon	Wadsworth	29.41	D
Wadsworth Ramps		25.12	C
Wadsworth	Kipling	66.54	F
Kipling Ramps		85.23	F
Kipling	Ken Caryl	37.94	E
Ken Caryl Ramps		50.40	F

6.2 TRAFFIC MODELING

Two traffic modeling software programs were used in the analysis of the express toll lanes. The TP+ model, an extension of the DRCOG MINUTP, was used initially due to its ability to model toll lane demand within a macroscopic model. By using the TP+ model initially, the number of access points that needed to be modeled later in the AIMSUN model was reduced. The AIMSUN micro-simulation model was primarily used for the majority of the express lane analysis. It was used to estimate the traffic diversion into the express lanes, and to analyze the traffic operations in the express lanes.

6.2.1 Initial Toll Diversion Forecasts Using Travel Demand Model

The TP+ model is an extension of the macroscopic travel demand model that allows for the assignment of trips to toll roads based on a given toll rate in order to predict volume at potential express lane access locations. Before using the AIMSUN micro-simulation model, a cursory analysis of access locations was performed to reduce the number of alternatives and the amount of calibration that needed to be performed to the AIMSUN model. The TP+ model also allowed for the modeling of the potential extension of C-470 to the northwest corridor to determine the amount of demand that was created through the extension. Using the origin and destination matrices in the travel demand model, the connection between C-470 and the northwest corridor showed little demand for trips between the two corridors. The majority of trips along C-470 are contained within the southwest quadrant of the metro area, with little demand to travel outside the area except to connect to I-70 or I-25. It is anticipated as the entire beltway system reaches full build out, and development exists along its entire length, trips between beltway segments will increase.

6.2.2 Forecasts and Traffic Operations Using Micro-simulation Model

Origin and destination matrices from the regional travel demand model were used as volume input into the simulation model, which was calibrated to mirror traffic operations for existing conditions along C-470. Various parameters including queue lengths, delays, and existing turning movement counts were used to compare and calibrate the dynamic assignment model in AIMSUN to produce results similar to existing conditions. Express lanes were introduced in the simulation model after calibrating the model for existing conditions.

The proportion of travelers using each section of the express lanes was calculated using the dynamic traffic assignment model in the AIMSUN micro-simulation program. The program uses dynamic traffic assignment algorithms to estimate the probability of travelers using a given route from a set of available routes between each origin and destination. The calculated probability is a function of a "utility" that is calculated for each route. The AIMSUN route choice model used is a discrete path choice model, referred to as the C-logit model, and is a variation of the multinomial logit model. The model calculates the choice probability for a given route using the value of the utility of that path as compared to utilities of all other alternative paths.

The utility or the "cost function" can be defined by the user to include a combination of path variables. In this study, the cost function is defined as a combination of travel time and monetary costs as follows:

$$\text{utility} = \text{travel time} + a * \text{monetary cost} \qquad (1)$$

The coefficient "a" in the above equation is used to convert the monetary cost in dollars to travel time in minutes. This value can be estimated based on how much commuters value their travel times; that is, how much they are willing to pay in dollars to save in their travel times.

The value of the coefficient "a" was estimated based on a model developed from results from the stated preference survey completed as part of the ELFS. The model was developed to estimate the monetary cost that the commuters are willing to pay to use the express lanes under different travel time conditions on the C-470 corridor. The model has the following format:

$$\text{time saved per mile} = \text{coefficient} * \text{cost per mile} \qquad (2)$$

The statistical analysis performed in the survey indicated that the following model produced the best fit for the data:

$$\text{time saved per mile (minutes)} = 10.019 * \text{cost per mile (dollars)} \qquad (3)$$

Thus, the utility equation to decide on the route choice probability (Equation 1) was coded in the simulation model as follows:

$$\text{utility} = \text{travel time} + 10.019 * \text{monetary cost} \qquad (4)$$

Also, in the simulation model, monetary costs were assigned to express lane sections as follows:

$$\text{express lane section monetary cost} = \text{express lane section length} * \text{cost per mile} \qquad (5)$$

For all other segments, the monetary costs were set to zero so that the utility values for these segments were equal to the travel time on the segments.

The dynamic traffic assignment model assigned the number of trips to the express lanes based on the congestion levels in the general purpose lanes and how much these travelers were willing to pay to avoid these congestion levels, according to Equation 4. During the calibration process, the number of express lane users projected by the simulation model was compared to the number of users derived from the responses in the stated preference survey. If necessary, the model parameters were refined to have the model more accurately reflect the survey results.

To determine the revenue generated from a given express lane cost per mile charge, the following equation was used:

revenue (dollars) = toll charged per vehicle per mile * EL VMT (6)

EL VMT in the above equation is the express lane vehicle mile traveled. Separate simulation runs were performed with different toll rates on the express lanes to determine the toll that produced the best traffic operations combined with the most users.

6.2.3 Calibration of AIMSUN Model

Various parameters including queue lengths, delays, and existing turning movement counts were used to compare and calibrate the dynamic assignment model in AIMSUN to produce results similar to existing conditions. All intersections in the study area were initially analyzed for the existing AM and PM peak volumes and for the existing laneage using the HCM methodologies to identify oversaturated movements and intersections.

Queue data were later collected for these pre-identified, oversaturated movements to measure queues and discharge volumes in the AM and PM peak period. Queue and discharge data were collected every 20 seconds for a minimum of 20 minutes, or 10 signal cycles, to obtain the queue build-up pattern, discharge rate for a specific movement, and queue length. These data, in conjunction with signal timing and phasing patterns were then used not only to verify existing counts but also to calibrate the model. Travel time data and spot traffic volume counts on C-470 were collected to calibrate the micro-simulation model and validate the data collected.

The micro-simulation model was developed using existing laneage, volume, speed, and signal timing information. The micro-simulation model was then calibrated by adjusting vehicle performance, link saturation flow rates, decision distances, and maximum allowable speeds for various turning movements such that the queue build-up patterns, travel speeds, discharge rates, and queue lengths observed in the micro-simulation model were similar to those observed in the field.

Express lanes were introduced into the micro-simulation model after the existing conditions model had been calibrated, validated, and verified against existing operational (field) conditions. The express lanes were introduced with an initially assumed toll rate and the pre-determined value of time to assess validity of traffic diverting into the express lanes. The express lane traffic volumes were then examined for reasonableness by using the pre-determined value of time and the delay or travel time savings (along C-470) that was being predicted by the micro-simulation model.

The micro-simulation model was further refined until equilibrium was achieved between the declared value of time, toll price, and projected travel time savings. This calibrated model was used as a basis for coding and analyzing the proposed future configurations.

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7.0 PROJECT ELEMENTS

In conjunction with beginning the access screening process, several key elements that were used in determining the feasibility of the alternatives were developed. General design considerations were determined including the typical section, method of separating the express and general purpose lanes, and access ramp types. Once the general design components were developed, the basis for cost estimating was initiated; this included compiling capital unit cost information and historic O&M costs. Another key element was the formulation of the present value analysis spreadsheet, which included determining a typical range in bonding rates, coverage rates, and present value calculations.

7.1 DESIGN CONSIDERATIONS

The express lane design began by establishing appropriate design criteria for the facility layout. To develop recommended alternatives to minimize impact to these constraints, key design constraints were identified and existing conditions were analyzed to these constraints. Next, a typical section analysis was performed to determine the express lanes configuration. Once the roadway layout was determined, cost estimates were prepared for use in determining the financial feasibility of the final alternative.

7.1.1 Design Criteria

The criteria used for the design of the express lane alternative included the CDOT Transportation Design Guide (1995), A Policy on Geometric Design of Highways and Streets (2001), Roadside Design Guide (2002), Colorado State Highway Access Code (2002), and the CALTRANS High Occupancy Vehicle Guidelines for Planning, Design and Operations (2003). Table 7.1 identifies the applicable design criteria used from these sources.

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Table 7.1
Roadway Design Criteria

Design Criteria	C-470 Mainline Criteria	Mainline Reference	Express Lanes Criteria	Express Lanes Reference	Normal Ramps Criteria	Normal Ramps Reference	Flyover/ Directional Ramps Criteria	Flyover/ Directional Ramps Reference	Loop Ramps Criteria	Loop Ramps Reference	Remarks
Posted Speed (mph)	65		65								
Design Speed (mph)	70	CDOT pg 8-1	70	CDOT pg 8-1	50	PGDH pg 829-830	60/(50)* 50/(40)**	PGDH pg 829-830	30/(25)	PGDH pg 829-830	* XX desirable/ (XX) minimum - System to System ** XX desirable/ (XX) minimum - System to Service
Lane Widths (ft)	12	CDOT pg 8-2	12	CDOT pg 8-2	15 or 12*	CDOT pg 3-31	15 or 12*	CDOT pg 3-31	16	CDOT pg 3-31	* 15' lane width for single lane ramps, 12' for dual lane ramps
Shoulder Widths (ft)											
Inside Shoulder Options	8*		8*		4	CDOT pg 10-36	4	CDOT pg 10-36	4	CDOT pg 10-36	* Recommended shoulder width, 4' minimum in areas of constraint
(Left Ramp Shoulder)	12**	PGDH pg 509	14***	NCHRP 414	6****	PGDH pg 319	6****	PGDH pg 319	6****	PGDH pg 319	** For use where truck DHV > 250 & number of express lanes exceeds 2 in one direction
	14***	NCHRP 414									*** Enforcement - Confirm location of enforcement shoulder with CSP
											**** For use next to barrier
											Note: All shoulder decisions may be dependant on horizontal sight distance considerations
Outside Shoulder Options	12	PGDH pg 818	12	PGDH pg 818	6	CDOT pg 10-36	6	CDOT pg 10-36	6	CDOT pg 10-36	* For use adjacent to auxiliary lanes
(Right Ramp Shoulder)	8*	PGDH pg 818	14**	NCHRP 414	8	CDOT pg 10-36	8	CDOT pg 10-36	8	CDOT pg 10-36	** Enforcement - Confirm location of enforcement shoulder with CSP
											Note: 6' right ramp shoulders are for single lane ramps, 8' for dual lane ramps or for shoulder adjacent to barrier
HOV Buffer	4										
Minimum Clear Zone (ft)	30	RDG pg 3-4	30	RDG pg 3-4	18	RDG pg 3-4	18	RDG pg 3-6	18	RDG pg 3-4	
Shy Line Offset (ft)	10	RDG pg 5-28	10	RDG pg 5-28	7	RDG pg 5-28	6	RDG pg 5-28	4	RDG pg 5-28	Note: For roadside structures such as signs
Normal Cross Slope (%)	2	CDOT pg 4-2	2	CDOT pg 4-2	2	CDOT pg 10-31	2	CDOT pg 10-31	2	CDOT pg 10-31	
"Z" Slope - 12 ft	6:1	CDOT pg 8-7	6:1	CDOT pg 8-7	6:1	CDOT pg 8-14	6:1	CDOT pg 8-14	6:1	CDOT pg 8-14	
Maximum Super Elevation (%)	0.06	CDOT pg 3-25	0.06	CDOT pg 3-25	0.06*		0.06*		0.06*		*CDOT Preference on ramps.
Minimum Horizontal Radius (ft)	2050	PGDH pg 145	2050	PGDH pg 145	835	PGDH pg 145	510-1340	PGDH pg 145	185-275	PGDH pg 145	Note: Based on maximum super elevation and design speed
Minimum Profile Grade (%)	0.5	CDOT pg 3-39	0.5	CDOT pg 3-39	0.5	CDOT pg 3-39	0.5	CDOT pg 3-39	0.5	CDOT pg 3-39	
Maximum Profile Grade (%)	4	CDOT pg 8-2	4	CDOT pg 8-2	5	CDOT pg 8-2	5	CDOT pg 8-2	5	CDOT pg 8-2	Note: Based on rolling terrain
Maximum Profile Grade at Intersections (%)					250' @ 2%	Douglas County	250' @ 2%	Douglas County	250' @ 2%	Douglas County	
Stopping Sight Distance (ft)	730	PGDH pg 112	730	PGDH pg 112	425	PGDH pg 112	305-570	PGDH pg 112	155-200	PGDH pg 112	Note: Allow horizontal sight distance across barriers. Use 3d graphical solutions for areas with vertical curvature. Glare screen not allowed.
Decision Sight Distance (ft)	1275	PGDH pg 116	1275	PGDH pg 116	1025	CDOT pg 3-15	825-1275	CDOT pg 3-15	625	CDOT pg 3-15	Note: Applies to express lane entrances and critical gores
Rate of Vertical Curve (K)											
Crest	247	PGDH pg 274	247	PGDH pg 274	84	PGDH pg 274	44-151	PGDH pg 274	12-19	PGDH pg 274	
Sag	181	PGDH pg 280	181	PGDH pg 280	96	PGDH pg 280	64-136	PGDH pg 280	26-37	PGDH pg 280	
Minimum Vertical Clearance (ft)	16.5	CDOT pg 3-38	16.5	CDOT pg 3-38	16.5	CDOT pg 3-38	16.5	CDOT pg 3-38	16.5	CDOT pg 3-38	
Light Rail Vertical Clearance (ft)	19-23.5		19-23.5		19-23.5		19-23.5		19-23.5		
Heavy Rail Vertical Clearance (ft)	25		25		25		25		25		
Pedestrian Bridge and Sign Bridge Clearance (ft)	17.5		17.5		17.5		17.5		17.5		
Accel Length (ft)	Varies	PGDH pg 851-855	Varies	PGDH pg 851-855	Varies	PGDH pg 851-855	Varies	PGDH pg 851-855	Varies	PGDH pg 851-855	
Decel Length (ft)	Varies	PGDH pg 851-855	Varies	PGDH pg 851-855	Varies	PGDH pg 851-855	Varies	PGDH pg 851-855	Varies	PGDH pg 851-855	
Transition Taper Rate	70:1	PGDH pg 822	70:1	PGDH pg 822	25:1	Access pg 55	25:1	Access pg 55			Note: For lane additions and lane drops
Redirect Taper Rate	70:1	Access pg 57	70:1	Access pg 57	50:1	Access pg 57	50:1	Access pg 57			
Terminals											
Entrance	Taper	CDOT pg 10-46									
Exit	Taper	CDOT pg 10-46									
Left Exit	Parallel	CDOT pg 10-46									
Dual Lane	Fig 10-19	CDOT pg 10-51									
Design Vehicle	WB-67		WB-67		WB-67		WB-67		WB-67		

CDOT = Colorado Department of Transportation Design Guide (1995)
PGDH = A Policy on Geometric Design of Highways and Streets (PGDH 2001 Second Printing)
RDG = Roadside Design Guide (PGDH 2002)
Access = Colorado State Highway Access Code (March 2002)

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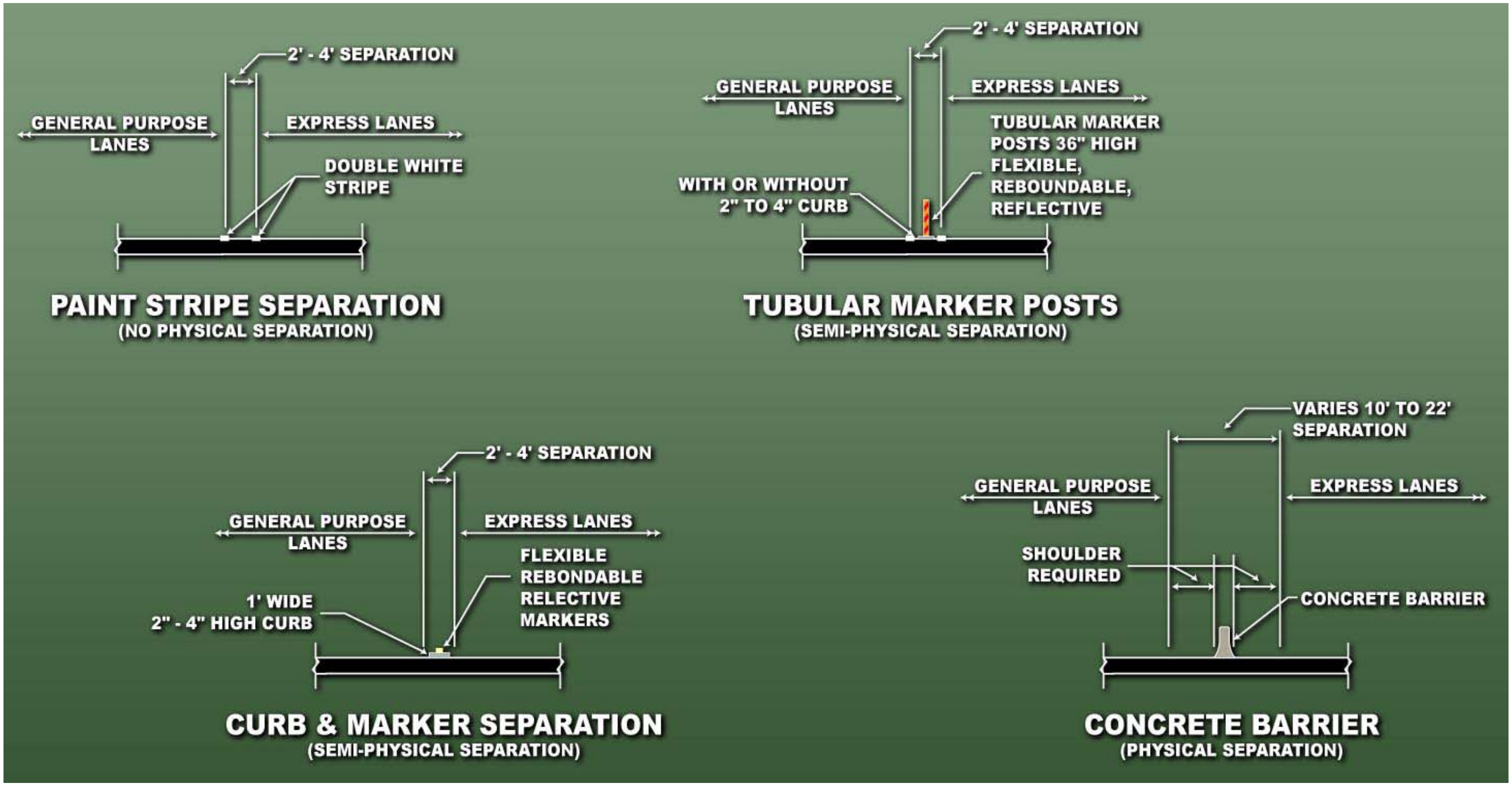
7.1.2 Key Design Issues

As with any roadway project, the final design is based on several factors; this project is no different. Construction costs, environmental impacts, environment justice, Section 4(f)/6(f), express lane ramp design, express lane access types and locations, impacts to the adjacent trail networks, right-of-way (ROW), methods of separation, noise impacts, and roadway typicals all were considered in the ultimate design.

7.1.3 Methods of Separation

Because the express and general purpose lane facilities are two separate facilities with different access locations and different operating characteristics, a separation method was developed that restricted vehicles from traveling between facilities except at designated access points. Four methods of separation were considered, including buffer-separation, tubular marker posts, raised curb and marker, and concrete barrier. Implementation costs, maintenance costs, safety characteristics, and enforcement were all key factors in deciding which method provides the best solution. All options have both positive and negative characteristics, which are shown in Figure 7.1 and discussed in the following actions.

Figure 7.1
Methods of Separation



7.1.4 Buffer Separation

The buffer separation consists of a 4-foot painted buffer between the express and general purpose lanes. While this method is cost effective, it lacks positive enforceability. Without a physical barrier separating the two facilities, vehicles could conceivably enter and exit the express lanes at any point, potentially avoiding the tolling zones and result in lost revenue. Also providing additional enforcement would increase operation costs. Unfortunately, no amount of enforcement would completely eliminate violations. In addition to enforcement difficulties, speed differential with no physical barrier between the two facilities could pose a serious safety hazard. It is anticipated that during the peak hours the general purpose lanes would be moving significantly slower than the express lanes. If a vehicle were to cross over into the other facility, the speed differential between the two facilities could result in a serious accident.

7.1.5 Tubular Marker Posts

Tubular marker posts would use a 2 to 4-foot painted buffer between the two facilities; also, a 3-foot-high tubular marker post/pylon would be installed to separate the two facilities. While providing a visual barrier to drivers in both facilities, the associated maintenance costs to maintain the tubular marker posts would be burdensome for CDOT maintenance staff. In addition to stray vehicles randomly impacting the tubular marker posts, causing CDOT to replace them, the difficulties in maintaining the markers during snow removal would pose a greater issue. The tubular markers would need to be spaced to prevent the possibility of general purpose lane users crossing into express lanes. Similar to the buffer separation method, tubular marker posts would provide little protection against a vehicle leaving one facility and entering another at a large difference in speed.

7.1.6 Curb and Marker

Curb and marker separation would consist of installing a 1-foot wide, 2- to 4-inch-high curb, with flexible re-bondable reflective markers affixed to the top. While reducing the associated maintenance costs found with the tubular marker posts, this method of separation would be problematic during a snow removal, as it would likely be obstructed from view when covered with snow, and it would be subject to impact and damage or removal by a snowplow. This option would pose little visual separation between the two facilities. Also, the raised curb would provide little restriction to a vehicle driving over it, or worse, having the vehicle become airborne upon impact. While providing more of a deterrent than just the buffer separation method, this option would still require manual enforcement to reduce the potential for general purpose lane users to cross into express lanes. Similar to the previous two separation methods, the curb and marker separation method would provide little protection against a vehicle leaving one facility and entering another at a large difference in speed.

7.1.7 Concrete Barrier

The concrete barrier section would involve the construction of a 3-foot-high, 2-foot-wide concrete barrier between the two facilities. The concrete barrier would necessitate the installation of wider shoulders than would the other three separation methods proposed. The concrete barrier would be the most costly of the four methods due to the increased road width and costs associated with constructing the concrete barrier; however, it would provide the greatest safety benefits and eliminate the concern of cross-over traffic between access points. The shoulder between the barrier and travel way should provide adequate room to store most snow during storm events. During storms, snow may need to be loaded onto dump trucks and hauled off site.

Based on the superior safety benefits and low overall maintenance costs associated with the concrete barrier section, this separation method has been chosen for implementation on most of the corridor. In the express lanes segment from Kipling Parkway to Wadsworth Boulevard, where only one express lane will be used in each direction, the buffer separation method has been proposed. The buffer separation method was recommended within this segment due to the potential widening of the express lanes in future years. It is anticipated that eventually four express lanes will be continued from Kipling Parkway to I-70 in a phased approach. This section could be initially constructed at a reduced cost, with the buffer separation fitting inside the existing median. When required, the additional lane in each direction could be added without having to remove the concrete barrier section.

7.1.8 Selection of Final Typical Section

The express lane typical section evolved throughout the study process. The initial typical section used a preferred layout that proposed the complete reconstruction of the general purpose lanes on the outside of the C-470 express lanes. The express and general purpose lanes would both have two 12-foot lanes in each direction. The opposing direction express lanes would be separated with concrete barrier. The initial typical section used preferred shoulder widths of 8-foot inside shoulders and 12-foot outside shoulders in both the express and general purpose lanes.

Based on initial cost estimates to construct the preferred typical section, the typical section required modification to reduce the capital costs. The initial modification reduced the inside shoulder width to 4 feet and the outside shoulder on the general purpose lane to 10 feet. The outside shoulders on both the express and general purpose lanes will still provide adequate width for a vehicle to be stored safely within its limits. The second modification was to reuse the existing pavement for the general purpose lanes and overlay as a means of extending the pavements lifespan. Some pavement sections will need to be replaced due to the substantial cracking and pumping that currently exists in some segments.

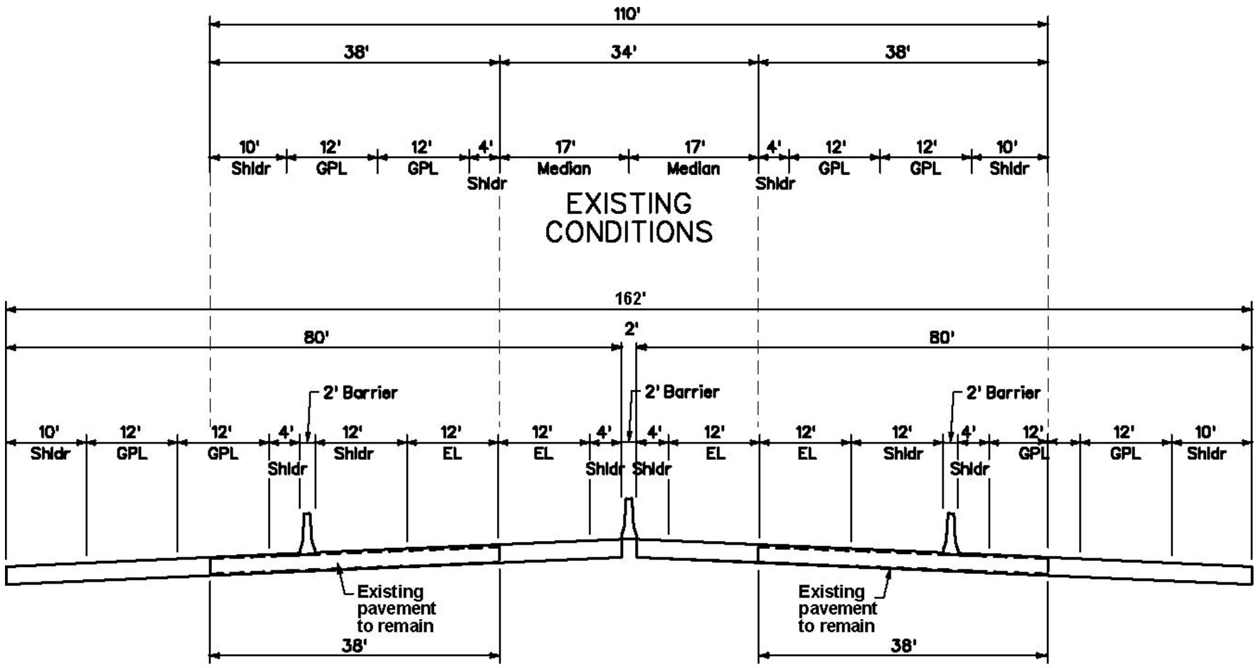
In addition to reducing shoulder widths and reusing existing pavement, other cost savings measures were evaluated. The evaluation determined whether adequate operations could still be provided with a reduced number of express lanes. Two alternatives were developed, including a two-lane reversible facility and a single express lane in each direction facility. A two-lane reversible facility would provide reliability to users in the peak direction at a reduced construction cost. However, the off-peak direction would have no additional capacity added. As the C-470 corridor reaches full build out, there will be less distinction between the peak directions, resulting in similar volumes in both directions during both peak hours. An analysis of corridor operations showed that the two-lane reversible option had significant operational problems in the off-peak direction, resulting in significant breakdowns in the general purpose lanes and surface streets. A cursory cost benefit analysis performed on this alternative showed the projected decrease in construction cost would be offset by the loss in revenue with having only two lanes.

Similar to the two-lane reversible option, the single express lane in each direction would also have a reduced construction cost, but that savings would also be offset by the loss in revenue with having only two lanes. Furthermore, similar operational problems occur along both the express and general purpose lanes due to the lack of capacity to accommodate the demand.

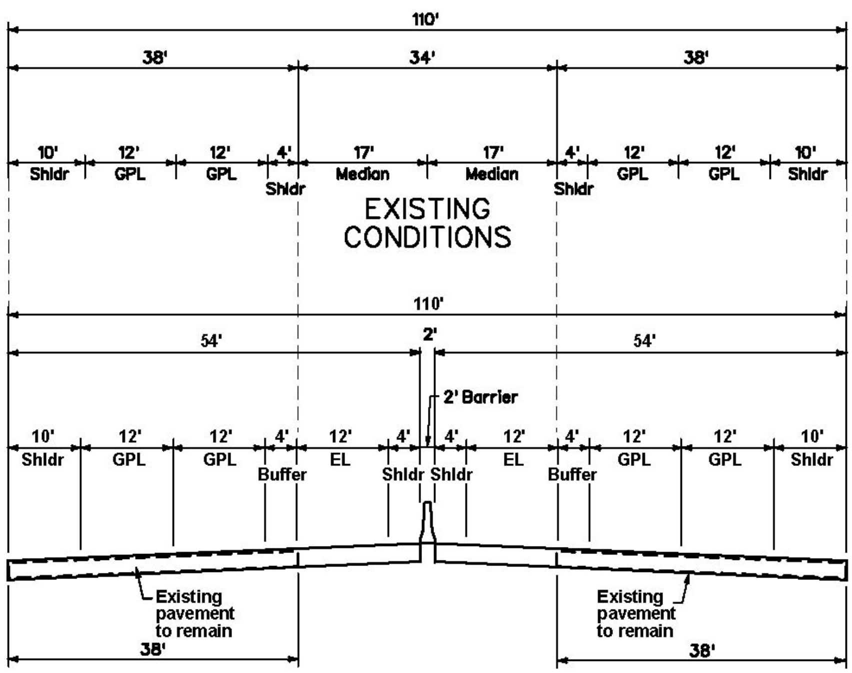
Operationally, these two alternatives did not provide the required capacity and necessary reliability required for an express lane facility.

The previously described four-lane, barrier-separated typical section was therefore selected for recommendation as the preferred concept. The recommended typical section is shown in Figure 7.2.

Figure 7.2
Typical Section



Platte Canyon to I-25

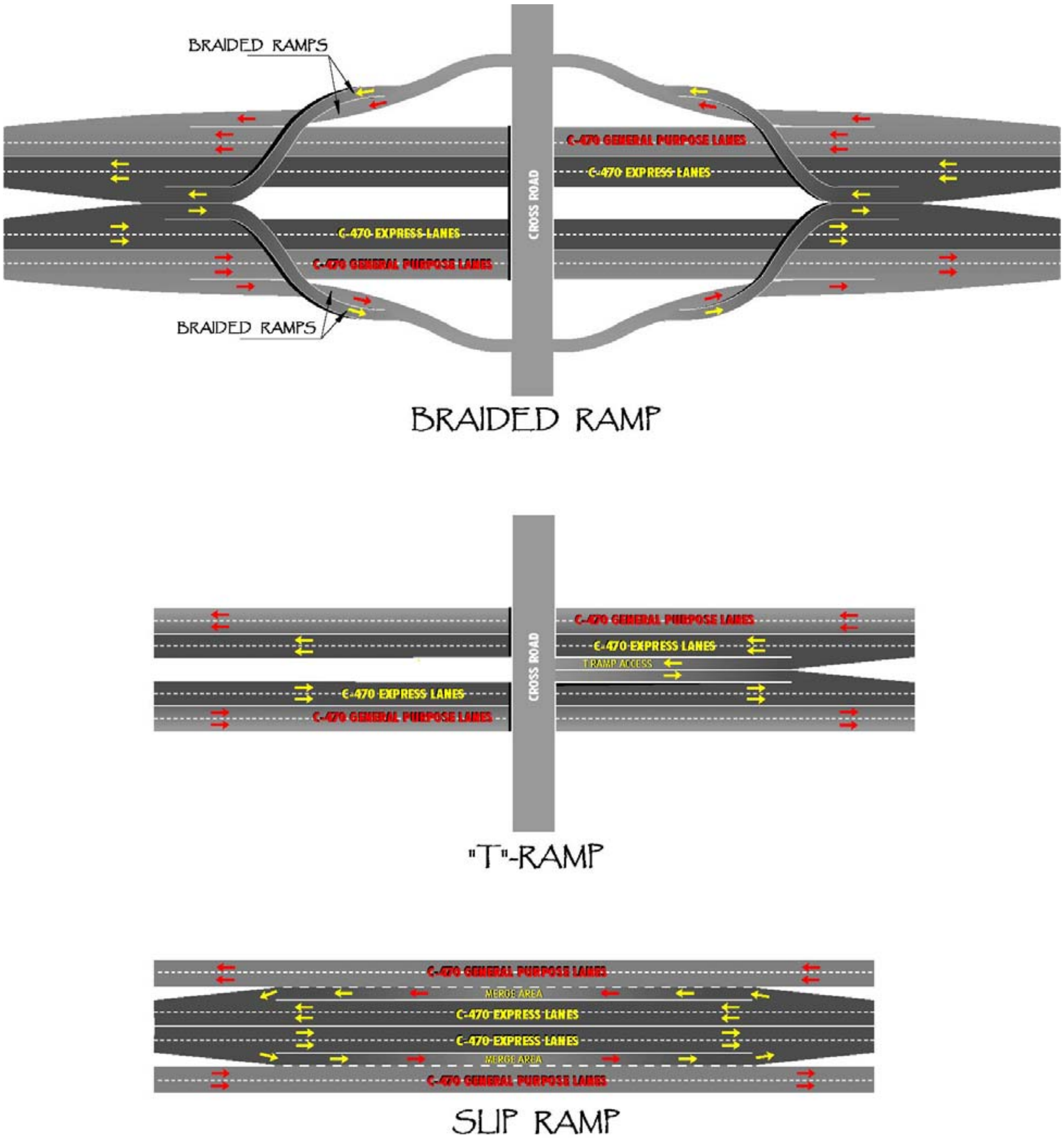


Kipling to Platte Canyon

7.1.9 Access Types

Three types of express lane access ramps were considered in the design: slip ramps, braided ramps, and T-ramps. Figure 7.3 shows their typical configurations, and a description of each type follows.

Figure 7.3
Access Types



The braided ramp configuration utilizes a direct ramp for express lane traffic to access the express lanes, thus avoiding the need to mix with general purpose lane traffic. The braided ramp begins on the outside of the general purpose lane on ramp prior to the ramp metering and connects directly to the inside of the express lanes. This configuration is the most costly due to the bridge structure required to span over the express and general purpose lanes. However, it provides the lowest impact to the adjacent through lanes and offers the best overall traffic operations.

The T-ramp configuration is a form of direct access in which the express lane ramps connect directly to a cross street so that no mixing of express and general purpose lane traffic occurs. On the C-470 corridor, T-ramps were considered only where no general purpose lane ramps were present. By limiting the number of intersections on the cross street to one, the cross street traffic operations are not impaired. The T-ramps will be developed on the inside portion of the express lanes, allowing for the use of a common retaining wall in developing the ramp. This will reduce the structure cost and minimize roadway width in the ramp area.

Slip ramps utilize a break in the barrier to provide an access point between the two facilities. To facilitate weave maneuvers between both facilities, an auxiliary lane is developed on the inside of the general purpose lanes between entry and exit points to the express lanes. This access type is the most cost-effective option as it requires no additional road width, but simply the removal of barrier. However, the least desirable characteristic of this configuration is that it requires express lane and general purpose lane traffic to mix. This mixing of heavy traffic and the need for express lane traffic to change multiple lanes to access a destination interchange can cause additional congestion in the free lanes and reduce the effective time savings for express lanes users. One of the key design considerations of this configuration is to carefully select the location and design features so as to minimize these effects.

7.1.10 Toll Collection Scheme

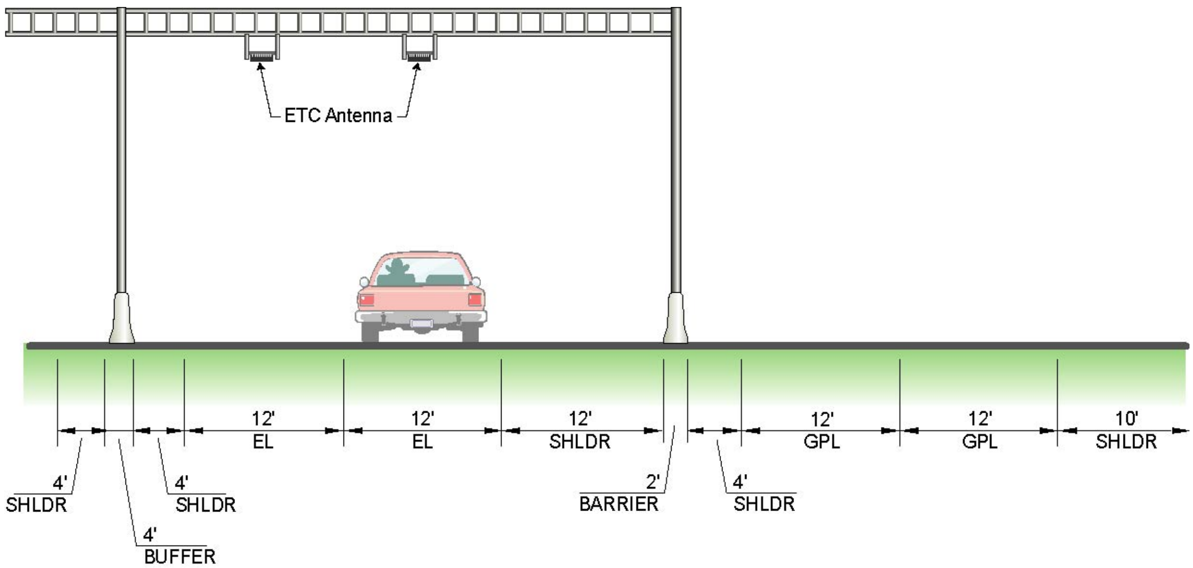
The C-470 express lanes will use electronic toll collection only. This will eliminate the need for traditional toll booths, allowing drivers to maintain their speed while traveling through toll collection zones. All C-470 express lanes facility users will be required to obtain a vehicle-mounted transponder. State statute requires that all toll facilities in Colorado be interoperable. Interoperability refers to the ability of a toll collection system to use the parts, equipment, and user support services of other systems. To meet this requirement, the EXpressToll transponder system which is currently used on both E-470 and the Northwest Parkway toll facilities will be used.

The electronic toll collection system will use antennas mounted on overhead structures caused gantries to record transactions when vehicles pass under the gantry. A driver's account information is stored in the transponder. As the vehicle passes under the gantry, the radio-frequency field emitted from the antenna activates the transponder, which then broadcasts a signal back to the lane antenna with basic account information. That information is transferred from the lane antenna to the central database. The toll is then automatically deducted from the driver's pre-paid EXpressToll account. Figure 7.4 shows a cross section and plan view of the toll collection zones.

Two types of toll systems were considered in the ELFS: barrier systems and closed systems. Barrier toll systems use a toll collection point on the mainline midway between access locations to detect vehicles that cross this imaginary barrier. It is simplistic and effective, especially for express lanes with limited access points. A vehicle that passes a barrier is charged the toll for that section of the express lanes. Closed toll systems use a toll collection gantry at every entry and exit point to track a vehicle's precise entry and exit location. That information is then used to calculate trip length and apply the appropriate rate per mile to compute the toll. Additional gantries required at each access point increase the capital cost of this scheme and make this alternative less attractive. The closed toll system, however, provides the most toll equity by tracking a vehicle through the entry and exit points.

For an express lanes facility, the higher level of vehicle tracking associated with the closed system is not necessary, and the additional capital cost does not provide an added benefit. Because the barrier system will provide the same functionality at a lower cost, the barrier system was selected as the preferred toll collection system for the C-470 express lanes. Figure 7.5 shows the proposed toll collection scheme and illustrates the locations of gantries on the corridor.

Figure 7.4
Typical Toll Collection Zone



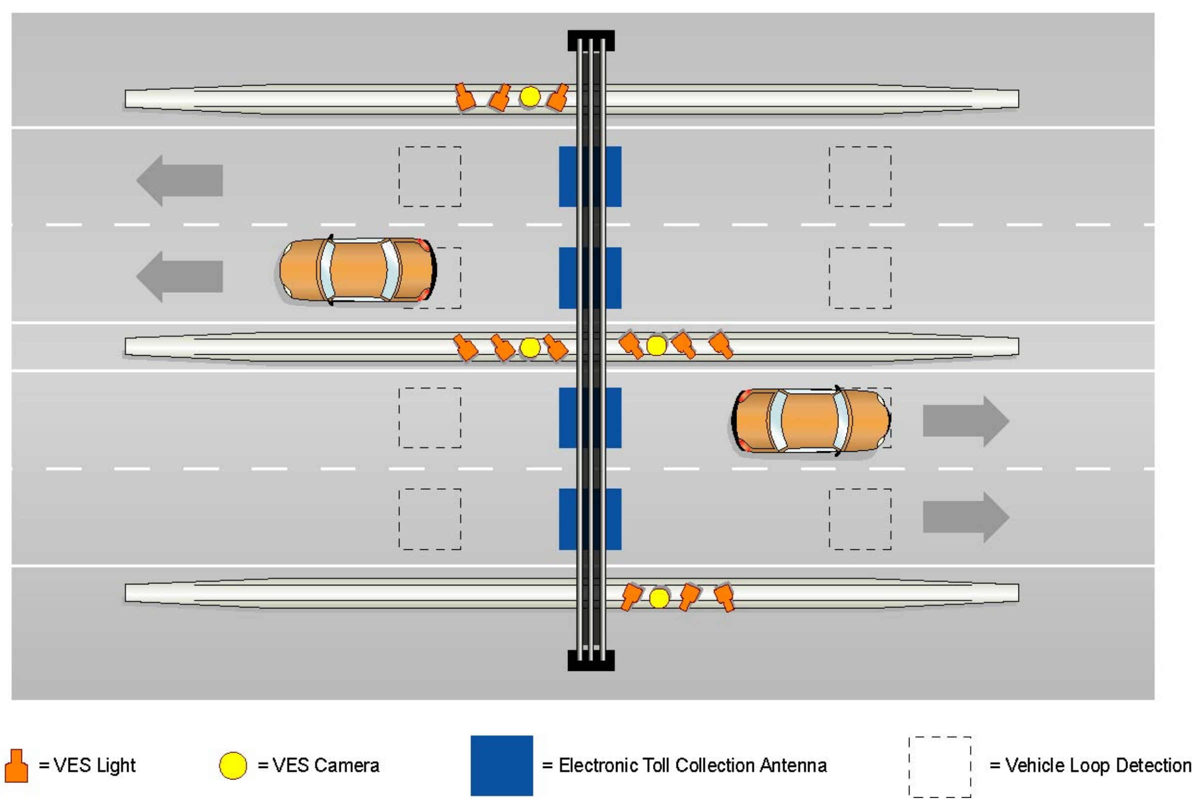
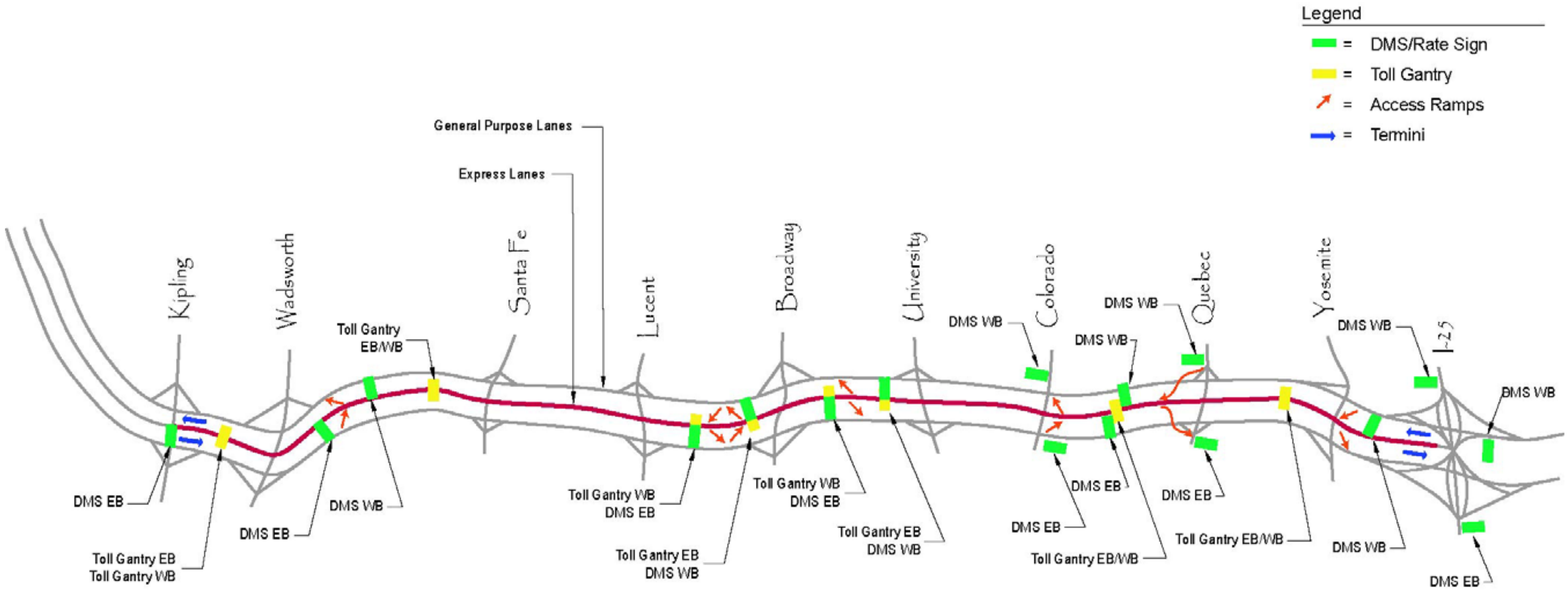


Figure 7.5
Toll Collection Scheme



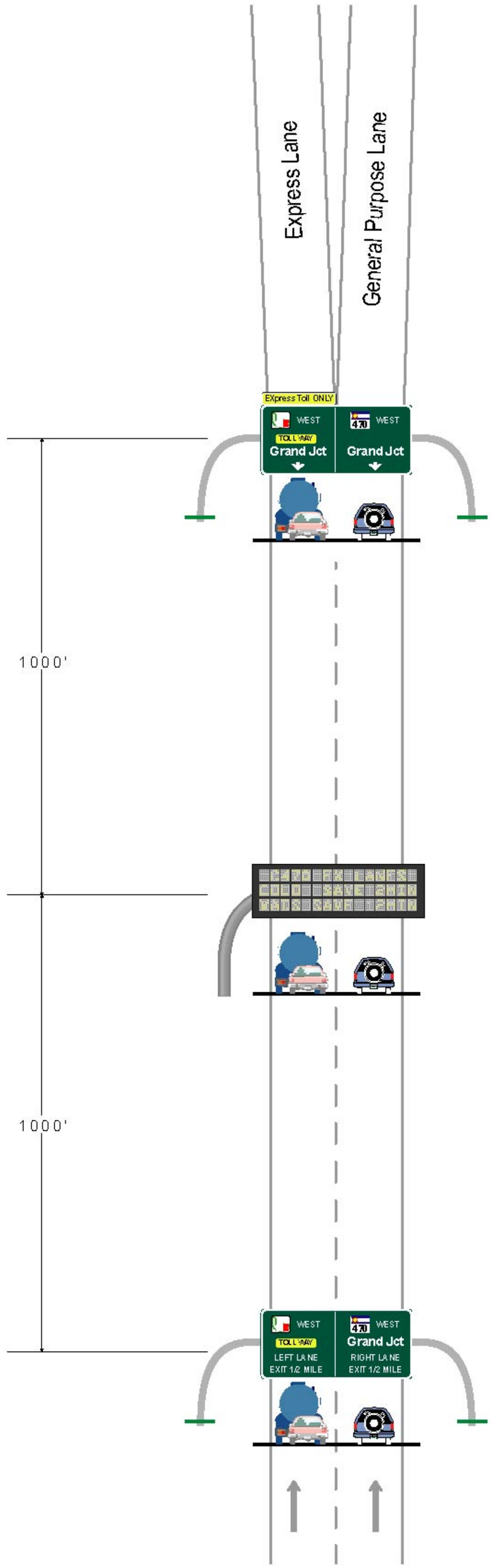
7.1.11 Signing

Because of the nature of two parallel roadways that each require separate markings, signing of express lane facilities is an important consideration. Too many signs carries the potential for driver confusion, leading to the possibility of missing exits, or worse, causing accidents. As a result, careful consideration must be given to the signing layout.

The first consideration in developing a signing concept is to distinguish between signs for express lanes and for general purpose lanes. This is typically accomplished with a supplemental plaque that identifies the express lane signing as separate from the general purpose lanes. FHWA is considering standardizing the color on signs as a universal indicator of toll facilities. Because purple has not yet been officially adopted, the project team opted for the current color of yellow, which alerts a driver to a cautionary situation. When a color is standardized for toll facilities, the yellow color can be changed accordingly.

A typical advance signing concept was developed for each access location, which considered both static guide signs and dynamic toll information signage. The typical configuration is shown in Figure 7.6.

Figure 7.6
Conceptual Signing Plan



After developing a typical sign configuration for access points, the project team considered the extent to which a specific signing plan was necessary in this study. After a cursory assessment of the character and complexity of the C-470 corridor, the project team concluded that only one location presented the potential for problematic signing – the I-25 Interchange complex. The rest of the corridor was thought to be straightforward, and it was believed that a safe and effective signing plan could be developed in final design.

A conceptual signing plan for the I-25 Interchange complex was developed to provide guidance to both the free and tolled lanes; this plan met the requirements for advance signing in the Manual on Uniform Traffic Control Devices. This concept was reviewed and initially accepted by the E-470 Public Highway Authority. The conceptual signing layout for the I-25 Interchange complex is included in Appendix D.

The C-470 express lanes will have two dynamic message signs (DMS) before each access point. The first DMS will display the expected time savings for the nearest destination and the express lanes terminus. The second DMS will display the toll price to the nearest destination and to the express lanes terminus. Both signs will be placed far enough in advance of the entry/exit point to allow drivers to read, process, and make a decision on the posted message. Figure 7.7 shows a layout of the potential messaging.

7.1.12 Intelligent Transportation Systems (ITS)

ITS will be used throughout the corridor to provide information on upcoming road conditions, toll rates, and travel times. As noted DMSs will be located before of each access point and will display the expected time savings and toll prices for using the express lanes. It is assumed that the posted travel time savings information would be computed from the loop detectors at the ramp metering locations on the general purpose lanes and compared to the travel time information compiled from the transponders on the express lanes.

In addition to the notification signs, electronic toll collection will be used throughout the system, reducing the need for toll plazas and allowing drivers to maintain freeway speeds. Fiber optic cable would be installed along the corridor length and connected to the existing E-470 fiber optic line to provide seamless data transfer between the two facilities.

Figure 7.7
Example Dynamic Message Sign Sequence

The C-470 toll facility would be monitored by pan-tilt-zoom video cameras positioned throughout the corridor to observe traffic conditions and alert facility personnel of incidents. At the toll gantries, video surveillance will provide violation enforcement.

7.2 COST ESTIMATES

Cost estimates were compiled for use in the financial feasibility calculations. The estimates included roadway capital costs, roadway operations and maintenance (O&M) costs, toll equipment capital costs, and toll equipment O&M costs. The capital costs were compiled from recent local and national unit costs for similar items. The roadway O&M costs were compiled based on 3-year historical averages for the C-470 corridor, while the toll equipment O&M costs were compiled based on national averages from similar toll facilities.

7.2.1 Roadway Capital Costs

Before beginning design of any corridor improvements, unit costs from CDOT construction projects completed in 2004 were compiled to develop average unit costs for bid items. These unit costs were then used to develop cost estimates used in the financial feasibility calculations. It was assumed that facility construction would begin in 2006; therefore, the 2004 unit costs were inflated to 2006 dollars, assuming a 3 percent inflation rate over 2 years. The unit costs used in the analysis are shown in Table 7.2.

Table 7.2
Roadway Capital Cost Unit Prices

Item Description	Unit	Unit Price $
Quantifiable Items		
Bridge Rail Type 10	LF	75.00
Concrete Median Cover	SF	8.00
Concrete Pavement (13")	SY	38.00
Curb and Gutter (Type 2)	LF	12.00
Earthwork (embankment)	CY	6.00
Guardrail Type 3	LF	12.00
Guardrail Type 7	LF	37.00
Retaining Walls	SF	50.00
Sidewalk	SY	25.00
Major Items		
Regular Straight Bridges	SF	80.00
Curved Flyovers	SF	130.00
Urban Over	SF	120.00
Railroad	SF	130.00
Remove Existing Bridges	SF	15.00
Noise Barrier	SF	35.00
Miscellaneous Items as Percentages		
Utilities		10.00
Removals, Resets, and Adjustments		10.00
Drainage		15.00
Landscape		6.00
Signing, Striping, Signals, Lighting		21.00
Traffic Control		26.00
Mobilization and Miscellaneous		20.00
Force Account Items		10.00
Total		118.00
Box Culvert Construction		
Box 1 (12x14)	LF	805.00

Note: All values are in 2004 Dollars

7.2.2 Toll Equipment Capital Costs

Unit cost information for toll collection equipment was compiled based on national averages for similar toll facilities. Unit costs were compiled for toll lane equipment, gantries, host servers, vehicle enforcement system (VES) data host, workstations, traffic management center (TMC)/video control, and transponders. Table 7.3 summarizes the necessary equipment, respective quantities, and unit costs for each element. The CTE will be required to purchase 20,000 transponders to initiate the system; therefore these costs are also included.

Table 7.3
Toll Equipment Capital Costs

Item Description	Quantity	Unit	Unit Price $	Total Cost $
Toll Lane Equipment	24	System Miles	200,000.00	4,800,000 .00
Gantries	10	Ea	300,000.00	3,000,000.00
Toll/VES Data Host	1	LS	1,000,000.00	1,000,000.00
Host Servers and Functions	1	LS	300,000.00	300,000.00
Workstations	4	Ea	10,000.00	40,000.00
TMC/Video Control	1	LS	500,000.00	500,000.00
Transponders	20,000	Ea	30.00	600,000.00
			Total (2004 Dollars)	10,240,000.00
			Total (2006 Dollars)	10,863,616.00

7.2.3 Operations Costs

The operations costs associated with the express lane facility include liability Insurance, highway patrol, roadside assistance, ITS equipment operation, toll audit and system inspection, toll transaction process, and video enforcement. A description of each is listed below.

- Liability insurance is based on the number of system miles along the express lane system using a national average for similar facilities.
- The highway patrol quantity assumes four full-time officers at an annual cost of $125,000. The roadside assistance item assumes one vehicle will be on call six hours per day, typically during the AM and PM peak hours.
- The annual cost for ITS equipment operation is based on national averages for similar facilities.
- The toll audit and system inspection element assumes five CTE staff members would be monitoring the tolling system and processing account information and billings from E-470. It is assumed that this cost will be distributed over five corridors; therefore the cost attributed to any one corridor is one fifth of this amount.
- The CTE is in negotiations with E-470 to process the toll transactions at a rate of $0.12 per transaction. This amount will include processing the transaction, general account maintenance, and mailing and processing bills.
- It is also assumed that E-470 will provide violation processing and video tolling of express toll customers when transponders fail or are not present in their vehicles. Operation unit costs are shown in Table 7.4.

Table 7.4
C-470 Express Lane Operations Costs

Item Description	Unit	Annual Cost $	Quantity	Total Annual Cost $
Liability Insurance	System Miles	18,000	12	216,000.00
Bond Insurance	% of Bond			-
Highway Patrol	LS	125,000	4	500,000.00
Roadside Assistance	LS	93,600	1	93,600.00
ITS Equipment Operation	LS	150,000	1	150,000.00
Toll Audit and System Inspection	LS	95,000	1	95,000.00
Total Operations Costs				**1,054,600.00***

(Total operations costs does not include toll transaction costs).
Note: All values are in 2004 Dollars

7.2.4 Maintenance Costs

Estimated maintenance costs for the C-470 express lanes were developed from historic maintenance costs of the existing corridor. The most recent 3 years of maintenance costs for the entire corridor were obtained from CDOT Region 6 Maintenance Staff. These costs were used to develop per-lane-mile costs that could be applied to the proposed lane miles of express lanes. The developed maintenance unit cost was calculated to be $7,620 per lane mile, which compares well within the average of similar corridors. Items such as fence repair, ditch repair, and landscaping were not included in the overall average because those items do not correspond to a self-contained express lane facility as compared to the general purpose lane facility. Maintenance costs calculations are shown in Table 7.5.

Table 7.5
C-470 Express Lane Maintenance Costs

Items Description	Unit	Annual Cost $	Quantity	Total Annual Cost $
Roadway Maintenance	Lane Mile	7,620.00	48	365,760.00
Roadside Gantry Toll System	Per Gantry	30,000.00	10	300,000.00
Host System Maintenance	LS	200,000.00	1	200,000.00
Engineering/Traffic Consulting	LS	100,000.00	1	100,000.00
Total Maintenance Costs				**965,760.00**

Note: All values are in 2004 Dollars

7.3 FINANCIAL FEASIBILITY ANALYSIS

7.3.1 Debt Financing Considerations

To determine the extent to which toll revenues can support debt retirement, it is instructive to compare the current value of the project's cash flow to its capital cost. The cash flow in this case refers to the annual stream of toll revenues remaining after paying for current O&M costs; which is referred to as net revenue. This long-term future cash flow is discounted back to present year dollars so as to allow a dollar-to-dollar correlation. The present value (or discount) rate is used to simulate the project owner's cost of capital. In the U.S., state and local governments finance capital infrastructure in the tax-exempt municipal bond market.

The Bond Buyer Revenue Bond index represents the average yields on a select 25 tax-exempt revenue bonds with 40-year maturities. The current bond market conditions are at approximately 5.75 percent. A range of bond rates from 5.50 percent to 6.0 percent was used in this analysis to represent variability in this rate.

In addition to varying the bond interest rates, coverage rates for senior and junior lien debt were also varied. While the senior lien coverage rate was held constant at 1.75, the junior lien coverage rate was varied from 2.19 to 2.99 to represent a range of variability. These individual rates yielded a composite coverage rate of 1.3 to 1.4.

By using varying rates for bond interest and coverage rates, an overall range of financial feasibility was determined. It was believed that such a range would be most appropriate at this preliminary feasibility level. It was believed that this would bracket the most likely range of scenarios that the CTE would face upon pursing bond issuance, and would therefore be a good indication of the likely feasibility of a potential express lanes facility on C-470.

The project's financial feasibility was measured by the financial feasibility factor, which simply compares the current value of its estimated future cash flow (net revenue after payment of financing costs, O&M costs, and capital reserve) to its initial capital construction cost. It is a measure of how much of the capital cost can be paid for by toll revenues. The final determination as to what percentage is or is not feasible is left to the discretion of the agency conducting the analysis.

Given the legislative and fiscal constraints of the CTE, the assumptions described were developed by the CTE for use in this study. As an Enterprise created in accordance with the Tax Payers' Bill of Rights (TABOR), the CTE can accept up to 10 percent of its annual revenue from state and local sources. It was assumed that the CTE would take full benefit of these sources of financing. The CTE estimates that it may be able to acquire up to 20 percent of a project's cost through various federal funding sources. Therefore, the underlying premise of the ELFS financial feasibility analysis is that up to 30 percent of a project's cost could be obtained from sources other than toll revenue. Considering that all senior lien and subordinated debt would be financed through toll revenue, the target feasibility factor for a financially feasible project was established at 70 percent.

7.3.2 Determination of Toll Structure

In theory, the concept of value pricing would allow toll rates to be varied dynamically as traffic conditions in the express lanes vary from minute to minute. Practically speaking, the interval with which toll rates are varied is limited by cost considerations for capital investment and operations costs. Accordingly, the CTE determined that the system would initially be set up with pre-set variable tolls. The decision to move toward a more dynamic toll structure would be deferred until revenues and technology made that option more realistic.

A graduated toll rate structure was developed based on the hourly distribution of traffic volumes. The model followed for establishing this structure was that of a peak period with the highest rate, a shoulder period with a somewhat reduced rate, and an off-peak period with a discount rate. The discussion below describes how each of those time periods and their respective toll rates were established.

Existing directional tube counts were used as the basis for determining the peak and off-peak shoulder periods. Existing traffic patterns were analyzed using projected 2025 traffic volumes. The time periods that exhibited volumes consistent with peak period volumes (95 to 100 percent of the peak volumes) were included in the peak period. Forecasted volumes indicated that the 2025 AM peak period will last for 90 minutes, and the PM peak period will last for 180 minutes. Similarly, volume to capacity ratios (V/C) and ratio of hourly volume to peak hour volume were used to determine the shoulder periods to the peak hour and off-peak periods. The shoulder period was established as the range of 75 to 95 percent of the peak volume, and the off-peak period was established as the range below 75 percent of the peak volume. The toll rate structure is shown in Table 7.6.

Table 7.6
Toll Rate Structure

Time Period	Hours
AM Off-Peak	5:00 - 5:30
AM Shoulder	5:30 - 6:30
AM Peak	6:30 - 8:00
AM Shoulder	8:00 - 9:00
AM Off-Peak	9:00 - 12:00
PM Off-Peak	12:00 - 2:00
PM Shoulder	2:00 - 3:00
PM Peak	3:00 - 6:00
PM Shoulder	6:00 - 7:00
PM Off-Peak	7:00 - 10:00

The driver's value of time derived from the value-of-time analysis discussed earlier in this report was used to establish the toll rate used in the AIMSUN model. The toll rate is set based on the requirement of maintaining operations at LOS C/D in the express lanes. The toll rate is varied until an equilibrium of LOS C/D is established. The actual toll rate and structure developed for the recommended alternative is discussed in Section 8.5, "Final Alternative Optimization."

7.3.3 Revenue and Feasibility Calculations

The gross revenue was calculated using the traffic volume, number of transactions, and toll rates generated from the AIMSUN model. The gross revenue was calculated by taking vehicles miles traveled for each corridor tolling segment and multiplying by the toll rate during that time period.

The net revenue was then calculated by subtracting the combined O&M costs from gross revenue. The senior lien debt was then determined by applying the 1.75 coverage rate. The remaining revenue was considered available to pay off subordinated debt, so the junior lien debt was determined using coverage rates of 2.19 and 2.99. The remaining net toll revenue (free cash) was then set aside as a capital reserve to pay for future maintenance and rehabilitation, and perhaps as additional revenue for future bonding.

The current value of the covered net toll revenue was then calculated. The aggregate current value of the covered net toll revenue over the 40-year bond term was then divided by the capital construction cost to produce the financial feasibility factor. As noted above, a range of factors was produced based on varying interest and coverage rates.

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8.0 ALTERNATIVES SCREENING

The first step in the screening process used the travel demand model to assess existing and projected 2025 volumes along the corridor to determine which segments were over capacity and thus had demand for express lanes. Step 2 evaluated the existing and projected volumes at existing and proposed interchange locations to determine which locations had high enough demand to warrant express lane access. The general impetus behind screening out access locations was to provide limited access to ensure operations are maintained and that the facility is used for longer trips. Generally, access points should be separated by approximately 2 miles to minimize turbulence typically found surrounding access points. The screening approach consisted of the following steps:

Step 1. Performing a corridor capacity analysis.
Step 2. Conducting a preliminary screening of access locations.
Step 3. Conducting a qualitative screening of access locations.
Step 4. Conducting a detailed quantitative screening of access locations and ramp types.

After the final access configuration was selected, the recommended alternative was refined with respect to design, traffic operations, toll pricing, traffic volume, and revenue optimization. This final step was termed optimization of the final alternative.

8.1 STEP 1. CORRIDOR CAPACITY ANALYSIS

Step 1 reviewed projected capacity levels along the general purpose lanes. This review was to determine which segments of C-470 had existing and projected volumes that exceeded roadway capacity. If volumes were reached or were under the capacity of the facility, there would not be sufficient demand for tolled express lanes. Because no significant time savings would be realized, motorists would be reluctant to choose to pay to use express lanes. Based on this supposition, the existing and projected volumes along C-470 were compared to the capacity.

Using HCS capacity analysis along C-470 was prepared to determine which sections might be candidates for tolling. This analysis began with several assumptions:

Capacity of a single mainline freeway lane is 2,200 vehicles per hour per lane (vphpl)
Capacity of 2-lane segments in each direction is 4,400 vphpl.
Capacity of 3-lane segments in each direction is 6,600 vphpl.

Volumes used in the analysis for PM peak hour existing and 2025 traffic volumes were taken from the existing traffic counts and the travel demand model projections. These volumes represent the highest directional peak hour on the mainline freeway segments.

The capacity between I-70 and I-25 was plotted on a graph for 2003 and 2025 conditions, assuming no improvements to the existing geometry. The existing geometry consists of three lanes in each direction between I-70 and Morrison Road, and between Quebec Street and I-25. The remaining segments of C-470 consist of two lanes in each direction. The 2025 analysis did include the proposed interchanges at Alameda Avenue and Yale Avenue. Figure 8.1 shows existing and proposed interchanges along the C-470 corridor. Figures 8.2 and 8.3 show the 2003 and 2025 V/C comparisons along the corridor.

Figure 8.1
C-470 Corridor Map

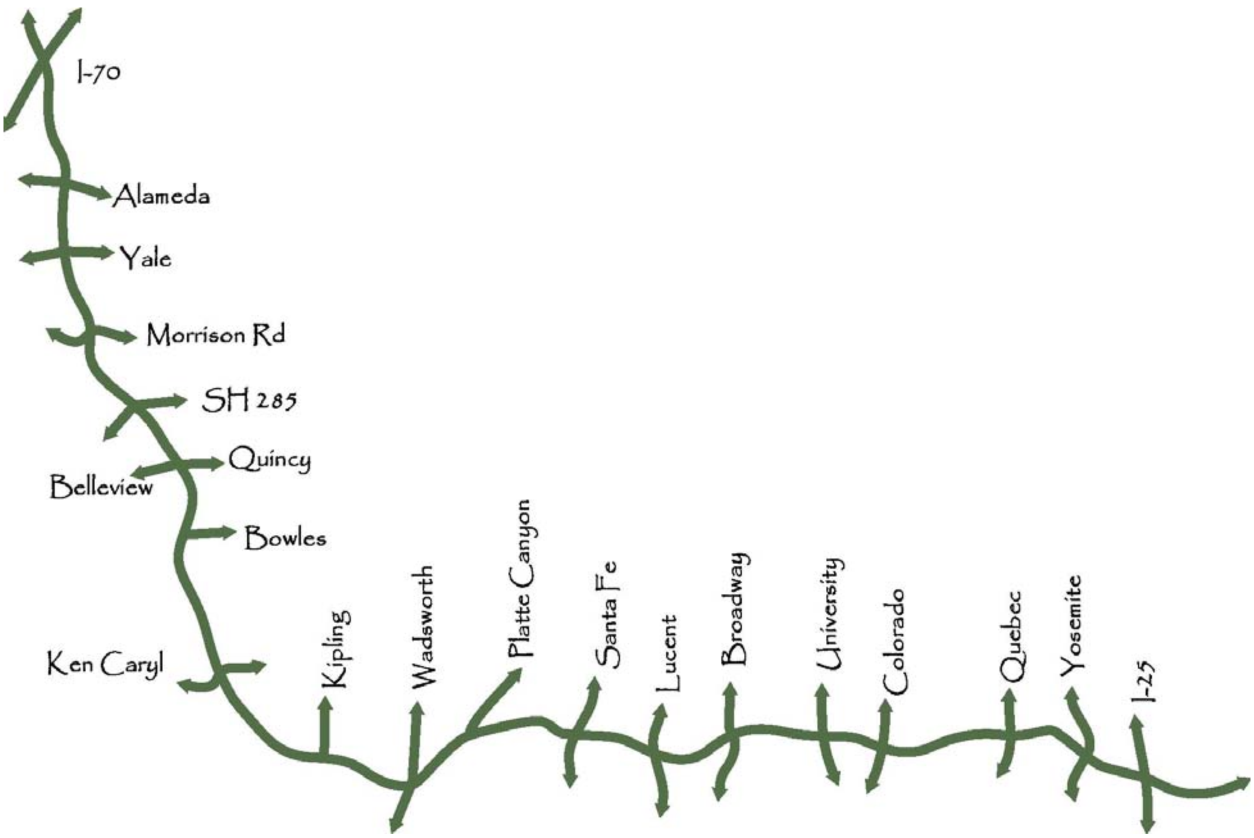


Figure 8.2
V/C Comparison – Existing (2003)

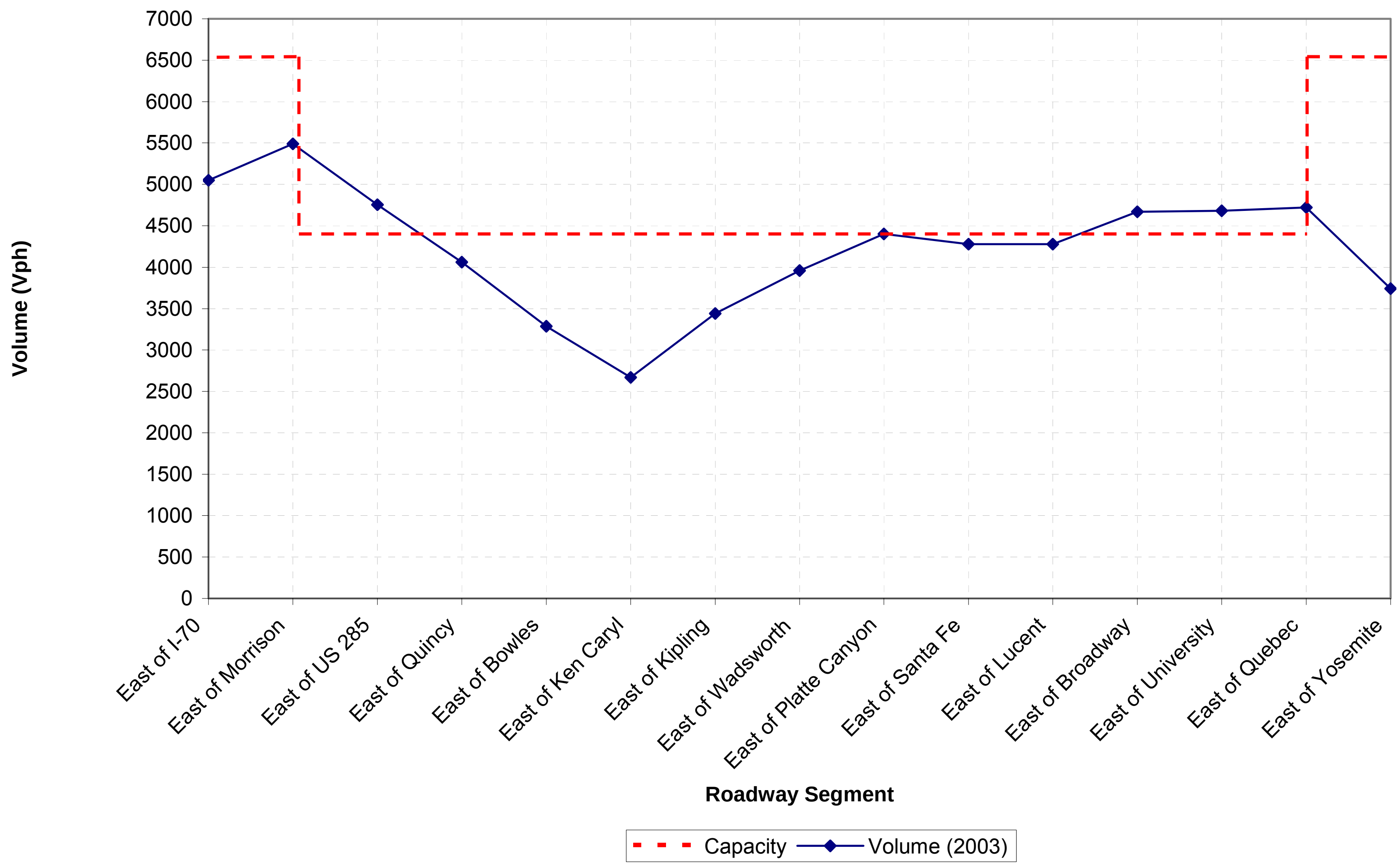
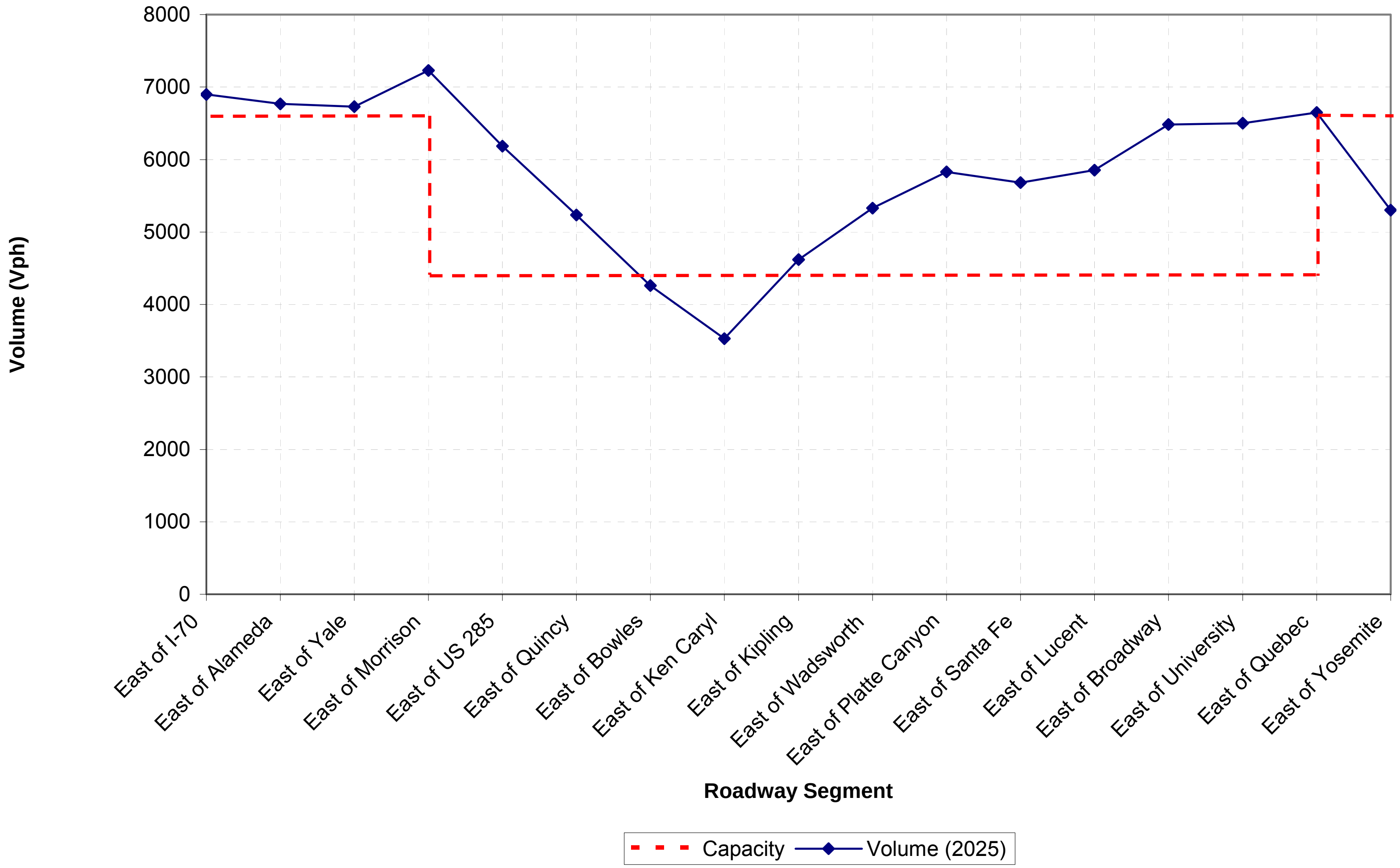


Figure 8.3
V/C Comparison – Projected (2025)



8.1.1 Existing Conditions Analysis

The volume and capacity graph for existing conditions (2003) shows that portions of the C-470 corridor are operating above capacity during peak hours in the peak direction. The volume exceeds the capacity between the Morrison Road and US 285 Interchanges. The volume between the Quincy Avenue and Wadsworth Boulevard Interchanges is well below capacity. The volume along C-470 then approaches capacity of the facility between the Wadsworth Boulevard and Lucent Boulevard Interchanges. The volumes along C-470 exceed the capacity between the Lucent Boulevard and Quebec Street Interchanges. At the Quebec Street Interchange, a third lane is introduced in each direction, increasing the capacity of C-470. The volumes along C-470 are therefore below the capacity again between the Quebec Street Interchange and the I-25 Interchange.

8.1.2 2025 Conditions Analysis

The volume and capacity graph of mainline C-470 for projected 2025 conditions follows the same trends as the existing conditions graph. The volumes along C-470 between the I-70 and Yale Avenue Interchanges are slightly above the capacity of the facility. The volumes between the Morrison Road and Bowles Avenue Interchanges are projected to be significantly higher than the capacity of C-470. Between the Bowles Avenue and Kipling Parkway Interchanges, volumes are projected to be under the capacity of C-470. Between the Kipling Parkway and Quebec Street Interchanges, 2025 volumes along C-470 are projected to be significantly higher than capacity up to the Quebec Street Interchange. East of the Quebec Street Interchange, the volume drops below capacity.

There does not appear to be adequate travel demand in 2025 between the Kipling Parkway and I-70 Interchanges to warrant express lanes in the western segment. With this segment not being significantly over capacity, demand would be insufficient to make the express lanes feasible.

The segment between the Morrison Road and Bowles Avenue Interchanges has volumes exceeding the mainline capacity. However, this segment is only 4 miles long and is not enough to provide enough time savings to entice drivers to pay a toll for using the express lanes. Further, it is in the middle of the corridor, and without an express lanes facility at either end to connect to, the facility would not be able to synergize with a longer, contiguous facility.

The segment between Bowles Avenue and Wadsworth Boulevard has the lowest volumes of any segment along the corridor. The projected 2025 volumes are shown to be well below capacity, resulting in little demand for express lanes.

The segment between the Wadsworth Boulevard and I-25 Interchanges shows volumes that are at or approaching capacity in 2003, and are projected to be significantly over the capacity of the mainline facility in 2025. This segment has the highest demand and highest potential for express lanes to be financially feasible. It was therefore recommended that this segment be studied further to evaluate the financial feasibility of the different express lane configurations during the 2003 to 2025 planning horizon.

8.1.3 Cursory Feasibility Assessment of I-70 to Morrison Road

Before the confident elimination of I-70 to Kipling Parkway segment, a cursory check of the potential financial feasibility was performed. The analysis provided the basis for developing a phased implementation plan, as discussed in Chapter 11.

In the cursory feasibility assessment, five alternatives were developed to determine whether varying the number of lanes on the general purpose or express lane facilities would produce results different from those for feasibility. The length of a potential western segment of express lanes was also varied to determine the impact of not including segments that are marginally above capacity. The intent of the analysis was to determine whether any alternatives warranted a more detailed analysis in the micro-simulation model.

8.1.4 Four-lane Barrier Separated Concept

To give the western segment express lanes concept the best chance to survive, a best-case scenario was developed in which the maximum conceivable number of users would divert into the express lanes. For this best-case scenario, it was assumed that 100 percent of all excess capacity on the general purpose lanes would use the express lanes. In cases where the forecasted general purpose lanes volume was below capacity, it is assumed that 10 percent of the total volume would use the express lanes. This estimate is based on the finding in the ELFS User Survey (see Appendix C) that 7 percent of all users would use the express lanes under any circumstance.

The five alternatives shown below were developed for the western segment express lanes concept using the assumptions listed above.

Alternative 1	Four general purpose lanes and 4 express lanes from Kipling Parkway to Morrison Road, and 6 general purpose lanes and four express lanes from Morrison Road to I-70.
Alternative 2	Four general purpose lanes and 4 express lanes from Bowles Avenue to Morrison Road, and six general purpose lanes and four express lanes from Morrison to I-70.
Alternative 3	Four general purpose lanes and four express lanes from Kipling Parkway to I-70.
Alternative 4	Four general purpose lanes and four express lanes from Bowles Avenue to I-70.

Alternative 5 Four general purpose lanes and four express lanes from Bowles Avenue to Morrison Road.

Although six lanes are currently in the segment from I-70 to Morrison Road, it was necessary to determine how sensitive the feasibility of this western segment was to the capacity. To determine this, Alternatives 3 and 4 were developed to represent a hypothetical situation in which only four free lanes were present.

The construction cost estimate for each alternative was based on the preliminary cost estimate for the eastern segment from Kipling Parkway to I-25. Based on a cost estimate of $23 million per mile for four express lanes and four general purpose lanes, a per lane mile cost of $2.875 million was used in the analysis below.

The express lane volume and corresponding vehicle miles traveled (VMT) input was used with projected toll rates to compute an overall financial feasibility of each alternative. The feasibility factor then gave an indication of the financial feasibility of the alternative.

Using these best case assumptions as input, traffic volumes in the express lanes were estimated, revenue was computed, and financial feasibility factors were calculated. These results show that the four-lane barrier-separated section under all five alternatives has nearly no potential for being financially feasible; the results also verify that the initial hypothesis that the western segment is not feasible for a toll lane facility.

It should be noted that the analysis above was performed assuming a four-lane barrier-separated section. To determine whether another typical section configuration could result in a more feasible rating, the sections below discuss reversible- and single-lane concepts.

8.1.5 Reversible Express Lane Concept

As a means of reducing the associated construction and O&M costs, another express lane alternative was analyzed. The volume trends observed on the western segment of C-470 showed a distinct directional split between the AM and PM peak hours. Typically, the AM peak hour direction is northbound, while the PM peak hour direction is southbound. Hence, a reversible two-lane express lane option was evaluated with the previously identified five alternatives. During the AM peak hour, the two express lanes would be open to northbound traffic, while during the PM peak hour, the southbound direction would be open. This would result in approximately half the original construction cost for the four-lane alternative. The O&M costs would also be reduced by half. With the reversible express lane concept, a corresponding reduction in the revenue generation occurred, because vehicles in the off peak direction did not have access to the express lanes.

As in the case of the four-lane barrier-separated segment, the reversible express lane concept was found to not be financially feasible.

8.1.6 Single Express Lane Concept

A final cost-saving scenario was evaluated using a single-lane concept (one lane in each direction). Similar to the reversible express lane concept, the construction and O&M costs would be reduced by approximately half.

As in the case with previous two alternatives, the single express lane concept was also found to not be financially feasible.

8.1.7 Conclusions of the I-70 to Kipling Parkway Analysis

The above analyses demonstrate that the western segment has no potential to be feasible in the planning horizon of this study. However, in the interest of identifying a long-term plan for implementation, discusses a potential phasing plan and associated timeframe for planning purposes only. Potentially, sometime after 2025, traffic volumes may continue to increase to the extent that express lanes could be considered a viable alternative.

8.1.8 Phasing Plan for Kipling Parkway to I-70

A potential phasing plan for constructing express lanes in the western segment could consider constructing two express lanes in each direction from Bowles Avenue to I-70 as an initial phase. The second phase would provide the connection between Bowles Avenue and Kipling Parkway. Based on a continued 1.5 percent annual growth rate beyond 2025, the first phase could be warranted around 2030, with the second phase potentially being needed around 2050. This more aggressive growth scenario represents the earliest tolls would be warranted. Using a less conservative growth rate of 1 percent, the segments between I-70 and Bowles Avenue, and between Bowles Avenue and Kipling Parkway, would not be worth considering until around 2040 and 2070, respectively. These estimates assume existing laneage and capacity. With the corridor approaching full build out at 2010, the anticipated growth rate beyond 2025 is expected to be more consistent with the conservative 1 percent rate. This analysis assumes a preferred four-lane barrier-separated facility due to the reliability and safety benefits mentioned in Sections.

8.2 STEP 2. PRELIMINARY SCREENING OF ACCESS LOCATIONS

With only the eastern segment of C-470 from I-25 to Kipling Parkway showing potential demand for express lanes, it was carried to the next phase of screening. Step 2 sought to evaluate all existing and proposed interchange locations to determine which had enough demand to warrant access to the express lanes. The first step was to determine which interchanges currently carry the most volume. As a representative measure of demand, the interchange locations that comprise 75 percent or more of the total corridor volume were carried forward for further consideration. Using this methodology, Platte Canyon Road was the only interchange eliminated from further consideration. Table 8.4 summarizes the projected 2025 combined AM and PM peak hour ramp volumes.

Table 8.1
Preliminary Access Location Screening
Based on Interchange Volumes

Interchange	Project 2025 AM and PM Peak Hour General Purpose Lane Ramp Combined Totals	Disposition
I-25	16,830	Carried Forward
Yosemite	4,375	Carried Forward
Quebec	11,135	Carried Forward
Colorado*	N/A	Carried Forward
University	7,110	Carried Forward
Broadway	9,165	Carried Forward
Lucent	8,650	Carried Forward
Santa Fe	9,290	Carried Forward
Platte Canyon	1,125	Eliminated
Wadsworth	8,695	Carried Forward
Kipling	5,640	Carried Forward
* No data for Colorado Interchange; ramps do not currently exist		

8.3 STEP 3. QUALITATIVE SCREENING OF ACCESS LOCATIONS

In Step 3, output from TP+ model runs was used to determine which locations had the highest average combined 2025 AM and PM peak hour ramp volumes. The locations with the lowest ramp volumes - Ken Caryl Avenue, Kipling Parkway, and Lucent Boulevard - were eliminated. Despite having the lowest volume of the remaining access locations, Colorado Boulevard was carried forward for further evaluation. This decision was made solely on its inclusion in the Public Private Initiative alternative. It should be noted that the locations of Lucent Boulevard and Kipling Parkway were later reintroduced into the screening process to alleviate some operational issues on the corridor. Table 8.5 summarizes the access locations that were carried forward or eliminated at this level of screening.

Table 8.2
Qualitative Access Location Screening
Based on TP+ Model

Access Locations	Average Combined AM and PM Peak Hour Express Lanes Ramp Volumes	Description	Disposition
Colorado	2,065	Carried forward for comparison to public private initiative alternative	Carried forward
Lucent	3,640	Low volume	Eliminated
Kipling	4,540	Lower volume on EL ramps and general purpose lane ramps and close proximity to Wadsworth	Eliminated
I-25/Yosemite	5,026	Medium volume and logical terminus of eastern segment	Carried forward
Santa Fe	5,104	Medium volume and connection to US Highway	Carried forward
Wadsworth	6,983	High volume	Carried forward
Broad/University	7,023	High volume	Carried forward
Quebec	7,304	High volume	Carried forward

During this third level of screening, only interchange nodes were considered; specific ramp configurations at access points were not considered. The travel demand model was not sensitive enough to distinguish between different access types. The exact locations, types, and directions that will be afforded access at each location were evaluated in the final level of screening for the short-listed alternatives only.

8.4 STEP 4. QUANTITATIVE SCREENING OF ACCESS LOCATIONS

Step 4 involved a detailed analysis of access locations, operations, design considerations, and projected construction costs. An accurate estimate of express lane users was developed using the AIMSUN micro-simulation model and results of the Stated Preference Survey. These tools considered the toll rate and time savings with which drivers would be willing to divert into the express lanes.

8.4.1 Access Alternatives

The remaining access points from Steps 2 and 3 of the screening process were analyzed in the AIMSUN micro-simulation model to determine specific access locations and types. From Steps 2 and 3, four locations were identified as having the highest traffic demand: Wadsworth Boulevard, Santa Fe Drive, Quebec Street, and I-25. These were logical locations for providing access based strictly on projected volumes. Direct access was provided at these high-volume locations in several alternatives to determine its overall benefit. The remaining locations of Lucent Boulevard, Broadway, and University Boulevard all experienced similar volumes and thus were combined into several alternatives to determine which combination of these access points provided the highest express lane ridership and best overall operations. Due to slightly lower volumes, these locations were analyzed only with slip ramp access. The access locations were then grouped into 10 distinct alternatives, as shown in Figure 8.4.

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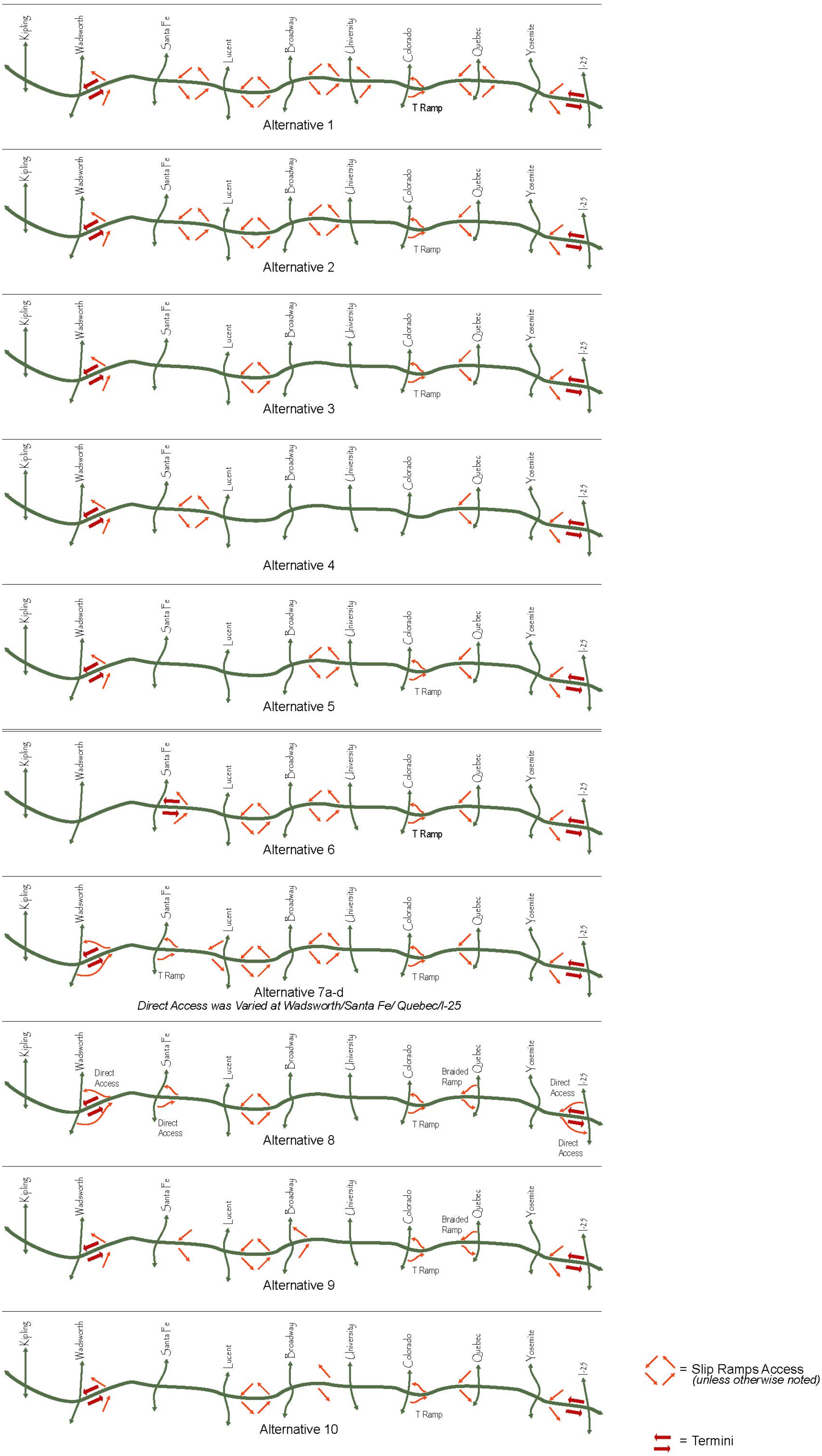
Figure 8.4
Access Configuration for Alternatives 1 through 10



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8.4.2 Direct Access

Because of the potential increased demand and potential operational problems at the high-volume locations of Wadsworth Boulevard, Santa Fe Drive, Quebec Street, and I-25, direct access was considered at these locations. In Alternatives 7a through d, direct access was alternated at the four locations, while in Alternative 8, direct access was provided at all four locations. It was anticipated that the direct access would provide a more attractive ramp configuration due to the elimination of the required weave in slip ramps, and would allow for easier access to and from the express lanes. The projected ramp volumes at these locations were evaluated with slip and direct access ramps to determine the difference in volume and thus potential revenue. A cost benefit analysis was then performed to determine the difference in revenue compared to the anticipated difference in construction cost of direct and slip ramps. Overall, little increase in traffic volumes was experienced by providing direct access at these locations. Direct access was therefore considered only in locations where operations necessitated providing such access. Locations that were recommended for direct access are discussed in Chapter 9.

8.4.3 Fourth Level Screening Criteria

The final screening of access locations considered several criteria. While each criterion was initially evaluated individually, the final decision as to whether an access point was eliminated was based on the overall performance of the following criteria:

- Projected traffic volume using the access location
- Interchange reserve capacity
- Geometric constraints
- Express lane and general purpose lane operations
- Access spacing
- Financial Feasibility Factor

8.4.4 Projected Traffic Volumes

The locations of I-25, Quebec Street, Colorado Boulevard, Broadway, and Wadsworth Boulevard had the highest demand. Lucent Boulevard and University Boulevard had slightly less demand, and Santa Fe Drive showed the lowest traffic volumes. The most probable reason for Santa Fe Drive's volumes decreasing from what the travel demand model projected was the overall interchange operations under its current configuration. The existing diamond operates well over capacity during the current AM and PM peak hours, ultimately restricting access to and from potential express lanes. With the AIMSUN micro-simulation model being more sensitive to congestion, the model is rerouting trips to other locations to avoid congestion. To determine the impact of improving the intersection operations, the recommended Santa Fe Drive Interchange improvements from the C-470 EA were modeled in Alternative 7b. Overall, the volume using the Santa Fe Drive access was shown to increase by approximately 200 vehicles.

This volume was compared to the projected volume at Lucent Boulevard to determine the overall benefit to the express lane facility by providing a direct access at Santa Fe Drive. The Santa Fe Drive volume was shown to be similar to the Lucent Boulevard access. A cursory cost estimate of $25 to $30 million to construct direct access ramps at Santa Fe Drive further reinforced the lack of benefit in providing access at that location.

8.4.5 Interchange Reserve Capacity

The interchange reserve capacity analysis sought to identify which interchanges currently had additional capacity to accommodate projected express lane traffic. The ratio of V/C was used as the criterion in the analysis. Throughout the public involvement process, many community stakeholders were concerned about the potential implications that providing an express lane access would have on the overall interchange operations. Therefore, interchange locations where reserve capacity was available were considered preferable to locations that potentially degraded operations to the point where the interchange began to fail. In the analysis, locations that operated at a LOS C/D were considered as providing adequate reserve capacity, while locations that operated at a LOS D/E had inadequate reserve capacity. University Boulevard, Broadway, and Santa Fe Drive were identified as having low reserve capacity, while the remaining locations had acceptable reserve capacity.

8.4.6 Geometric Constraints

The level of geometric constraints considered the ease of providing access in relation to constructability, anticipated costs, and environmental impacts. I-25 and Santa Fe Drive were shown to have the most constraints. I-25 constraints involve the complexity of providing full movement access to all directions from both the express lane and general purpose lane facilities.

Another constraint was the braided ramp that would be required on westbound C-470 to access the Santa Fe Drive Interchange. At Santa Fe Drive, the 7 percent grade east of the interchange, the connection to the proposed southbound Santa Fe Drive to the eastbound C-470 flyover, and the connection to the northbound Santa Fe Drive to eastbound C-470 from two separate access points all contributed to the geometric constraints. Several environmental concerns were identical in the area, including the historic Highline Canal east of the interchange and the pedestrian and bicycle trail south of the interchange. As mentioned earlier, the associated cost of providing access to and from C-470 to Santa Fe Drive far outweighs the additional revenue generated by providing a direct access. Given the geometric constraints and the operational problems they create, access is not being recommended at Santa Fe Drive. Many, if not all, of the challenges could theoretically be overcome with diligent engineering; however, the economic and environmental costs would be prohibitive or undesirable.

8.4.7 Express Lane and General Purpose Lane Operations

Consideration was also given to how the access point affected operations in both the express lanes and general purpose lanes. The goal of the express lane facility was to minimize its impacts it had on the operations of the general purpose lanes. Also, potential impacts to operations within the express lanes were evaluated to ensure that reliability and LOS C/D standards were maintained. The locations identified as having operational impacts to both the express lanes and general purpose lanes included I-25, Quebec Street, and Wadsworth Boulevard. Due to high volumes on both facilities in these locations, evaluating direct access was recommended. University Boulevard and Santa Fe Drive showed impacts to the operations of the general purpose lanes only. The remaining locations showed minimal impact to either facility.

8.4.8 Access Spacing

To provide the free flowing traffic conditions and reliability a toll paying customer expects, limited facility access is required. Ideally, access locations should be spaced intervals of at least 2 miles to minimize turbulence caused when successive access points are introduced. The type of access ramps being considered also effects the spacing of access points. With a slip ramp, the access point will need to be positioned to provide a driver the opportunity to complete the weaving maneuver. The majority of access locations remaining in the screening process meet the 2-mile guideline, with the exception of the points between Santa Fe Drive and University Boulevard. With four access points spread over approximately 4 miles of the corridor, the number of access points needed to be reduced to approximately one location.

8.4.9 Financial Feasibility

The financial feasibility factor was used to compare the projected net toll revenue to the estimated capital costs for the various access configurations. Based on the assumptions noted below, the initial financial feasibility for the final access configuration was calculated to be 0.26. (Note that the feasibility was then revised in a subsequent process of optimizing the traffic and revenue, which is discussed in Section 9.0.)

- $6 value of time
- Opening year toll rate of $0.12
- Toll rate increase every 5 years
- Toll collection during the peak hours
- Express lane capital costs only
- Express lane shoulder width of 12-foot outside shoulders and 10-foot inside shoulders
- $0.09 per transaction for E-470 processing transactions
- 6.25% bond rate
- 1.25 coverage rate

8.4.10 Selection of Final Access Configuration

Based on the screening analysis, the final recommendation of access points was determined. Access will be provided at I-25, Quebec Street, Colorado Boulevard, Lucent Boulevard, and Wadsworth Boulevard.

With I-25 and Quebec Street having very high volumes and potential operational problems, both were evaluated in the optimization phase to determine the operation benefits of providing direct access at these locations.

The Colorado Boulevard access has high demand and good operations due to the proposed direct access, good access spacing, and good reserve capacity, making it a logical choice for recommendation.

University Boulevard was eliminated based on its having the lowest demand of the four interchange locations between Santa Fe Drive and University Boulevard. It was determined that providing access in the vicinity of Broadway and Lucent Boulevard would provide good spacing, while potentially drawing traffic from the Santa Fe Drive and University Boulevard locations. With Lucent Boulevard providing a higher reserve capacity than Broadway, the access point in this section is proposed for Lucent Boulevard. The Lucent Boulevard location will also provide access to a potential future express bus service that might originate from the existing Santa Fe Drive/Mineral Avenue or Lucent Boulevard park-n-Ride location. The operations at Lucent Boulevard required further evaluation during the alternative refinement stage to determine whether a slip ramp access can accommodate the projected demand.

The access at Santa Fe Drive was eliminated due to relatively low demand, high geometric constraints, and associated construction costs.

The Wadsworth Boulevard location has high demand, good spacing, and moderate reserve capacity. The operations along both the express lanes and general purpose lanes needed to be evaluated during the refinement stage to determine whether the express lanes should be extended past Wadsworth Boulevard to Kipling Parkway to disperse the express lane traffic.

Table 8.6 summarizes the results of the analysis performed under each criterion.

Table 8.3
Fourth Level Screening Summary

Express Lane Access Location Quantitative Screening Analysis								
Access Locations	**Average PM Peak Hour EL Ramp Volumes**	**Interchange Reserve Capacity**	**Geometric Constraints**	**Toll/Non Toll Lane Operations**	**Access Spacing**	**Description**	**Disposition**	
I-25	High	Moderate	High	Poor / Poor	Good	High demand with poor operations. Evaluate need for direct access.	Carried Forward	√
Quebec	High	Moderate	Low	Poor / Poor	Good	High demand with poor operations. Evaluate need for direct access.	Carried Forward	√
Colorado	High	High	Low	Good / Good	Good	Evaluate need for express lane auxiliary lane between Quebec and Colorado.	Carried Forward	√
University	Moderate	Low	Low	Moderate / Poor	Moderate does not	Moderate volumes with low reserve capacity. RTD require bus access due to short trip to I-25.	Eliminated	X
Broadway	High	Low	Low	Moderate / Moderate	Moderate	Evaluate limiting access in some directions to reduce impact to reserve capacity.	Carried Forward	√
Lucent	Moderate	Moderate	Low	Good / Moderate	Moderate	Access would draw a portion of the Santa Fe/RTD traffic with good reserve capacity.	Carried Forward	√
Santa Fe	Low	Low	High	Moderate / Poor	Moderate	Geometric constraints would require expensive access combined with low volume.	Eliminated	X
Wadsworth Blvd.	High	Moderate	Moderate	Poor / Poor	Good	Evaluate extension of express lanes to Kipling to allow dispersion of traffic.	Carried Forward	√

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9.0 OPTIMIZATION OF FINAL ALTERNATIVE

The optimization of the final alternative sought to refine the express lane configuration and develop an alternative with the highest potential to be financially feasible. Ultimately, cost and operations played the biggest part in shaping the final alternative. The roadway design was revised to provide a cost-effective design that would allow for the best operation and highest express lane ridership.

9.1 ACCESS LOCATION REFINEMENT

Through numerous micro-simulation model runs, alternatives were evaluated to determine the final access configuration, ramp type, and location. Based on the previous screening analyses, the locations of I-25, Quebec Street, Lucent Boulevard, and Wadsworth Boulevard required further analysis before to finalizing their configurations. During the public outreach process, representatives from the City of Centennial and Arapahoe County requested that further analysis be performed along Colorado Boulevard to ensure the impacts imposed by providing an express lane access at Colorado Boulevard would not significantly impact the adjacent surface street network. These topics were considered in this study phase, and are discussed below.

9.1.1 I-25 Interchange

Seven alternatives were evaluated for providing access to I-25 from C-470. The alternatives, which included both direct and non-direct connections, are described below.

- **Direct Connection A.** Direct connection from existing Southbound I-25 ramp to Westbound express lanes and direct connection from Eastbound express lanes to existing Northbound I-25 fly-over ramp.
- **Direct Connection B.** Direct connection from Southbound I-25 to Westbound C-470 express lanes. Direct connection flyover ramp from Eastbound C-470 express lanes to Northbound I-25.
- **Slip Ramp A.** Full access to and from C-470 express lanes at I-25.
- **Slip Ramp B.** Full access to and from C-470 express lanes at I-25. C-470 express lane access to and from Yosemite Street.
- **Slip Ramp with Westbound Collector Distributor.** Full access to and from C-470 express lanes at I-25.
- **Direct Connection C.** Direct connection from Southbound I-25 to Westbound express lanes and Eastbound express lanes to Northbound I-25. (Different ramp configurations from Direct Connection A.)
- **Direct Connection C.** Direct connection from Southbound I-25 to Westbound C-470 express lanes. Separate flyover for direct connection of Eastbound C-470 express lanes to Northbound I-25. (Different ramp configurations from Direct Connection B.)

Plan views of these alternatives are included in Appendix E.

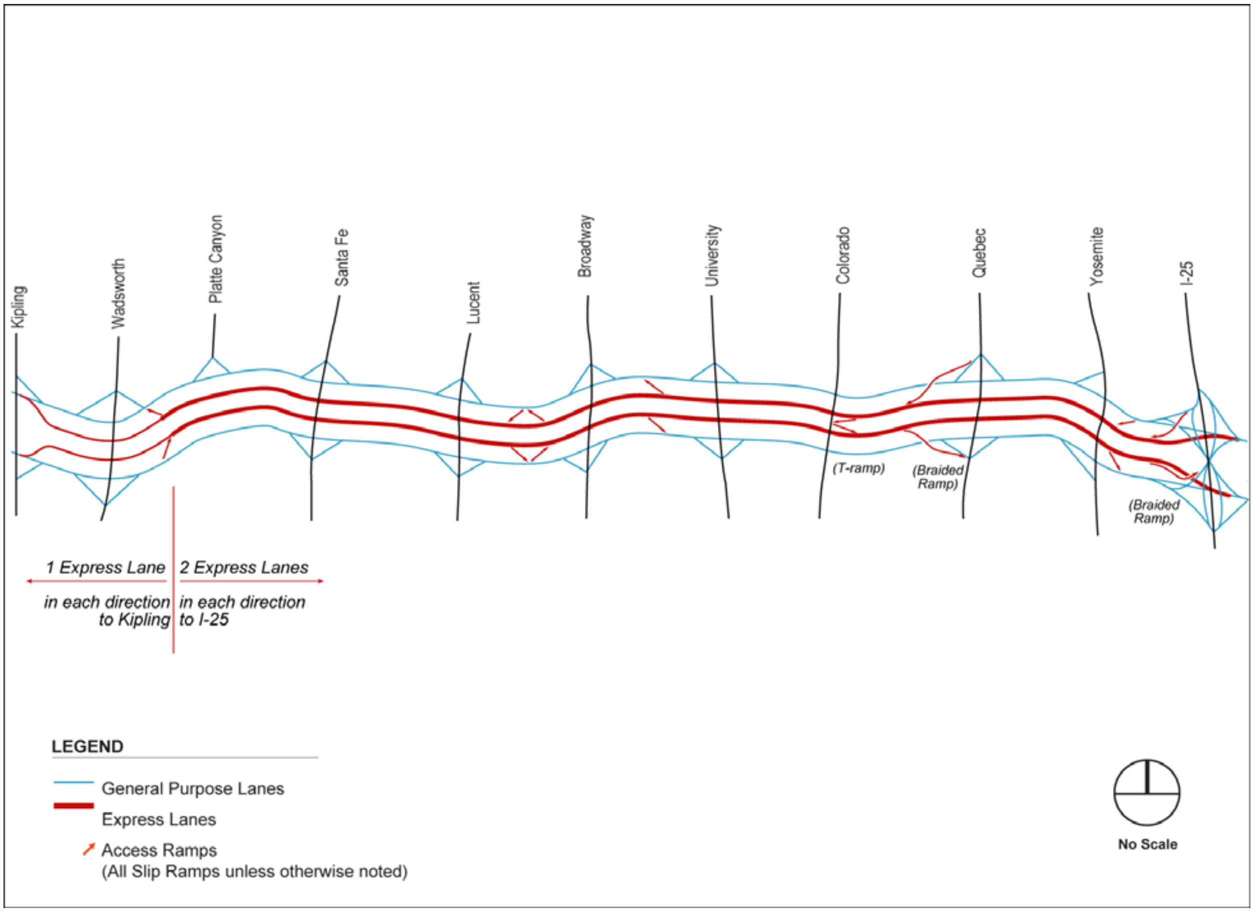
Throughout the screening process, portions of each alternative were substituted to determine the interchange configuration that provided the best combination of accessibility, operations, and cost.

To provide adequate operations from C-470 to and from the north along I-25, some form of direct access needed to be provided. The projected volume destined to and from the south along I-25 was accommodated via a slip ramp positioned just east of Yosemite Street. Two main direct access alternatives considered in the analysis were a variation of the Direct Connection Alternative A and Alternative B. The variation provided a slip ramp access just east of Yosemite Street to allow for vehicles to access I-25 to and from the south. The only difference between the two alternatives was the connection between eastbound C-470 express lanes and I-25 northbound.

Alternative A included a braided ramp from the eastbound C-470 express lanes to the northbound I-25 flyover ramp. This option required no widening to the existing structure over I-25. Alternative B provided a direct flyover access ramp from eastbound C-470 to northbound I-25.

Model runs were performed to determine the potential benefit in operations and increase in revenue versus the construction cost difference for each alternative. Alternative B was estimated to cost approximately $25 to $30 million more than Alternative A. The micro-simulation model showed little operational benefits combined with little increase in traffic with Alternative B. The model showed that in Alternative A, the eastbound distance where the express lanes merge into the general purpose flyover ramp needed to be lengthened to improve operations. With this modification, operations were determined to be adequate. Therefore, the variation of Alternative A was recommended. Figure 9.1 shows the recommended alternative at I-25.

Figure 9.1
I-25/C-470 Interchange



9.1.2 Quebec Street

In the previous screening analysis, providing slip ramp access at Quebec Street resulted in operational problems along both the express lanes and general purpose lanes due to the amount of weaving between facilities. For that reason, a braided ramp between the existing general purpose lane ramp and the express lanes to and from the west was evaluated. It was determined that operations on both facilities improved significantly with the braided ramp in place. A cursory cost benefit analysis was performed to confirm the projected revenue generated by providing access at Quebec Street. The estimated construction cost for providing direct access at this location was approximately $16 million, in 2004 dollars. The projected revenue exceeded the construction cost and therefore a direct connection at Quebec Street has been proposed.

9.1.3 Colorado Boulevard

Providing express lane access at Colorado Boulevard was logical due to the projected high volumes, good overall operations, and good access spacing, because the access provides a new interchange along the corridor, several issues were raised during the public involvement process regarding the potential change in travel patterns along Colorado Boulevard. Members of the public both supported and disapproved of the proposed interchange.

The concerns stem from the perception of increased traffic along Colorado Boulevard and the potential for increased cut-through traffic in the adjacent neighborhoods. Support for providing an access at Colorado Boulevard was also documented. Proponents liked the increased efficiency of reaching the C-470 corridor; and the added reliability over taking surface streets such as County Line Road and Quebec Street to access the existing corridor interchanges.

The analysis showed that there would be minimal increase in traffic along Colorado Boulevard and the adjacent arterial street network. Traffic volumes along Colorado Boulevard and County Line Road were expected to increase by approximately 800 vehicles in vicinity of the interchange during the peak hour. Due to the additional reserve capacity along both Colorado Boulevard and County Line Road, the additional traffic can easily be accommodated within the existing geometry. Due to the excess reserve capacity on the major arterials in the area, it is anticipated that that there would be little demand for drivers to use local streets to bypass arterial congestion. Therefore, express lane access at Colorado Boulevard to and from the east has been proposed. This analysis is summarized in Appendix F.

9.1.4 Lucent Boulevard

The previous screening analysis identified the Lucent Boulevard location as having the best overall potential for accommodating an express lane access. The Lucent Boulevard location was analyzed in the micro-simulation model to determine whether a single express lane access would accommodate the demand for this location. It was determined that a single express lane access between Lucent Boulevard and Broadway would likely fail operationally. Before evaluating a direct access at this location, additional slip ramps were evaluated due to the minimal construction cost associated with them. Supplemental slip ramp access points were evaluated to the east of Broadway to serve as a relief valve for access between Lucent Boulevard and Broadway. It was determined that providing access eastbound and westbound, just west of Broadway, would provide for adequate operations on the express lane facility. For this area, full access between Lucent and Broadway and an Eastbound exit and Westbound exit between Broadway and University was prepared.

9.1.5 Wadsworth Boulevard

Due to the projected through traffic remaining on and entering the express lanes before and after the Wadsworth Boulevard Interchange, consideration was given to extending the express lanes to Kipling Parkway. This would provide eastbound drivers a queue jump to bypass the congestion at Wadsworth Boulevard and offer westbound drivers a better opportunity to complete the merge from three lanes into two lanes. Based on the analysis, extending a single lane to the Kipling Parkway overpass would enhance operations. It is anticipated that single lane in each direction could be constructed in the existing median, utilizing a buffer separation between the express lanes and general purpose lanes. This section would also be tolled.

9.1.6 Final Access Alternative

Figures 9.2 and 9.3 show the proposed access locations, access types, and corresponding AM and PM peak hour volumes for the preferred alternative.

Figure 9.2
Projected AM Peak Hour Volumes Final Configuration

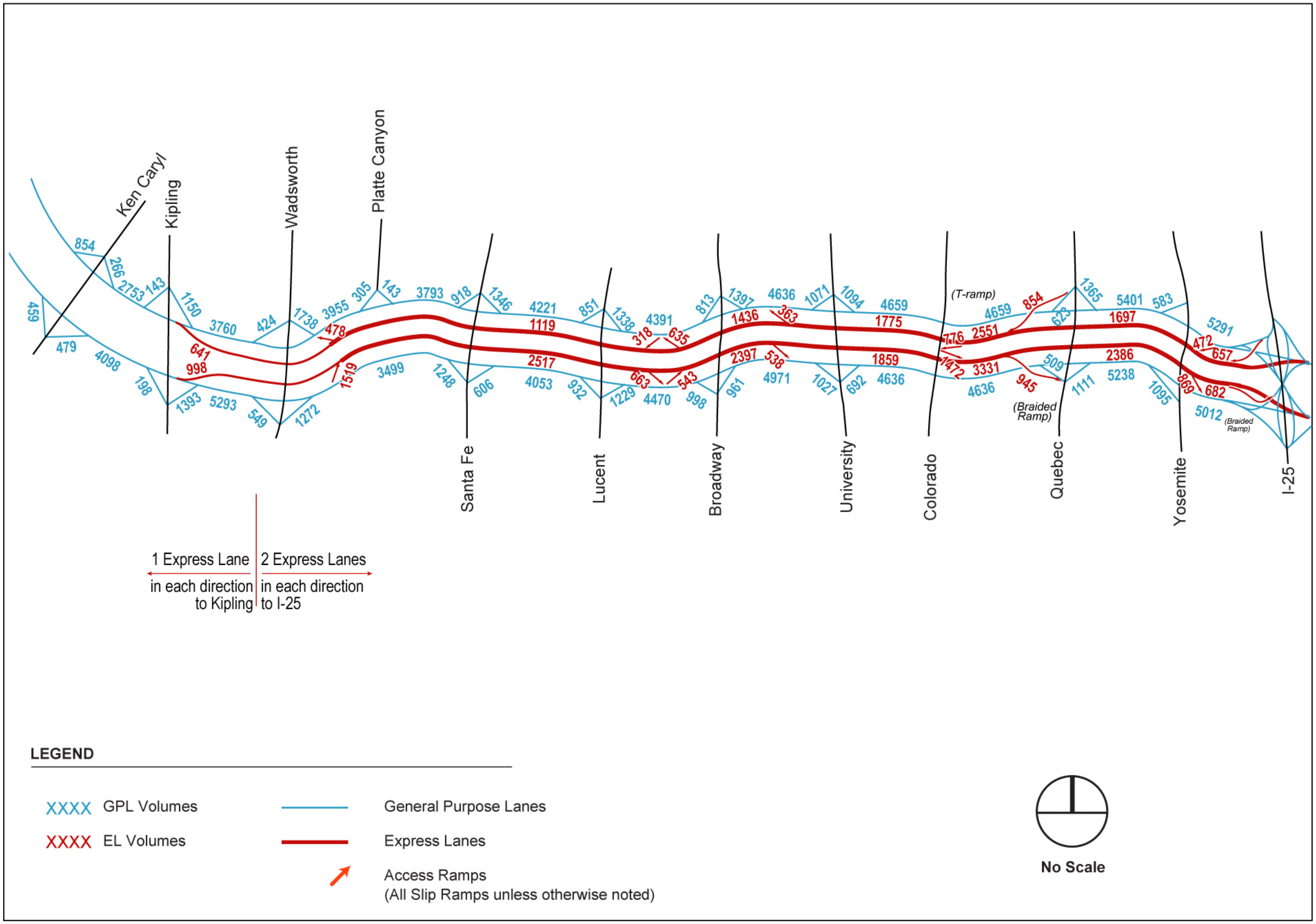
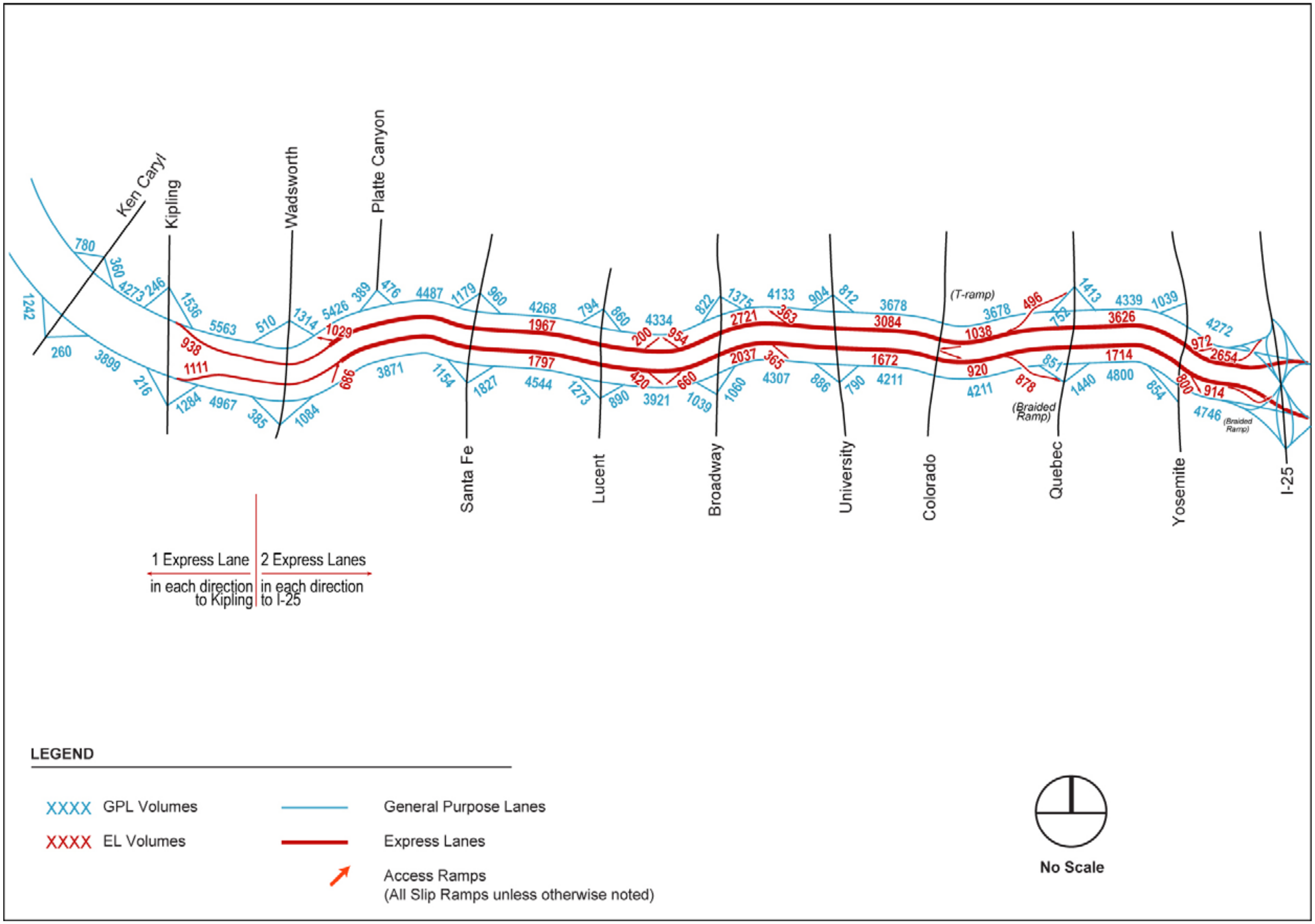


Figure 9.3
Projected PM Peak Hour Volumes Final Configuration



9.2 FINANCIAL FEASIBILITY OF FINAL CONFIGURATION

The calculated financial feasibility factors of the scenarios of the final configurations were used to refine the final alternative. Initial model runs for determining access locations, and even for determining the order of magnitude of feasibility, were conducted so that any recommended alternative could eventually pass the test of an investment grade Traffic and Revenue (T&R) study.

Several refinements to the initial assumptions were made in an attempt to increase the project's potential feasibility and to correspond to the assumptions used by the CTE in the Statewide Tolling Feasibility Study. Even though modifications were made to the input parameters, it is still believed that the assumptions in this study are conservative, and will hold up to a later test in a T&R study. The sections below describe refinements made during optimization of the financial feasibility analysis.

9.2.1 Toll Rate Optimization

Initially, the toll rate used in the financial feasibility calculation was based on a projected toll rate for 2025 and then interpolated to arrive at a potential opening year toll rate. The initial opening year toll rate for the peak hours was calculated to be $0.12 per mile. This was based on a lower value of time of $6 per hour, derived based on existing drivers' perception of existing traffic conditions. As traffic volumes and congestion increase, so does a drivers' value of time. The value of time analysis showed that an increase to $15 per hour was justified during the peak hours (Section 5.3.2). With the updated value of time, the micro-simulation model was run for opening year conditions and then optimized. A new toll rate of $0.18 per mile (In 2004 dollars) was developed. By calibrating the toll rate at both opening year and 2025, an accurate picture of the tolling rates over the 40-year bond life was produced.

Another refinement was to revise the schedule for toll rate increases. Initially, toll rate increases were assumed to occur every 5 years. This was based on past experience with cash collection systems that require more capital investment, and thus reduce the effective net revenue increase. Because this facility will use electronic toll collection, raising the toll rate annually will be easy. The benefit is that the cash flow can be accelerated, thus leveraging toll increases. The toll rate was, therefore assumed to be increased annually at 1.5% per year.

The toll collection period assumed in the analysis was also modified. Initially, the toll revenue analysis considered toll collection only during the AM and PM peak hours, accounting for toll collection during only 6 hours of a weekday. Most express lane corridors across the country implement a peak shoulder and off-peak toll period, allowing for toll collection for most of the day. Accordingly, revenue estimates were revised to consider off-peak tolls, including off-peak daytime, nighttime, and weekend hours. Consistent with the lower demand during these non-peak periods, the toll rate in these periods was reduced.

The tolling schedule subsequently produced assumes three defined toll collection periods on weekdays: peak period, peak shoulder, and off-peak. The weekend consists of an off-peak period only. The AM and PM peak hour toll rate for an assumed 2008 opening year would be approximately $0.18 in 2004 dollars. The projected 2025 AM and PM peak hour toll rate will be approximately $0.28 in 2004 dollars. This would be an approximate cost of $2.24 for opening year and $3.50 in 2025 in 2004 dollars, to travel the entire corridor from Kipling Parkway to I-25. The proposed toll schedule is shown in Table 9.2.

Table 9.1
Toll Schedule
Final Configuration

		Opening Year 2008		2025	
Time Period	Hours	Toll Rate/Mile ($)	Through Trip ($)*	Toll Rate/Mile ($)	Through Trip ($)*
AM Off-Peak	5:00 - 5:30	0.06	0.71	0.10	1.25
AM Shoulder	5:30 - 6:30	0.10	1.25	0.14	1.75
AM Peak	6:30 - 8:00	0.18	2.24	0.28	3.50
AM Shoulder	8:00 - 9:00	0.10	1.25	0.14	1.75
AM Off-Peak	9:00 - 12:00	0.06	0.75	0.10	1.25
PM Off-Peak	12:00 - 2:00	0.06	0.75	0.10	1.25
PM Shoulder	2:00 - 3:00	0.10	1.25	0.14	1.75
PM Peak	3:00 - 6:00	0.18	2.24	0.28	3.50
PM Shoulder	6:00 - 7:00	0.10	1.25	0.14	1.75
PM Off-Peak	7:00 - 10:00	0.06	0.75	0.10	1.25

** Through trip assumes travel of the entire 12.5-mile express lane corridor length.*
All dollar amounts are in 2004 dollars.

These values are shown strictly for analysis purposes; ultimately, it will be the responsibility of the CTE to determine the final toll structure, toll rates, and escalation schedule.

9.2.2 Roadway Design Capital Cost Estimates

The initial roadway typical section assumed complete reconstruction of the existing facility in order to add express lanes in the center. The initial typical section used preferred shoulder widths in accordance with AASHTO requirements. The typical section consisted of 8-foot inside shoulders and 12-foot outside shoulders in both the express lanes and general purpose lanes. Due to the high cost of reconstructing the entire pavement section, cost saving measures were considered. These measures included reducing the shoulder width, removing the proposed barrier section and replacing it with a 4-foot buffer separation, constructing a two-lane reversible facility, and providing a single lane in each direction. Ultimately, it was determined that reusing the existing pavement and reducing the shoulder width while maintaining the barrier separation would provide a desirable balance between competing interests. The final recommended typical section consists of salvaging the existing pavement, paving the median, widening to the outside, and overlaying the entire section. The proposed shoulders were also reduced to 4-foot inside and 12-foot outside shoulders.

Based on only one express lane in each direction between Platte Canyon Road and Kipling Parkway, the C-470 express lanes will be constructed in the median on the existing facility and be separated from the general purpose lanes by a 4-foot painted median. Figure 9.4 shows the proposed typical sections for the C-470 express lanes for I-25 to Platte Canyon Road, and from Platte Canyon Road to Kipling Parkway.

The final cost estimate for this configuration consists of the reconstruction of the general purpose lanes in addition to the new express lanes, and all interchange accesses except Santa Fe Drive. The Santa Fe Drive Interchange improvements are being treated as a separate action because they have Independent utility from the express lanes. Therefore, the costs of the Santa Fe Drive Interchange reconstruction are not included in the express lanes cost estimate. The final construction cost is $316,022,000 in 2004 dollars. These costs include all proposed direct access ramps and toll equipment capital costs. The roadway capital costs estimate is included in Appendix G.

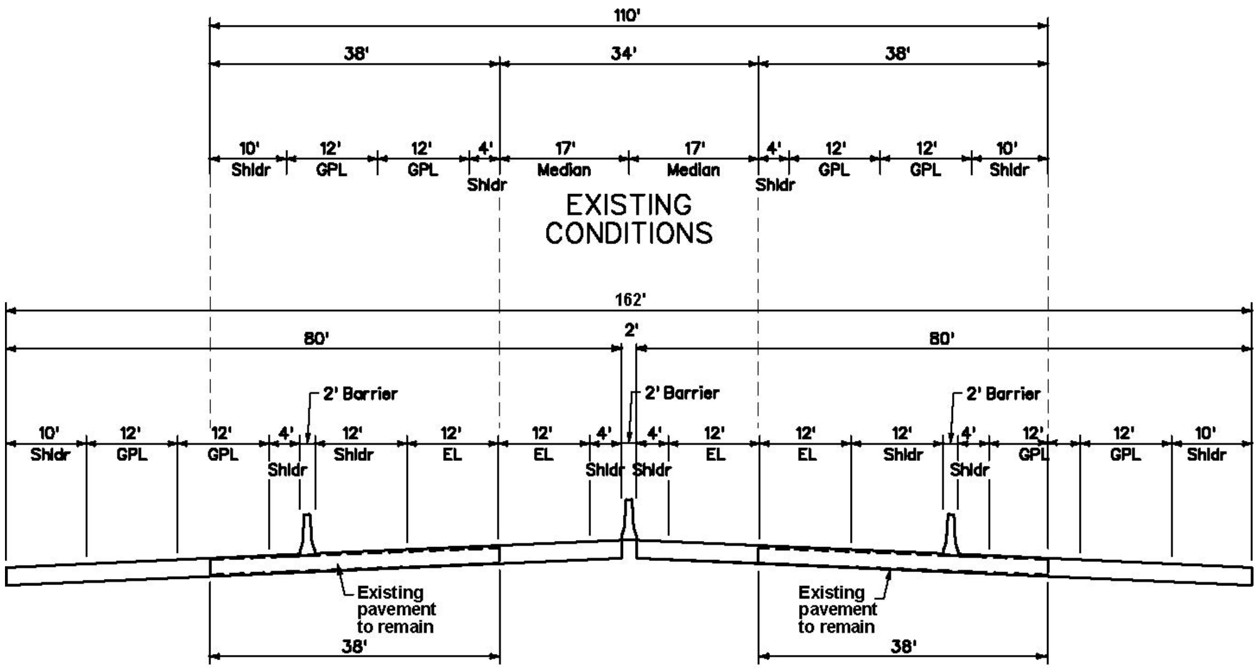
9.2.3 Toll Collection Fees

The CTE is currently negotiating with E-470 for a toll collection agreement. Though no final agreement has been reached, a toll transaction cost of $0.12 per transaction for planning purposes only was assumed in these calculations. Only one transaction would be created when a vehicle enters the express lane facility. The transaction cost was based on an audit that E-470 performed on the Northwest Parkway, which identified a higher operating cost than originally predicted. E-470 is currently processing all of Northwest Parkway's toll transactions. This transaction includes the cost of processing each transaction, account maintenance, and mailing monthly billing statements.

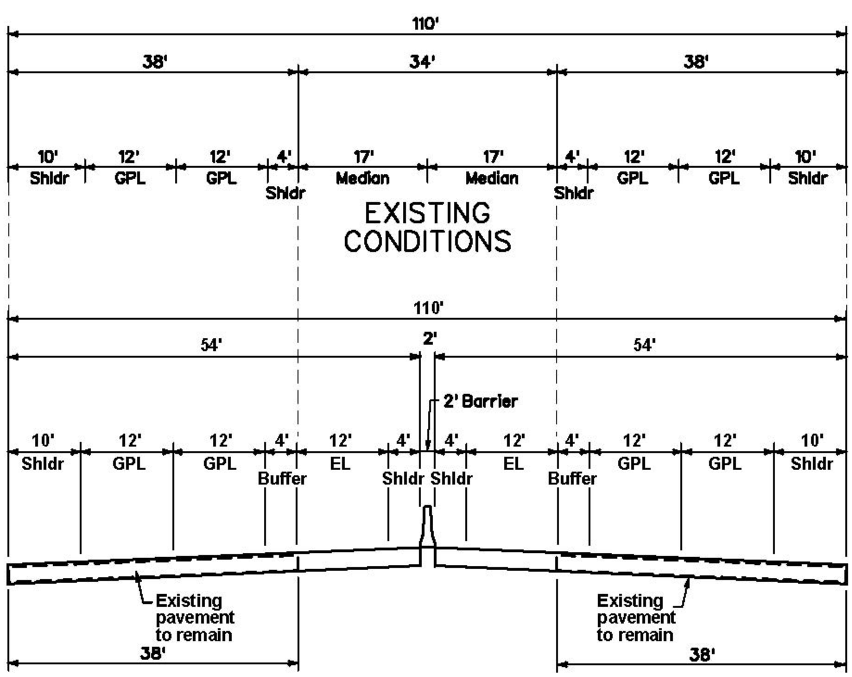
9.2.4 Financial Feasibility of Final Configuration

Incorporating the refinements and new assumptions described above, the financial feasibility was recalculated. Based on a capital construction cost of $316 million and net revenue of $196 to $259 million in 2004 dollars, it is believed that the C-470 express lanes could support a bond sale of between 68 and 80 percent of the capital cost with toll revenue. This will require that approximately 20 to 32 percent of the construction cost will need to be funded through other sources. The CTE is in the process of preparing a complete funding package that would address the source of the required 20 to 32 percent supplemental funding. Potential strategies to close the funding gap include leveraging the toll revenue, and supplementing funding sources. The financial feasibility calculations for each scenario are shown in Tables 9.4, 9.5, 9.6, and 9.7.

Figure 9.4
Proposed Typical Section



Platte Canyon to I-25



Kipling to Platte Canyon

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Table 9.2
Financial Feasibility Analysis with 5.5% Bond Rate and 1.75 Senior Lien/ 2.19 Subordinate Lien

Calendar Year	Annual Transactions[1]	Gross Toll Revenue	Operation Costs[2]	Recurring Maintenance Costs	Toll Operation and Recurring Maintenance Costs	Net Toll Revenue	Senior Lien Covered Net Revenue 1.75x's	Net Revenue after Senior Lien Debt Service	Subordinate Lien Covered Net Revenue 2.19x's	Net Revenue after Subordinate Lien Debt Service	Composite Coverage Rate (Net Toll Revenue / (Senior Lien + Subordinate Lien)	Covered Net Toll Revenue[5]	Remaining Net Toll Revenue	Present Value Covered Net Toll Revenue 5.50%
Year	# of transactions	$	$	$	$	$	$	$	$	$	%	$	$	$
2006														
2007														
2008	7,869,829	$10,209,785.21	$1,995,979.50	$1,074,657.27	$3,070,636.77	$7,139,148.44	$4,079,513.40	$3,059,635.05	$1,397,093.63	$1,662,541.42	1.30	$5,476,607.03	$2,167,241.49	$4,790,495.43
2009	7,987,877	$10,978,632.60	$2,041,693.20	$1,106,896.98	$3,148,590.18	$7,830,042.42	$4,474,309.95	$3,355,732.46	$1,532,297.93	$1,823,434.54	1.30	$6,006,607.88	$2,376,977.16	$4,980,187.26
2010	8,107,695	$11,805,608.21	$2,088,565.81	$1,140,103.89	$3,228,669.71	$8,576,938.50	$4,901,107.72	$3,675,830.79	$1,678,461.55	$1,997,369.24	1.30	$6,579,569.26	$2,603,713.47	$5,170,843.51
2011	8,229,310	$12,695,123.76	$2,136,628.94	$1,174,307.01	$3,310,935.95	$9,384,187.81	$5,362,393.03	$4,021,794.77	$1,836,435.97	$2,185,358.80	1.30	$7,198,829.00	$2,848,771.30	$5,362,574.39
2012	8,352,750	$13,651,927.03	$2,185,915.05	$1,209,536.22	$3,395,451.27	$10,256,475.76	$5,860,843.29	$4,395,632.47	$2,007,138.11	$2,388,494.35	1.30	$7,867,981.40	$3,113,573.00	$5,555,489.58
2013	8,478,041	$14,681,127.59	$2,236,457.55	$1,245,822.31	$3,482,279.86	$11,198,847.73	$6,399,341.56	$4,799,506.17	$2,191,555.33	$2,607,950.84	1.30	$8,590,896.89	$3,399,650.20	$5,749,698.33
2014	8,605,212	$15,788,224.46	$2,288,290.80	$1,283,196.98	$3,571,487.78	$12,216,736.68	$6,980,992.39	$5,235,744.29	$2,390,750.82	$2,844,993.47	1.30	$9,371,743.21	$3,708,652.21	$5,945,309.57
2015	8,734,290	$16,979,135.88	$2,341,450.14	$1,321,692.89	$3,663,143.03	$13,315,992.85	$7,609,138.77	$5,706,854.08	$2,605,869.44	$3,100,984.64	1.30	$10,215,008.21	$4,042,354.97	$6,142,431.95
2016	8,865,304	$18,260,231.42	$2,395,971.93	$1,361,343.67	$3,757,315.60	$14,502,915.82	$8,287,380.47	$6,215,535.35	$2,838,144.00	$3,377,391.35	1.30	$11,125,524.46	$4,402,670.87	$6,341,173.95
2017	8,998,284	$19,638,366.48	$2,451,893.54	$1,402,183.98	$3,854,077.52	$15,784,288.95	$9,019,593.69	$6,764,695.27	$3,088,901.95	$3,675,793.32	1.30	$12,108,495.64	$4,791,659.15	$6,541,643.97
2018	9,133,258	$21,120,919.51	$2,509,253.43	$1,444,249.50	$3,953,502.94	$17,167,416.57	$9,809,952.33	$7,357,464.25	$3,359,572.71	$3,997,891.53	1.30	$13,169,525.04	$5,211,537.17	$6,743,950.39
2019	9,270,257	$22,715,832.06	$2,568,091.17	$1,487,576.99	$4,055,668.16	$18,660,163.90	$10,662,950.80	$7,997,213.10	$3,651,695.48	$4,345,517.62	1.30	$14,314,646.28	$5,664,692.61	$6,948,201.68
2020	9,409,311	$24,431,651.89	$2,628,447.44	$1,532,204.30	$4,160,651.74	$20,271,000.15	$11,583,428.66	$8,687,571.49	$3,966,927.62	$4,720,643.87	1.30	$15,550,356.28	$6,153,696.47	$7,154,506.44
2021	9,550,450	$26,277,579.42	$2,690,364.11	$1,578,170.43	$4,268,534.53	$22,009,044.88	$12,576,597.08	$9,432,447.81	$4,307,053.79	$5,125,394.01	1.30	$16,883,650.87	$6,681,317.20	$7,362,973.52
2022	9,693,707	$28,263,517.72	$2,753,884.22	$1,625,515.54	$4,379,399.76	$23,884,117.97	$13,648,067.41	$10,236,050.56	$4,673,995.69	$5,562,054.87	1.30	$18,322,063.10	$7,250,535.81	$7,573,712.07
2023	9,839,113	$30,400,126.42	$2,819,052.07	$1,674,281.01	$4,493,333.08	$25,906,793.34	$14,803,881.91	$11,102,911.43	$5,069,822.57	$6,033,088.86	1.30	$19,873,704.48	$7,864,562.27	$7,786,831.63
2024	9,986,700	$32,698,879.64	$2,885,913.23	$1,724,509.44	$4,610,422.67	$28,088,456.97	$16,050,546.84	$12,037,910.13	$5,496,762.62	$6,541,147.51	1.30	$21,547,309.46	$8,526,853.01	$8,002,442.19
2025	10,136,500	$35,137,014.47	$2,954,514.57	$1,776,244.72	$4,730,759.29	$30,406,255.18	$17,375,002.96	$13,031,252.22	$5,950,343.48	$7,080,908.74	1.30	$23,325,346.44	$9,230,470.32	$8,211,171.82
2026	10,288,548	$36,733,991.78	$3,024,904.31	$1,829,532.06	$4,854,436.37	$31,879,555.41	$18,216,888.81	$13,662,666.60	$6,238,660.55	$7,424,006.05	1.30	$24,455,549.36	$9,677,722.18	$8,160,222.50
2027	10,442,876	$38,403,551.70	$3,097,132.05	$1,884,418.02	$4,981,550.07	$33,422,001.63	$19,098,286.65	$14,323,714.98	$6,540,509.13	$7,783,205.86	1.30	$25,638,795.77	$10,145,964.78	$8,109,045.57
2028	10,599,519	$40,148,993.13	$3,171,248.84	$1,940,950.56	$5,112,199.40	$35,036,793.73	$20,021,024.99	$15,015,768.74	$6,856,515.41	$8,159,253.33	1.30	$26,877,540.40	$10,636,169.53	$8,057,664.52
2029	10,758,512	$41,973,764.87	$3,247,307.17	$1,999,179.08	$5,246,486.25	$36,727,278.62	$20,987,016.35	$15,740,262.27	$7,187,334.37	$8,552,927.90	1.30	$28,174,350.72	$11,149,352.44	$8,006,101.93
2030	10,919,889	$43,881,472.48	$3,325,361.06	$2,059,154.45	$5,384,515.51	$38,496,956.97	$21,998,261.12	$16,498,695.84	$7,533,651.07	$8,965,044.77	1.30	$29,531,912.19	$11,686,576.22	$7,954,379.51
2031	11,083,688	$45,875,885.40	$3,405,466.09	$2,120,929.09	$5,526,395.18	$40,349,490.23	$23,056,851.56	$17,292,638.67	$7,896,182.04	$9,396,456.63	1.30	$30,953,033.60	$12,248,952.39	$7,902,518.09
2032	11,249,943	$47,960,944.40	$3,487,679.44	$2,184,556.96	$5,672,236.40	$42,288,708.00	$24,164,976.00	$18,123,732.00	$8,275,676.71	$9,848,055.29	1.30	$32,440,652.71	$12,837,643.50	$7,850,537.70
2033	11,418,692	$50,140,769.32	$3,572,059.92	$2,250,093.67	$5,822,153.59	$44,318,615.73	$25,324,923.27	$18,993,692.45	$8,672,918.93	$10,320,773.53	1.30	$33,997,842.20	$13,453,865.49	$7,798,457.58
2034	11,589,972	$52,419,667.28	$3,658,668.08	$2,317,596.48	$5,976,264.55	$46,443,402.73	$26,539,087.28	$19,904,315.46	$9,088,728.52	$10,815,586.94	1.30	$35,627,815.79	$14,098,890.12	$7,746,296.19
2035	11,763,822	$54,802,141.16	$3,747,566.17	$2,387,124.37	$6,134,690.54	$48,667,450.62	$27,809,971.79	$20,857,478.84	$9,523,962.94	$11,333,515.90	1.30	$37,333,934.73	$14,774,047.51	$7,694,071.27
2036	11,940,279	$57,292,898.48	$3,838,818.27	$2,458,738.10	$6,297,556.38	$50,995,342.10	$29,140,195.49	$21,855,146.62	$9,979,519.00	$11,875,627.61	1.30	$39,119,714.49	$15,480,728.85	$7,641,799.83
2037	12,119,384	$59,896,860.71	$3,932,490.32	$2,532,500.25	$6,464,990.56	$53,431,870.15	$30,532,497.23	$22,899,372.92	$10,456,334.67	$12,443,038.25	1.30	$40,988,831.90	$16,220,389.15	$7,589,498.22
2038	12,301,174	$62,619,173.03	$4,028,650.14	$2,608,475.25	$6,637,125.39	$55,982,047.64	$31,989,741.51	$23,992,306.13	$10,955,390.93	$13,036,915.20	1.30	$42,945,132.44	$16,994,550.18	$7,537,182.10
2039	12,485,692	$65,465,214.45	$4,127,367.53	$2,686,729.51	$6,814,097.04	$58,651,117.41	$33,514,924.23	$25,136,193.18	$11,477,713.78	$13,658,479.40	1.30	$44,992,638.01	$17,804,803.50	$7,484,866.52
2040	12,672,977	$68,440,608.44	$4,228,714.31	$2,767,331.40	$6,996,045.70	$61,444,562.74	$35,111,178.71	$26,333,384.03	$12,024,376.27	$14,309,007.76	1.30	$47,135,554.98	$18,652,813.69	$7,432,565.88
2041	12,863,072	$71,551,234.10	$4,332,764.38	$2,850,351.34	$7,183,115.72	$64,368,118.38	$36,781,781.93	$27,586,336.45	$12,596,500.66	$14,989,835.79	1.30	$49,378,282.60	$19,540,321.65	$7,380,294.02
2042	13,056,018	$74,803,237.69	$4,439,593.78	$2,935,861.88	$7,375,455.66	$67,427,782.03	$38,530,161.16	$28,897,620.87	$13,195,260.67	$15,702,360.20	1.30	$51,725,421.83	$20,469,148.12	$7,328,064.18
2043	13,251,858	$78,203,044.84	$4,549,280.76	$3,023,937.73	$7,573,218.49	$70,629,826.35	$40,359,900.77	$30,269,925.58	$13,821,883.83	$16,448,041.75	1.30	$54,181,784.59	$21,441,197.28	$7,275,889.07
2044	13,450,636	$81,757,373.23	$4,661,905.84	$3,114,655.87	$7,776,561.70	$73,980,811.53	$42,274,749.44	$31,706,062.08	$14,477,653.92	$17,228,408.16	1.30	$56,752,403.36	$22,458,460.64	$7,223,780.85
2045	13,652,396	$85,473,245.84	$4,777,551.87	$3,208,095.54	$7,985,647.41	$77,487,598.43	$44,278,627.68	$33,208,970.76	$15,163,913.59	$18,045,057.17	1.30	$59,442,541.26	$23,523,020.95	$7,171,751.16
Total	**399,156,835**	**$1,523,577,756.10**	**$120,626,897.00**	**$74,322,704.74**	**$194,949,601.74**	**$1,328,628,154.36**	**$759,216,088.21**	**$569,412,066.16**	**$260,005,509.66**	**$309,406,556.50**		**$1,019,221,597.87**	**$403,333,546.86**	**$269,708,624.36**

4 EL Barrier Separated Partial Reconstruct in 2006 Dollars	Present Value Net Revenue[3]	Capital Costs[4]	Feasibility Factor
	$0.06		5.50%
	$269,708,624.36	$335,267,740	0.80

[1] Assumes $0.02 Annual increase in transactions based on 2025 projected values that are interpolated to arrive at yearly projections

[2] Assumes $0.12 Transaction fee for E-470 Back Office Operation plus liability insurance, highway patrol, roadside assistance, ITS equipment operations, and toll audit and system inspection

[3] Assumes $0.06 Proxy rate for all in cost of borrowing (Current Market Rate)

[4] Assumes 4 EL with narrow shoulders related capital costs in 2006 Dollars including Quebec Direct Access and excluding Santa Fe Drive Interchange improvements

[5] Assumes $1.30 Composite coverage for all debt

Assumes contracting letting and project financing would begin on January 1, 2006

Table 9.3
Financial Feasibility Analysis with 6.0% Bonding Rate and 1.75 Senior Lien/ 2.19 Subordinate Lien

Calendar Year	Annual Transactions1	Gross Toll Revenue	Operation Costs2	Recurring Maintenance Costs	Toll Operation and Recurring Maintenance Costs	Net Toll Revenue	Senior Lien Covered Net Revenue 1.75x's	Net Revenue after Senior Lien Debt Service	Subordinate Lien Covered Net Revenue 2.19x's	Net Revenue after Subordinate Lien Debt Service	Composite Coverage Rate (Net Toll Revenue / (Senior Lien + Subordinate Lien)	Covered Net Toll Revenue5	Remaining Net Toll Revenue	Present Value Covered Net Toll Revenue 6.00%
Year	# of transactions	$	$	$	$	$	$	$	$	$	%	$	$	$
2006														
2007														
2008	7,869,829	$10,209,785.21	$1,995,979.50	$1,074,657.27	$3,070,636.77	$7,139,148.44	$4,079,513.40	$3,059,635.05	$1,397,093.63	$1,662,541.42	1.30	$5,476,607.03	$2,167,241.49	$4,734,203.43
2009	7,987,877	$10,978,632.60	$2,041,693.20	$1,106,896.98	$3,148,590.18	$7,830,042.42	$4,474,309.95	$3,355,732.46	$1,532,297.93	$1,823,434.54	1.30	$6,006,607.88	$2,376,977.16	$4,898,450.83
2010	8,107,695	$11,805,608.21	$2,088,565.81	$1,140,103.89	$3,228,669.71	$8,576,938.50	$4,901,107.72	$3,675,830.79	$1,678,461.55	$1,997,369.24	1.30	$6,579,569.26	$2,603,713.47	$5,061,987.51
2011	8,229,310	$12,695,123.76	$2,136,628.94	$1,174,307.01	$3,310,935.95	$9,384,187.81	$5,362,393.03	$4,021,794.77	$1,836,435.97	$2,185,358.80	1.30	$7,198,829.00	$2,848,771.30	$5,224,919.44
2012	8,352,750	$13,651,927.03	$2,185,915.05	$1,209,536.22	$3,395,451.27	$10,256,475.76	$5,860,843.29	$4,395,632.47	$2,007,138.11	$2,388,494.35	1.30	$7,867,981.40	$3,113,573.00	$5,387,350.11
2013	8,478,041	$14,681,127.59	$2,236,457.55	$1,245,822.31	$3,482,279.86	$11,198,847.73	$6,399,341.56	$4,799,506.17	$2,191,555.33	$2,607,950.84	1.30	$8,590,896.89	$3,399,650.20	$5,549,380.67
2014	8,605,212	$15,788,224.46	$2,288,290.80	$1,283,196.98	$3,571,487.78	$12,216,736.68	$6,980,992.39	$5,235,744.29	$2,390,750.82	$2,844,993.47	1.30	$9,371,743.21	$3,708,652.21	$5,711,110.00
2015	8,734,290	$16,979,135.88	$2,341,450.14	$1,321,692.89	$3,663,143.03	$13,315,992.85	$7,609,138.77	$5,706,854.08	$2,605,869.44	$3,100,984.64	1.30	$10,215,008.21	$4,042,354.97	$5,872,634.88
2016	8,865,304	$18,260,231.42	$2,395,971.93	$1,361,343.67	$3,757,315.60	$14,502,915.82	$8,287,380.47	$6,215,535.35	$2,838,144.00	$3,377,391.35	1.30	$11,125,524.46	$4,402,670.87	$6,034,050.04
2017	8,998,284	$19,638,366.48	$2,451,893.54	$1,402,183.98	$3,854,077.52	$15,784,288.95	$9,019,593.69	$6,764,695.27	$3,088,901.95	$3,675,793.32	1.30	$12,108,495.64	$4,791,659.15	$6,195,448.33
2018	9,133,258	$21,120,919.51	$2,509,253.43	$1,444,249.50	$3,953,502.94	$17,167,416.57	$9,809,952.33	$7,357,464.25	$3,359,572.71	$3,997,891.53	1.30	$13,169,525.04	$5,211,537.17	$6,356,920.74
2019	9,270,257	$22,715,832.06	$2,568,091.17	$1,487,576.99	$4,055,668.16	$18,660,163.90	$10,662,950.80	$7,997,213.10	$3,651,695.48	$4,345,517.62	1.30	$14,314,646.28	$5,664,692.61	$6,518,556.59
2020	9,409,311	$24,431,651.89	$2,628,447.44	$1,532,204.30	$4,160,651.74	$20,271,000.15	$11,583,428.66	$8,687,571.49	$3,966,927.62	$4,720,643.87	1.30	$15,550,356.28	$6,153,696.47	$6,680,443.53
2021	9,550,450	$26,277,579.42	$2,690,364.11	$1,578,170.43	$4,268,534.53	$22,009,044.88	$12,576,597.08	$9,432,447.81	$4,307,053.79	$5,125,394.01	1.30	$16,883,650.87	$6,681,317.20	$6,842,667.72
2022	9,693,707	$28,263,517.72	$2,753,884.22	$1,625,515.54	$4,379,399.76	$23,884,117.97	$13,648,067.41	$10,236,050.56	$4,673,995.69	$5,562,054.87	1.30	$18,322,063.10	$7,250,535.81	$7,005,313.86
2023	9,839,113	$30,400,126.42	$2,819,052.07	$1,674,281.01	$4,493,333.08	$25,906,793.34	$14,803,881.91	$11,102,911.43	$5,069,822.57	$6,033,088.86	1.30	$19,873,704.48	$7,864,562.27	$7,168,465.27
2024	9,986,700	$32,698,879.64	$2,885,913.23	$1,724,509.44	$4,610,422.67	$28,088,456.97	$16,050,546.84	$12,037,910.13	$5,496,762.62	$6,541,147.51	1.30	$21,547,309.46	$8,526,853.01	$7,332,204.03
2025	10,136,500	$35,137,014.47	$2,954,514.57	$1,776,244.72	$4,730,759.29	$30,406,255.18	$17,375,002.96	$13,031,252.22	$5,950,343.48	$7,080,908.74	1.30	$23,325,346.44	$9,230,470.32	$7,487,963.70
2026	10,288,548	$36,733,991.78	$3,024,904.31	$1,829,532.06	$4,854,436.37	$31,879,555.41	$18,216,888.81	$13,662,666.60	$6,238,660.55	$7,424,006.05	1.30	$24,455,549.36	$9,677,722.18	$7,406,400.37
2027	10,442,876	$38,403,551.70	$3,097,132.05	$1,884,418.02	$4,981,550.07	$33,422,001.63	$19,098,286.65	$14,323,714.98	$6,540,509.13	$7,783,205.86	1.30	$25,638,795.77	$10,145,964.78	$7,325,234.29
2028	10,599,519	$40,148,993.13	$3,171,248.84	$1,940,950.56	$5,112,199.40	$35,036,793.73	$20,021,024.99	$15,015,768.74	$6,856,515.41	$8,159,253.33	1.30	$26,877,540.40	$10,636,169.53	$7,244,485.62
2029	10,758,512	$41,973,764.87	$3,247,307.17	$1,999,179.08	$5,246,486.25	$36,727,278.62	$20,987,016.35	$15,740,262.27	$7,187,334.37	$8,552,927.90	1.30	$28,174,350.72	$11,149,352.44	$7,164,173.30
2030	10,919,889	$43,881,472.48	$3,325,361.06	$2,059,154.45	$5,384,515.51	$38,496,956.97	$21,998,261.12	$16,498,695.84	$7,533,651.07	$8,965,044.77	1.30	$29,531,912.19	$11,686,576.22	$7,084,315.10
2031	11,083,688	$45,875,885.40	$3,405,466.09	$2,120,929.09	$5,526,395.18	$40,349,490.23	$23,056,851.56	$17,292,638.67	$7,896,182.04	$9,396,456.63	1.30	$30,953,033.60	$12,248,952.39	$7,004,927.66
2032	11,249,943	$47,960,944.40	$3,487,679.44	$2,184,556.96	$5,672,236.40	$42,288,708.00	$24,164,976.00	$18,123,732.00	$8,275,676.71	$9,848,055.29	1.30	$32,440,652.71	$12,837,643.50	$6,926,026.58
2033	11,418,692	$50,140,769.32	$3,572,059.92	$2,250,093.67	$5,822,153.59	$44,318,615.73	$25,324,923.27	$18,993,692.45	$8,672,918.93	$10,320,773.53	1.30	$33,997,842.20	$13,453,865.49	$6,847,626.42
2034	11,589,972	$52,419,667.28	$3,658,668.08	$2,317,596.48	$5,976,264.55	$46,443,402.73	$26,539,087.28	$19,904,315.46	$9,088,728.52	$10,815,586.94	1.30	$35,627,815.79	$14,098,890.12	$6,769,740.76
2035	11,763,822	$54,802,141.16	$3,747,566.17	$2,387,124.37	$6,134,690.54	$48,667,450.62	$27,809,971.79	$20,857,478.84	$9,523,962.94	$11,333,515.90	1.30	$37,333,934.73	$14,774,047.51	$6,692,382.25
2036	11,940,279	$57,292,898.48	$3,838,818.27	$2,458,738.10	$6,297,556.38	$50,995,342.10	$29,140,195.49	$21,855,146.62	$9,979,519.00	$11,875,627.61	1.30	$39,119,714.49	$15,480,728.85	$6,615,562.64
2037	12,119,384	$59,896,860.71	$3,932,490.32	$2,532,500.25	$6,464,990.56	$53,431,870.15	$30,532,497.23	$22,899,372.92	$10,456,334.67	$12,443,038.25	1.30	$40,988,831.90	$16,220,389.15	$6,539,292.84
2038	12,301,174	$62,619,173.03	$4,028,650.14	$2,608,475.25	$6,637,125.39	$55,982,047.64	$31,989,741.51	$23,992,306.13	$10,955,390.93	$13,036,915.20	1.30	$42,945,132.44	$16,994,550.18	$6,463,582.93
2039	12,485,692	$65,465,214.45	$4,127,367.53	$2,686,729.51	$6,814,097.04	$58,651,117.41	$33,514,924.23	$25,136,193.18	$11,477,713.78	$13,658,479.40	1.30	$44,992,638.01	$17,804,803.50	$6,388,442.22
2040	12,672,977	$68,440,608.44	$4,228,714.31	$2,767,331.40	$6,996,045.70	$61,444,562.74	$35,111,178.71	$26,333,384.03	$12,024,376.27	$14,309,007.76	1.30	$47,135,554.98	$18,652,813.69	$6,313,879.27
2041	12,863,072	$71,551,234.10	$4,332,764.38	$2,850,351.34	$7,183,115.72	$64,368,118.38	$36,781,781.93	$27,586,336.45	$12,596,500.66	$14,989,835.79	1.30	$49,378,282.60	$19,540,321.65	$6,239,901.93
2042	13,056,018	$74,803,237.69	$4,439,593.78	$2,935,861.88	$7,375,455.66	$67,427,782.03	$38,530,161.16	$28,897,620.87	$13,195,260.67	$15,702,360.20	1.30	$51,725,421.83	$20,469,148.12	$6,166,517.37
2043	13,251,858	$78,203,044.84	$4,549,280.76	$3,023,937.73	$7,573,218.49	$70,629,826.35	$40,359,900.77	$30,269,925.58	$13,821,883.83	$16,448,041.75	1.30	$54,181,784.59	$21,441,197.28	$6,093,732.11
2044	13,450,636	$81,757,373.23	$4,661,905.84	$3,114,655.87	$7,776,561.70	$73,980,811.53	$42,274,749.44	$31,706,062.08	$14,477,653.92	$17,228,408.16	1.30	$56,752,403.36	$22,458,460.64	$6,021,552.06
2045	13,652,396	$85,473,245.84	$4,777,551.87	$3,208,095.54	$7,985,647.41	$77,487,598.43	$44,278,627.68	$33,208,970.76	$15,163,913.59	$18,045,057.17	1.30	$59,442,541.26	$23,523,020.95	$5,949,982.52
Total	**399,156,835**	**$1,523,577,756.10**	**$120,626,897.00**	**$74,322,704.74**	**$194,949,601.74**	**$1,328,628,154.36**	**$759,216,088.21**	**$569,412,066.16**	**$260,005,509.66**	**$309,406,556.50**		**$1,019,221,597.87**	**$403,333,546.86**	**$243,319,828.92**

4 EL Barrier Separated Partial Reconstruct in 2006 Dollars	Present Value Net Revenue[3]	Capital Costs[4]	Feasibility Factor
	6.00%		6.00%
	$243,319,829	$335,267,740	0.73

[1] Assumes 1.5% Annual increase in transactions based on 2025 projected values that are interpolated to arrive at yearly projections

[2] Assumes $0.12 Transaction fee for E-470 Back Office Operation plus liability insurance, highway patrol, roadside assistance, ITS equipment operations, and toll audit and system inspection

[3] Assumes 6.00% Proxy rate for all in cost of borrowing (Current Market Rate plus 50 basis points)

[4] Assumes 4 EL with narrow shoulders related capital costs in 2006 Dollars including Quebec Direct Access and excluding Santa Fe Drive Interchange improvements

[5] Assumes 1.30 Composite coverage for all debt

Assumes contracting letting and project financing would begin on January 1, 2006

PV(2006) of EL O&M Costs =	$59,763,134
PV(2004) of EL O&M Costs =	$56,332,486
Total 40 Year GPL O&M Costs=	$140,100,793.57
PV(2004) of GPL O&M Costs =	$40,483,417
PV(2006) of GPL O&M Costs =	$42,948,857

Note: All values are in 2006 Dollars

Table 9.4
Financial Feasibility Analysis with 5.5% Bonding Rate and 1.75 Senior Lien/ 2.99 Subordinate Lien

Calendar Year	Annual Transactions1	Gross Toll Revenue	Operation Costs2	Recurring Maintenance Costs	Toll Operation and Recurring Maintenance Costs	Net Toll Revenue	Senior Lien Covered Net Revenue 1.75x's	Net Revenue after Senior Lien Debt Service	Subordinate Lien Covered Net Revenue 2.99x's	Net Revenue after Subordinate Lien Debt Service	Composite Coverage Rate (Net Toll Revenue/(Senior Lien + Subordinate Lien)	Covered Net Toll Revenue5	Remaining Net Toll Revenue	Present Value Covered Net Toll Revenue 5.50%
Year	# of transactions	$	$	$	$	$	$	$	$	$	%	$	$	$
2006		$0.00	$0.00			$0.00	$0.00	$0.00	$0.00	$0.00				
2007		$0.00	$0.00			$0.00	$0.00	$0.00	$0.00	$0.00				
2008	7,869,829	$10,209,785.21	$1,995,979.50	$1,074,657.27	$3,070,636.77	$7,139,148.44	$4,079,513.40	$3,059,635.05	$1,023,289.31	$2,036,345.73	1.40	$5,102,802.71	$2,848,978.36	$4,463,521.47
2009	7,987,877	$10,978,632.60	$2,041,693.20	$1,106,896.98	$3,148,590.18	$7,830,042.42	$4,474,309.95	$3,355,732.46	$1,122,318.55	$2,233,413.91	1.40	$5,596,628.50	$3,124,689.39	$4,640,265.94
2010	8,107,695	$11,805,608.21	$2,088,565.81	$1,140,103.89	$3,228,669.71	$8,576,938.50	$4,901,107.72	$3,675,830.79	$1,229,374.84	$2,446,455.94	1.40	$6,130,482.56	$3,422,748.85	$4,817,909.00
2011	8,229,310	$12,695,123.76	$2,136,628.94	$1,174,307.01	$3,310,935.95	$9,384,187.81	$5,362,393.03	$4,021,794.77	$1,345,081.86	$2,676,712.91	1.40	$6,707,474.90	$3,744,893.13	$4,996,553.34
2012	8,352,750	$13,651,927.03	$2,185,915.05	$1,209,536.22	$3,395,451.27	$10,256,475.76	$5,860,843.29	$4,395,632.47	$1,470,111.19	$2,925,521.27	1.40	$7,330,954.48	$4,092,992.00	$5,176,301.15
2013	8,478,041	$14,681,127.59	$2,236,457.55	$1,245,822.31	$3,482,279.86	$11,198,847.73	$6,399,341.56	$4,799,506.17	$1,605,186.01	$3,194,320.16	1.40	$8,004,527.57	$4,469,058.89	$5,357,254.25
2014	8,605,212	$15,788,224.46	$2,288,290.80	$1,283,196.98	$3,571,487.78	$12,216,736.68	$6,980,992.39	$5,235,744.29	$1,751,085.05	$3,484,659.24	1.40	$8,732,077.44	$4,875,261.90	$5,539,514.09
2015	8,734,290	$16,979,135.88	$2,341,450.14	$1,321,692.89	$3,663,143.03	$13,315,992.85	$7,609,138.77	$5,706,854.08	$1,908,646.85	$3,798,207.23	1.40	$9,517,785.62	$5,313,935.65	$5,723,181.94
2016	8,865,304	$18,260,231.42	$2,395,971.93	$1,361,343.67	$3,757,315.60	$14,502,915.82	$8,287,380.47	$6,215,535.35	$2,078,774.36	$4,136,760.99	1.40	$10,366,154.83	$5,787,594.08	$5,908,358.86
2017	8,998,284	$19,638,366.48	$2,451,893.54	$1,402,183.98	$3,854,077.52	$15,784,288.95	$9,019,593.69	$6,764,695.27	$2,262,439.89	$4,502,255.38	1.40	$11,282,033.58	$6,298,944.19	$6,095,145.85
2018	9,133,258	$21,120,919.51	$2,509,253.43	$1,444,249.50	$3,953,502.94	$17,167,416.57	$9,809,952.33	$7,357,464.25	$2,460,690.38	$4,896,773.86	1.40	$12,270,642.71	$6,850,900.86	$6,283,643.90
2019	9,270,257	$22,715,832.06	$2,568,091.17	$1,487,576.99	$4,055,668.16	$18,660,163.90	$10,662,950.80	$7,997,213.10	$2,674,653.21	$5,322,559.89	1.40	$13,337,604.01	$7,446,602.84	$6,473,954.07
2020	9,409,311	$24,431,651.89	$2,628,447.44	$1,532,204.30	$4,160,651.74	$20,271,000.15	$11,583,428.66	$8,687,571.49	$2,905,542.30	$5,782,029.19	1.40	$14,488,970.96	$8,089,429.87	$6,666,177.56
2021	9,550,450	$26,277,579.42	$2,690,364.11	$1,578,170.43	$4,268,534.53	$22,009,044.88	$12,576,597.08	$9,432,447.81	$3,154,664.82	$6,277,782.99	1.40	$15,731,261.89	$8,783,021.25	$6,860,415.78
2022	9,693,707	$28,263,517.72	$2,753,884.22	$1,625,515.54	$4,379,399.76	$23,884,117.97	$13,648,067.41	$10,236,050.56	$3,423,428.28	$6,812,622.28	1.40	$17,071,495.69	$9,531,295.74	$7,056,770.42
2023	9,839,113	$30,400,126.42	$2,819,052.07	$1,674,281.01	$4,493,333.08	$25,906,793.34	$14,803,881.91	$11,102,911.43	$3,713,348.31	$7,389,563.13	1.40	$18,517,230.22	$10,338,473.01	$7,255,343.56
2024	9,986,700	$32,698,879.64	$2,885,913.23	$1,724,509.44	$4,610,422.67	$28,088,456.97	$16,050,546.84	$12,037,910.13	$4,026,056.90	$8,011,853.23	1.40	$20,076,603.74	$11,209,096.80	$7,456,237.69
2025	10,136,500	$35,137,014.47	$2,954,514.57	$1,776,244.72	$4,730,759.29	$30,406,255.18	$17,375,002.96	$13,031,252.22	$4,358,278.33	$8,672,973.89	1.40	$21,733,281.30	$12,134,047.02	$7,650,720.53
2026	10,288,548	$36,733,991.78	$3,024,904.31	$1,829,532.06	$4,854,436.37	$31,879,555.41	$18,216,888.81	$13,662,666.60	$4,569,453.71	$9,093,212.89	1.40	$22,786,342.52	$12,721,988.36	$7,603,248.74
2027	10,442,876	$38,403,551.70	$3,097,132.05	$1,884,418.02	$4,981,550.07	$33,422,001.63	$19,098,286.65	$14,323,714.98	$4,790,540.13	$9,533,174.86	1.40	$23,888,826.77	$13,337,523.38	$7,555,564.88
2028	10,599,519	$40,148,993.13	$3,171,248.84	$1,940,950.56	$5,112,199.40	$35,036,793.73	$20,021,024.99	$15,015,768.74	$5,021,996.23	$9,993,772.51	1.40	$25,043,021.22	$13,981,929.05	$7,507,690.83
2029	10,758,512	$41,973,764.87	$3,247,307.17	$1,999,179.08	$5,246,486.25	$36,727,278.62	$20,987,016.35	$15,740,262.27	$5,264,301.76	$10,475,960.50	1.40	$26,251,318.12	$14,656,541.00	$7,459,647.63
2030	10,919,889	$43,881,472.48	$3,325,361.06	$2,059,154.45	$5,384,515.51	$38,496,956.97	$21,998,261.12	$16,498,695.84	$5,517,958.48	$10,980,737.37	1.40	$27,516,219.60	$15,362,756.22	$7,411,455.51
2031	11,083,688	$45,875,885.40	$3,405,466.09	$2,120,929.09	$5,526,395.18	$40,349,490.23	$23,056,851.56	$17,292,638.67	$5,783,491.19	$11,509,147.47	1.40	$28,840,342.75	$16,102,035.87	$7,363,133.87
2032	11,249,943	$47,960,944.40	$3,487,679.44	$2,184,556.96	$5,672,236.40	$42,288,708.00	$24,164,976.00	$18,123,732.00	$6,061,448.83	$12,062,283.17	1.40	$30,226,424.83	$16,875,908.21	$7,314,701.39
2033	11,418,692	$50,140,769.32	$3,572,059.92	$2,250,093.67	$5,822,153.59	$44,318,615.73	$25,324,923.27	$18,993,692.45	$6,352,405.50	$12,641,286.95	1.40	$31,677,328.78	$17,685,971.65	$7,266,175.99
2034	11,589,972	$52,419,667.28	$3,658,668.08	$2,317,596.48	$5,976,264.55	$46,443,402.73	$26,539,087.28	$19,904,315.46	$6,656,961.69	$13,247,353.77	1.40	$33,196,048.97	$18,533,898.02	$7,217,574.86
2035	11,763,822	$54,802,141.16	$3,747,566.17	$2,387,124.37	$6,134,690.54	$48,667,450.62	$27,809,971.79	$20,857,478.84	$6,975,745.43	$13,881,733.41	1.40	$34,785,717.22	$19,421,435.84	$7,168,914.53
2036	11,940,279	$57,292,898.48	$3,838,818.27	$2,458,738.10	$6,297,556.38	$50,995,342.10	$29,140,195.49	$21,855,146.62	$7,309,413.58	$14,545,733.03	1.40	$36,449,609.07	$20,350,413.93	$7,120,210.87
2037	12,119,384	$59,896,860.71	$3,932,490.32	$2,532,500.25	$6,464,990.56	$53,431,870.15	$30,532,497.23	$22,899,372.92	$7,658,653.15	$15,240,719.77	1.40	$38,191,150.38	$21,322,744.97	$7,071,479.09
2038	12,301,174	$62,619,173.03	$4,028,650.14	$2,608,475.25	$6,637,125.39	$55,982,047.64	$31,989,741.51	$23,992,306.13	$8,024,182.65	$15,968,123.48	1.40	$40,013,924.16	$22,340,429.44	$7,022,733.80
2039	12,485,692	$65,465,214.45	$4,127,367.53	$2,686,729.51	$6,814,097.04	$58,651,117.41	$33,514,924.23	$25,136,193.18	$8,406,753.57	$16,729,439.61	1.40	$41,921,677.80	$23,405,559.55	$6,973,989.00
2040	12,672,977	$68,440,608.44	$4,228,714.31	$2,767,331.40	$6,996,045.70	$61,444,562.74	$35,111,178.71	$26,333,384.03	$8,807,151.85	$17,526,232.18	1.40	$43,918,330.56	$24,520,323.50	$6,925,258.13
2041	12,863,072	$71,551,234.10	$4,332,764.38	$2,850,351.34	$7,183,115.72	$64,368,118.38	$36,781,781.93	$27,586,336.45	$9,226,199.48	$18,360,136.97	1.40	$46,007,981.41	$25,687,009.81	$6,876,554.07
2042	13,056,018	$74,803,237.69	$4,439,593.78	$2,935,861.88	$7,375,455.66	$67,427,782.03	$38,530,161.16	$28,897,620.87	$9,664,756.14	$19,232,864.73	1.40	$48,194,917.30	$26,908,011.95	$6,827,889.17
2043	13,251,858	$78,203,044.84	$4,549,280.76	$3,023,937.73	$7,573,218.49	$70,629,826.35	$40,359,900.77	$30,269,925.58	$10,123,720.93	$20,146,204.65	1.40	$50,483,621.70	$28,185,833.11	$6,779,275.25
2044	13,450,636	$81,757,373.23	$4,661,905.84	$3,114,655.87	$7,776,561.70	$73,980,811.53	$42,274,749.44	$31,706,062.08	$10,604,034.14	$21,102,027.94	1.40	$52,878,783.58	$29,523,091.23	$6,730,723.66
2045	13,652,396	$85,473,245.84	$4,777,551.87	$3,208,095.54	$7,985,647.41	$77,487,598.43	$44,278,627.68	$33,208,970.76	$11,106,679.18	$22,102,291.57	1.40	$55,385,306.86	$30,922,524.24	$6,682,245.25
Total	**399,156,835**	**$1,523,577,756.10**	**$120,626,897.00**	**$74,322,704.74**	**$194,949,601.74**	**$1,328,628,154.36**	**$759,216,088.21**	**$569,412,066.16**	**$190,438,818.11**	**$378,973,248.04**		**$949,654,906.32**	**$530,207,893.15**	**$251,299,735.93**

4 EL Barrier Separated Partial Reconstruct in 2006 Dollars	**Present Value Net Revenue[3]**	**Capital Costs[4]**	**Feasibility Factor**
	5.50%		**5.50%**
	$251,299,736	**$335,267,739.80**	**0.75**

[1] Assumes 1.5% Annual increase in transactions based on 2025 projected values that are interpolated to arrive at yearly projections

[2] Assumes $0.12 Transaction fee for E-470 Back Office Operation plus liability insurance, highway patrol, roadside assistance, ITS equipment operations, and toll audit and system inspection

[3] Assumes 5.50% Proxy rate for all in cost of borrowing (Current Market Rate)

[4] Assumes 4 EL with narrow shoulders related capital costs in 2006 Dollars including Quebec Direct Access and excluding Santa Fe Drive Interchange improvements

[5] Assumes 1.4 Composite coverage for all debt

Assumes contracting letting and project financing would begin on January 1, 2006

Note: All values are in 2006 Dollars

Table 9.5
Financial Feasibility Analysis with 6.0% Bonding Rate and 1.75 Senior Lien/ 2.99 Subordinate Lien

Calendar Year	Annual Transactions[1]	Gross Toll Revenue	Operation Costs[2]	Recurring Maintenance Costs	Toll Operation and Recurring Maintenance Costs	Net Toll Revenue	Senior Lien Covered Net Revenue 1.75x's	Net Revenue after Senior Lien Debt Service	Subordinate Lien Covered Net Revenue 2.99x's	Net Revenue after Subordinate Lien Debt Service	Composite Coverage Rate (Net Toll Revenue / (Senior Lien + Subordinate Lien)	Covered Net Toll Revenue[5]	Remaining Net Toll Revenue	Present Value Covered Net Toll Revenue 6.00%
Year	# of transactions	$	$	$	$	$	$	$	$	$	%	$	$	$
2006														
2007														
2008	7,869,829	$10,209,785.21	$1,995,979.50	$1,074,657.27	$3,070,636.77	$7,139,148.44	$4,079,513.40	$3,059,635.05	$1,023,289.31	$2,036,345.73	1.40	$5,102,802.71	$2,848,978.36	$4,411,071.67
2009	7,987,877	$10,978,632.60	$2,041,693.20	$1,106,896.98	$3,148,590.18	$7,830,042.42	$4,474,309.95	$3,355,732.46	$1,122,318.55	$2,233,413.91	1.40	$5,596,628.50	$3,124,689.39	$4,564,108.41
2010	8,107,695	$11,805,608.21	$2,088,565.81	$1,140,103.89	$3,228,669.71	$8,576,938.50	$4,901,107.72	$3,675,830.79	$1,229,374.84	$2,446,455.94	1.40	$6,130,482.56	$3,422,748.85	$4,716,482.94
2011	8,229,310	$12,695,123.76	$2,136,628.94	$1,174,307.01	$3,310,935.95	$9,384,187.81	$5,362,393.03	$4,021,794.77	$1,345,081.86	$2,676,712.91	1.40	$6,707,474.90	$3,744,893.13	$4,868,293.99
2012	8,352,750	$13,651,927.03	$2,185,915.05	$1,209,536.22	$3,395,451.27	$10,256,475.76	$5,860,843.29	$4,395,632.47	$1,470,111.19	$2,925,521.27	1.40	$7,330,954.48	$4,092,992.00	$5,019,638.01
2013	8,478,041	$14,681,127.59	$2,236,457.55	$1,245,822.31	$3,482,279.86	$11,198,847.73	$6,399,341.56	$4,799,506.17	$1,605,186.01	$3,194,320.16	1.40	$8,004,527.57	$4,469,058.89	$5,170,609.21
2014	8,605,212	$15,788,224.46	$2,288,290.80	$1,283,196.98	$3,571,487.78	$12,216,736.68	$6,980,992.39	$5,235,744.29	$1,751,085.05	$3,484,659.24	1.40	$8,732,077.44	$4,875,261.90	$5,321,299.75
2015	8,734,290	$16,979,135.88	$2,341,450.14	$1,321,692.89	$3,663,143.03	$13,315,992.85	$7,609,138.77	$5,706,854.08	$1,908,646.85	$3,798,207.23	1.40	$9,517,785.62	$5,313,935.65	$5,471,799.79
2016	8,865,304	$18,260,231.42	$2,395,971.93	$1,361,343.67	$3,757,315.60	$14,502,915.82	$8,287,380.47	$6,215,535.35	$2,078,774.36	$4,136,760.99	1.40	$10,366,154.83	$5,787,594.08	$5,622,197.61
2017	8,998,284	$19,638,366.48	$2,451,893.54	$1,402,183.98	$3,854,077.52	$15,784,288.95	$9,019,593.69	$6,764,695.27	$2,262,439.89	$4,502,255.38	1.40	$11,282,033.58	$6,298,944.19	$5,772,579.69
2018	9,133,258	$21,120,919.51	$2,509,253.43	$1,444,249.50	$3,953,502.94	$17,167,416.57	$9,809,952.33	$7,357,464.25	$2,460,690.38	$4,896,773.86	1.40	$12,270,642.71	$6,850,900.86	$5,923,030.85
2019	9,270,257	$22,715,832.06	$2,568,091.17	$1,487,576.99	$4,055,668.16	$18,660,163.90	$10,662,950.80	$7,997,213.10	$2,674,653.21	$5,322,559.89	1.40	$13,337,604.01	$7,446,602.84	$6,073,634.29
2020	9,409,311	$24,431,651.89	$2,628,447.44	$1,532,204.30	$4,160,651.74	$20,271,000.15	$11,583,428.66	$8,687,571.49	$2,905,542.30	$5,782,029.19	1.40	$14,488,970.96	$8,089,429.87	$6,224,471.68
2021	9,550,450	$26,277,579.42	$2,690,364.11	$1,578,170.43	$4,268,534.53	$22,009,044.88	$12,576,597.08	$9,432,447.81	$3,154,664.82	$6,277,782.99	1.40	$15,731,261.89	$8,783,021.25	$6,375,623.31
2022	9,693,707	$28,263,517.72	$2,753,884.22	$1,625,515.54	$4,379,399.76	$23,884,117.97	$13,648,067.41	$10,236,050.56	$3,423,428.28	$6,812,622.28	1.40	$17,071,495.69	$9,531,295.74	$6,527,168.07
2023	9,839,113	$30,400,126.42	$2,819,052.07	$1,674,281.01	$4,493,333.08	$25,906,793.34	$14,803,881.91	$11,102,911.43	$3,713,348.31	$7,389,563.13	1.40	$18,517,230.22	$10,338,473.01	$6,679,183.63
2024	9,986,700	$32,698,879.64	$2,885,913.23	$1,724,509.44	$4,610,422.67	$28,088,456.97	$16,050,546.84	$12,037,910.13	$4,026,056.90	$8,011,853.23	1.40	$20,076,603.74	$11,209,096.80	$6,831,746.45
2025	10,136,500	$35,137,014.47	$2,954,514.57	$1,776,244.72	$4,730,759.29	$30,406,255.18	$17,375,002.96	$13,031,252.22	$4,358,278.33	$8,672,973.89	1.40	$21,733,281.30	$12,134,047.02	$6,976,874.78
2026	10,288,548	$36,733,991.78	$3,024,904.31	$1,829,532.06	$4,854,436.37	$31,879,555.41	$18,216,888.81	$13,662,666.60	$4,569,453.71	$9,093,212.89	1.40	$22,786,342.52	$12,721,988.36	$6,900,878.54
2027	10,442,876	$38,403,551.70	$3,097,132.05	$1,884,418.02	$4,981,550.07	$33,422,001.63	$19,098,286.65	$14,323,714.98	$4,790,540.13	$9,533,174.86	1.40	$23,888,826.77	$13,337,523.38	$6,825,252.43
2028	10,599,519	$40,148,993.13	$3,171,248.84	$1,940,950.56	$5,112,199.40	$35,036,793.73	$20,021,024.99	$15,015,768.74	$5,021,996.23	$9,993,772.51	1.40	$25,043,021.22	$13,981,929.05	$6,750,015.24
2029	10,758,512	$41,973,764.87	$3,247,307.17	$1,999,179.08	$5,246,486.25	$36,727,278.62	$20,987,016.35	$15,740,262.27	$5,264,301.76	$10,475,960.50	1.40	$26,251,318.12	$14,656,541.00	$6,675,184.61
2030	10,919,889	$43,881,472.48	$3,325,361.06	$2,059,154.45	$5,384,515.51	$38,496,956.97	$21,998,261.12	$16,498,695.84	$5,517,958.48	$10,980,737.37	1.40	$27,516,219.60	$15,362,756.22	$6,600,777.11
2031	11,083,688	$45,875,885.40	$3,405,466.09	$2,120,929.09	$5,526,395.18	$40,349,490.23	$23,056,851.56	$17,292,638.67	$5,783,491.19	$11,509,147.47	1.40	$28,840,342.75	$16,102,035.87	$6,526,808.24
2032	11,249,943	$47,960,944.40	$3,487,679.44	$2,184,556.96	$5,672,236.40	$42,288,708.00	$24,164,976.00	$18,123,732.00	$6,061,448.83	$12,062,283.17	1.40	$30,226,424.83	$16,875,908.21	$6,453,292.53
2033	11,418,692	$50,140,769.32	$3,572,059.92	$2,250,093.67	$5,822,153.59	$44,318,615.73	$25,324,923.27	$18,993,692.45	$6,352,405.50	$12,641,286.95	1.40	$31,677,328.78	$17,685,971.65	$6,380,243.55
2034	11,589,972	$52,419,667.28	$3,658,668.08	$2,317,596.48	$5,976,264.55	$46,443,402.73	$26,539,087.28	$19,904,315.46	$6,656,961.69	$13,247,353.77	1.40	$33,196,048.97	$18,533,898.02	$6,307,673.96
2035	11,763,822	$54,802,141.16	$3,747,566.17	$2,387,124.37	$6,134,690.54	$48,667,450.62	$27,809,971.79	$20,857,478.84	$6,975,745.43	$13,881,733.41	1.40	$34,785,717.22	$19,421,435.84	$6,235,595.53
2036	11,940,279	$57,292,898.48	$3,838,818.27	$2,458,738.10	$6,297,556.38	$50,995,342.10	$29,140,195.49	$21,855,146.62	$7,309,413.58	$14,545,733.03	1.40	$36,449,609.07	$20,350,413.93	$6,164,019.22
2037	12,119,384	$59,896,860.71	$3,932,490.32	$2,532,500.25	$6,464,990.56	$53,431,870.15	$30,532,497.23	$22,899,372.92	$7,658,653.15	$15,240,719.77	1.40	$38,191,150.38	$21,322,744.97	$6,092,955.19
2038	12,301,174	$62,619,173.03	$4,028,650.14	$2,608,475.25	$6,637,125.39	$55,982,047.64	$31,989,741.51	$23,992,306.13	$8,024,182.65	$15,968,123.48	1.40	$40,013,924.16	$22,340,429.44	$6,022,412.84
2039	12,485,692	$65,465,214.45	$4,127,367.53	$2,686,729.51	$6,814,097.04	$58,651,117.41	$33,514,924.23	$25,136,193.18	$8,406,753.57	$16,729,439.61	1.40	$41,921,677.80	$23,405,559.55	$5,952,400.84
2040	12,672,977	$68,440,608.44	$4,228,714.31	$2,767,331.40	$6,996,045.70	$61,444,562.74	$35,111,178.71	$26,333,384.03	$8,807,151.85	$17,526,232.18	1.40	$43,918,330.56	$24,520,323.50	$5,882,927.17
2041	12,863,072	$71,551,234.10	$4,332,764.38	$2,850,351.34	$7,183,115.72	$64,368,118.38	$36,781,781.93	$27,586,336.45	$9,226,199.48	$18,360,136.97	1.40	$46,007,981.41	$25,687,009.81	$5,813,999.13
2042	13,056,018	$74,803,237.69	$4,439,593.78	$2,935,861.88	$7,375,455.66	$67,427,782.03	$38,530,161.16	$28,897,620.87	$9,664,756.14	$19,232,864.73	1.40	$48,194,917.30	$26,908,011.95	$5,745,623.41
2043	13,251,858	$78,203,044.84	$4,549,280.76	$3,023,937.73	$7,573,218.49	$70,629,826.35	$40,359,900.77	$30,269,925.58	$10,123,720.93	$20,146,204.65	1.40	$50,483,621.70	$28,185,833.11	$5,677,806.09
2044	13,450,636	$81,757,373.23	$4,661,905.84	$3,114,655.87	$7,776,561.70	$73,980,811.53	$42,274,749.44	$31,706,062.08	$10,604,034.14	$21,102,027.94	1.40	$52,878,783.58	$29,523,091.23	$5,610,552.67
2045	13,652,396	$85,473,245.84	$4,777,551.87	$3,208,095.54	$7,985,647.41	$77,487,598.43	$44,278,627.68	$33,208,970.76	$11,106,679.18	$22,102,291.57	1.40	$55,385,306.86	$30,922,524.24	$5,543,868.09
Total	**399,156,835**	**$1,523,577,756.10**	**$120,626,897.00**	**$74,322,704.74**	**$194,949,601.74**	**$1,328,628,154.36**	**$759,216,088.21**	**$569,412,066.16**	**$190,438,818.11**	**$378,973,248.04**		**$949,654,906.32**	**$530,207,893.15**	**$226,712,100.51**

4 EL Barrier Separated Partial Reconstruct in 2006 Dollars	Present Value Net Revenue[3]	Capital Costs[4]	Feasibility Factor
	6.00%		6.00%
	$226,712,101	**$ 335,267,740**	**0.68**

[1] Assumes 1.5% Annual increase in transactions based on 2025 projected values that are interpolated to arrive at yearly projections

[2] Assumes $0.12 Transaction fee for E-470 Back Office Operation plus liability insurance, highway patrol, roadside assistance, ITS equipment operations, and toll audit and system inspection

[3] Assumes 6.00% Proxy rate for all in cost of borrowing (Current Market Rate plus 50 basis points)

[4] Assumes 4 EL with narrow shoulders related capital costs in 2006 Dollars including Quebec Direct Access and excluding Santa Fe Drive Interchange improvements

[5] Assumes 1.3 Composite coverage for all debt

Assumes contracting letting and project financing would begin on January 1, 2006

Note: All values are in 2006 Dollars

9.3 TRAFFIC OPERATIONS OF LOCAL ARTERIAL NETWORK

In addition to evaluating the traffic operations in the C-470 express lanes and the general purpose lanes; the surface street network was also analyzed to determine whether the proposed facility would cause any adverse effects to arterial capacity or signal operations. Potential impacts were identified by comparing the operations of the express lane alternative to the 2025 No-Actions Alternative. The analysis of the surface street network looked specifically at intersection delay and LOS.

The LOS analysis indicates that 56 of the 67 intersections in the study area operate at LOS D or better during the AM peak hour, and 45 intersections during the PM peak hour. Those intersections projected to operate at LOS E or worse are the major arterial signalized intersections located along County Line Road from Broadway to Yosemite Street, and along Dry Creek Road from University Boulevard to Yosemite Street. Locations where the overall intersection delay was larger than the No-Action Alternative were evaluated to determine potential improvements to mitigate the increase in delay. The analysis identified the locations noted below as having some degradation of operations as a result of the express lanes:

- Lucent Boulevard/County Line Road
- Broadway/County Line Road
- University Boulevard/County Line Road
- Quebec Street/County Line Road
- Colorado Boulevard/Dry Creek Road

To mitigate the increased delay and congestion as a result of the express lanes, the following intersection improvements are recommended. It is important to note that the improvements identified below are in addition to the improvements outlined in the County Line Road EA that are assumed to be pre-existing.

Lucent Boulevard/County Line Road

- Construct an additional westbound left turn lane along County Line Road.

Broadway/County Line Road

- Construct a 450 foot right turn acceleration lane on County Line Road west of Broadway.
- Construct a 550 foot right turn acceleration lane on County Line Road east of Broadway.
- Construct a continuous northbound right turn lane between the C-470 westbound off-ramp and County Line Road.
- Construct a 300 foot right turn auxiliary lane on southbound Broadway between County Line Road and C-470.

University Boulevard/County Line Road

- Construct a continuous northbound right turn lane between the C-470 westbound off-ramp and County Line Road.
- Construct a 600 foot right turn acceleration lane on University Boulevard south of County Line Road.
- Construct a 500 foot acceleration lane for the northbound to eastbound right turn lane.

Colorado Boulevard/Dry Creek Road

- Construct a 175 foot southbound right turn deceleration lane along Colorado Boulevard.
- Construct a 200 foot right turn acceleration lane on Dry Creek Road west of Colorado Boulevard.
- Construct a 400 foot right turn acceleration lane on Dry Creek Road east of Colorado Boulevard.

Quebec Street/County Line Road

- Construct a continuous southbound right turn acceleration/deceleration lane on Quebec Street north of County Line Road.

As noted previously in Chapter 9.1, the proposed express lane access at Colorado Boulevard received considerable attention from local residents and stakeholders who voiced both support and opposition to the concept. Extensive analysis and outreach were performed to address the public's concerns and identify potential impacts.

Results of the traffic impact analysis for Colorado Boulevard between University Boulevard and Dry Creek Road indicate all the intersections along Colorado Boulevard operate acceptably with the proposed express lane access in place. The intersections are all projected to have enough reserve capacity to handle additional traffic despite increased volumes along Colorado Boulevard due to the proposed T-ramp access. The alternative provision of an access at University or complete elimination of access in the vicinity of Colorado Boulevard would translate to an increased burden on already congested intersections on major streets, higher out-of-way trips, and significant congestion on C-470. These detrimental effects due to providing access at other locations or completely eliminating the access to express lanes in this area are not offset by the benefits of lower volumes on Colorado Boulevard. A significant portion of the additional volume (due to the T-ramps) is south of Dry Creek Road. The T-ramp serves residents adjacent to Colorado Boulevard, which helps reduce out-of-way trips on adjacent streets. The T-ramp access also provides better and more reliable access to C-470. A summary of the Colorado Boulevard analysis is in Appendix F.

9.4 ROW REQUIREMENTS

As part of the roadway design, an assessment of necessary ROW acquisition was completed to estimate a cost to acquire the properties identified. In locations where ROW impacts were identified, impacted property owners were contacted and invited to attend public meetings. The majority of the ROW impacts required only minor ROW acquisitions from each parcel and no impact to any structures. The projected ROW impacts for C-470 between I-25 and Kipling Parkway is 58 parcels, totaling 20.36 acres.

9.5 HIGH-OCCUPANCY VECHICLE COMPONENT

The original application by CDOT to the FHWA's VPPP proposed the study of High Occupancy Toll lanes along the C-470 corridor. Based on results from the C-470 user survey and regional vehicle occupancy studies performed by DRCOG, fewer than 6 percent of Denver commuters carpool daily. Also, underutilization of HOV facilities around the county is causing many of them to be converted to HOT lane facilities to optimize the benefit of the capital investment. Such a conversion is currently being implemented on the I-25 HOV lanes from downtown Denver to US 36.

A HOT lane facility carries with it several additional characteristics that must be considered when evaluating whether to allow HOVs to ride free in express lanes. HOT lanes require additional enforcement to catch violators because automated HOT technology does not yet exist. Manual enforcement has many adverse consequences and operational challenges, as well as additional operation costs. Manual enforcement typically requires an enforcement viewing area adjacent to the express lanes, thus requiring additional roadway width, resulting in increased capital cost. Manual enforcement is difficult when identifying the number of vehicle occupants when vehicles are traveling through the enforcement zone at high speeds. Also, the larger footprint of HOT lanes translates to more environmental impacts, greater ROW impacts, and increased construction and operational cost. Operationally, enforcement becomes a major challenge – both logistically and financially. Debate is still ongoing as to how best to separate single occupancy vehicles and HOVs and ensure efficient, equitable enforcement.

Another consideration in this assessment is how free HOV use would affect revenue generation. A quick assessment would be to assume that a maximum of 6 percent of potential express lane users would be removed from the revenue stream. This equates to approximately $14 million in lost revenue over 40 years, reducing the feasibility factor by 5 percent. This minor reduction in revenue probably has a negligible effect on the feasibility rating.

Given all these considerations, it is believed that the decision of whether HOVs would be tolled or allowed to use the facility free would ultimately be a policy decision made by the CTE.

9.6 TRANSIT COMPONENT

Due to a lack of reliability and the congestion on the corridor, metro Denver's transit agency, the RTD, has eliminated bus service on C-470. Existing bus routes that do exist in the area use the less congested side streets.

With the resultant predictable travel times, express lanes would allow for bus service to be resumed along the corridor. Discussions were held with RTD throughout the access screening process to ensure the proposed access configuration met the needs of existing and proposed RTD facilities. Two park-n-Ride facilities are currently located along the eastern portion of C-470 at University Boulevard and Santa Fe Drive/Mineral Avenue. As part of the ensuing FasTracks project, the existing light rail line along Santa Fe Drive will be extended to Lucent Boulevard creating a new park-n-Ride location along C-470. RTD staff noted that the proposed Lucent Boulevard, park-n-Ride would be the origin for most of the potential bus service along the corridor. RTD has not yet identified a need to develop a direct access from the C-470 express lanes into the park-n-Ride facility at Lucent Boulevard; however, if desired, the proposed slip ramp access east of Lucent Boulevard would be adequate.

RTD deemed the University Avenue location too close to the I-25/DTC area to provide express bus service. It is believed that the majority of drivers will choose to drive instead of park and take a bus. However, the express lane design would not preclude the creation of a bus-only slip ramp access east of University Avenue to facilitate access to the express lanes in the future, if deemed necessary. The low cost associated with removing the center barrier to provide access to the express lanes makes the concept relatively easy to implement.

It is has been assumed in all financial calculations that RTD buses would be excluded from paying a toll, consistent with historical practice in the region. However, it is anticipated that commercial buses would be required to pay a toll based on the number of axles.

10.0 FUNDING PLAN

Based on preliminary projections that 68 to 80 percent of the capital construction cost can be funded through toll revenue, 20 to 32 percent of the cost is expected to be derived from other sources to complete the funding package. The sections below outline potential strategies to make up this difference.

10.1 STRATEGIES TO LEVERAGE TOLL REVENUES

To close the gap between the projected toll revenues and the project cost, various funding strategies were developed to increase the leveraging power of the toll revenue. Two strategies believed to fall within TABOR guidelines are CDOT guaranteeing the O&M costs and CDOT donating ROW to the CTE.

If CDOT would guarantee payment of annual O&M costs, gross revenues could be used to determine bond capacity, thus increasing the leveraging of the toll revenue. The affect on the financial feasibility ranking of this strategy is an increase of approximately 13 percent.

The strategy of ROW donation is authorized under House Bill 1310, which allows CDOT to grant land purchases to CTE, thus reducing ROW costs and in turn increasing the financial feasibility factor. It is anticipated that by subtracting approximately $7 million in ROW costs, the financial feasibility factor would increase by approximately 4 percent.

By combining the O&M guarantee and ROW purchasing techniques to increase the toll revenue leveraging capabilities, the financial feasibility factor could be increased. Table 10.1 summarizes the increase in the financial feasibility factor using the different toll revenue leveraging techniques.

Table 10.1
Toll Revenue Leveraging Techniques

<table>
<tr><th colspan="2">Scenario</th><th>Present Value Net Revenue ($)</th><th>Capital Costs ($)</th><th>Feasibility Factor</th></tr>
<tr><td rowspan="3">1.75 Senior Lien/2.99 Subordinate Lien and 6.0% Bonding Rate</td><td>Base Case</td><td>226,712,101</td><td>335,267,740</td><td>0.68</td></tr>
<tr><td>O&M Guarantee</td><td>268,318,817</td><td>335,267,740</td><td>0.80</td></tr>
<tr><td>O&M with Right-of-Way Purchase</td><td>268,318,817</td><td>321,067,740</td><td>0.84</td></tr>
<tr><td rowspan="3">1.75 Senior Lien/2.19 Subordinate Lien and 6.0% Bonding Rate</td><td>Base Case</td><td>243,319,829</td><td>335,267,740</td><td>0.70</td></tr>
<tr><td>O&M Guarantee</td><td>287,099,398</td><td>335,267,740</td><td>0.86</td></tr>
<tr><td>O&M with Right-of-Way Purchase</td><td>287,099,398</td><td>321,067,740</td><td>0.89</td></tr>
<tr><td rowspan="3">1.75 Senior Lien/2.99 Subordinate Lien and 5.5% Bonding Rate</td><td>Base Case</td><td>251,299,736</td><td>335,267,740</td><td>0.75</td></tr>
<tr><td>O&M Guarantee</td><td>296,492,930</td><td>335,267,740</td><td>0.88</td></tr>
<tr><td>O&M with Right-of-Way Purchase</td><td>296,492,930</td><td>321,067,740</td><td>0.92</td></tr>
<tr><td rowspan="3">1.75 Senior Lien/2.19 Subordinate Lien and 5.5% Bonding Rate</td><td>Base Case</td><td>269,708,624</td><td>335,267,740</td><td>0.80</td></tr>
<tr><td>O&M Guarantee</td><td>317,403,840</td><td>335,267,740</td><td>0.95</td></tr>
<tr><td>O&M with Right-of-Way Purchase</td><td>317,403,840</td><td>321,067,740</td><td>0.99</td></tr>
</table>

By employing these strategies, the project could be as much as 99 percent funded with toll revenues, thereby reducing the supplemental funds needed from other sources.

10.2 SUPPLEMENTAL FUNDING

Potential supplemental funding sources include federal funds through earmarks or grants, and state/local funding. Both the federal and state/local sources must fulfill the requirements set forth in the Metropolitan Planning Organization process discussed below. Federal loans are another potential strategy. Additionally, state/local funding is limited to 10 percent of the project cost, in accordance with enterprise guidelines under TABOR. The final funding package must be developed by the CTE. This funding package must identify the source of funds so as to comply with both the regional planning process and TABOR/enterprise guidelines. Such a funding plan is required for a project to be included on DRCOG's RTP, which is, in turn, required before FHWA can issue a decision document for the C-470 EA.

Another strategy that could be pursued is private participation.

10.2.1 Metropolitan Planning Organization Process

Under federal law, the FHWA may only approve and provide funding for projects in a metropolitan area if they are included in a metropolitan area Transportation Improvement Program (TIP) and the Statewide Transportation Improvement Program (STIP). These programs are updated every 2 years, with potential amendments during the interim period.

As with many of the projects currently under environmental review in CDOT Region 6, DRCOG's 2025 Interim RTP does not identify any improvements to the C-470 corridor between now and 2025, other than partial funding for the Santa Fe Drive Interchange project. The project team has been engaged in ongoing coordination with DRCOG throughout the study process, with the intent of seeking an amendment to the RTP to add the preferred alternative. Travel demand modeling, air quality evaluation, and fiscal analyses for the C-470 alternatives have been coordinated with DRCOG throughout this process, and it is anticipated that the preferred alternative will be included as part of the 2030 RTP when it is released in 2005.

10.2.2 TABOR

In Colorado, TABOR sets the limits of state/local funding for transportation improvement projects to 10 percent for established Enterprises. If the CTE were to accept more than 10 percent of its annual revenue in state/local grants in a particular year, they could potentially lose their enterprise status.

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11.0 CONCLUSIONS

Based on the initial capacity analysis of the C-470 corridor, only the eastern segment from Kipling Parkway to I-25 showed a potential for developing express lanes within the planning horizon year 2025. A detailed analysis of the eastern segment showed that a financially feasible express lane facility could be developed. The final alternative shown in Figure 11.1 proposes a four-lane barrier-separated express lane facility constructed inside the general purpose lane facility from Kipling Parkway to I-25. The C-470 express lanes are expected to be able to support a bond issue of approximately of 70 to 80 percent of the capital construction cost after payment of financing, O&M, and capital reserve costs. If certain strategies to leverage toll revenues are found to be within TABOR enterprise guidelines and employed by the CTE, the project feasibility could increase to as high as 99 percent. As the CTE targets a 70 percent feasibility measure, it is believed that the C-470 express lanes could pass a more rigorous investment grade T&R test if the concept were to advance to that stage. Potential strategies and funding sources needed to make up the remaining funding were identified in Chapter 10.

11.1 PHASING PLAN

The analysis of this study has shown that only the eastern segment from Kipling Parkway to I-25 has the potential to be financially feasible within the 2025 planning horizon. Therefore, this 12.5-mile section should be the first to be implemented. Implementation of express lanes in other segments will be dependant on several factors including traffic growth, capacity of existing highway segments, development of other corridors, and a contiguous beltway around Denver. Possible phasing schemes have been developed to serve as planning documents for potential expansion of the first phase into a larger C-470 system.

A potential phasing plan for constructing express lanes on C-470 as shown in Figure 11.1 could be sequenced as follows:

Phase 1 - Kipling Parkway to I-25

Phase 2 - Bowles Avenue to I-70

Phase 3 - Kipling Parkway to Bowles Avenue

Figure 11.1
Proposed Final Alternative

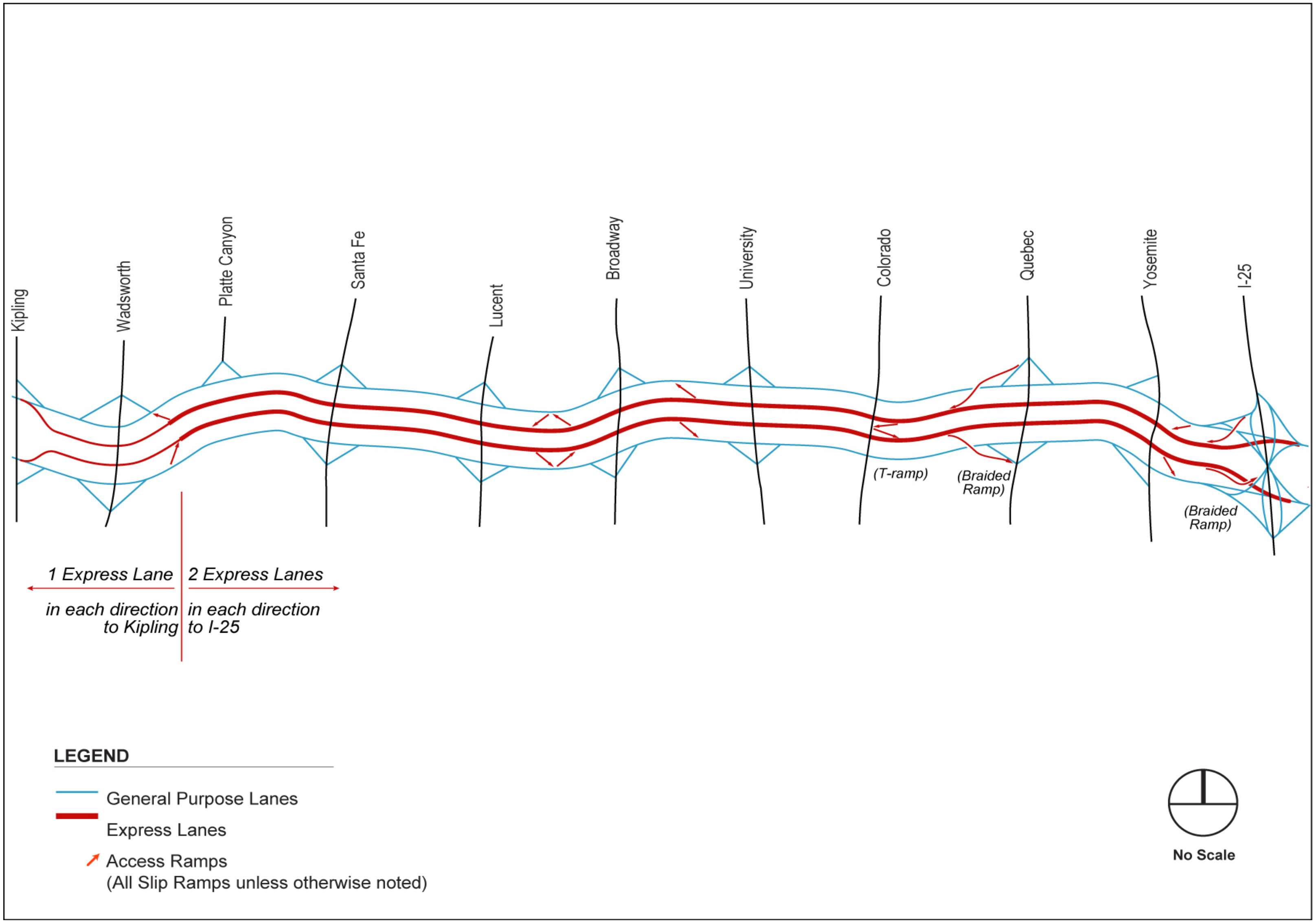
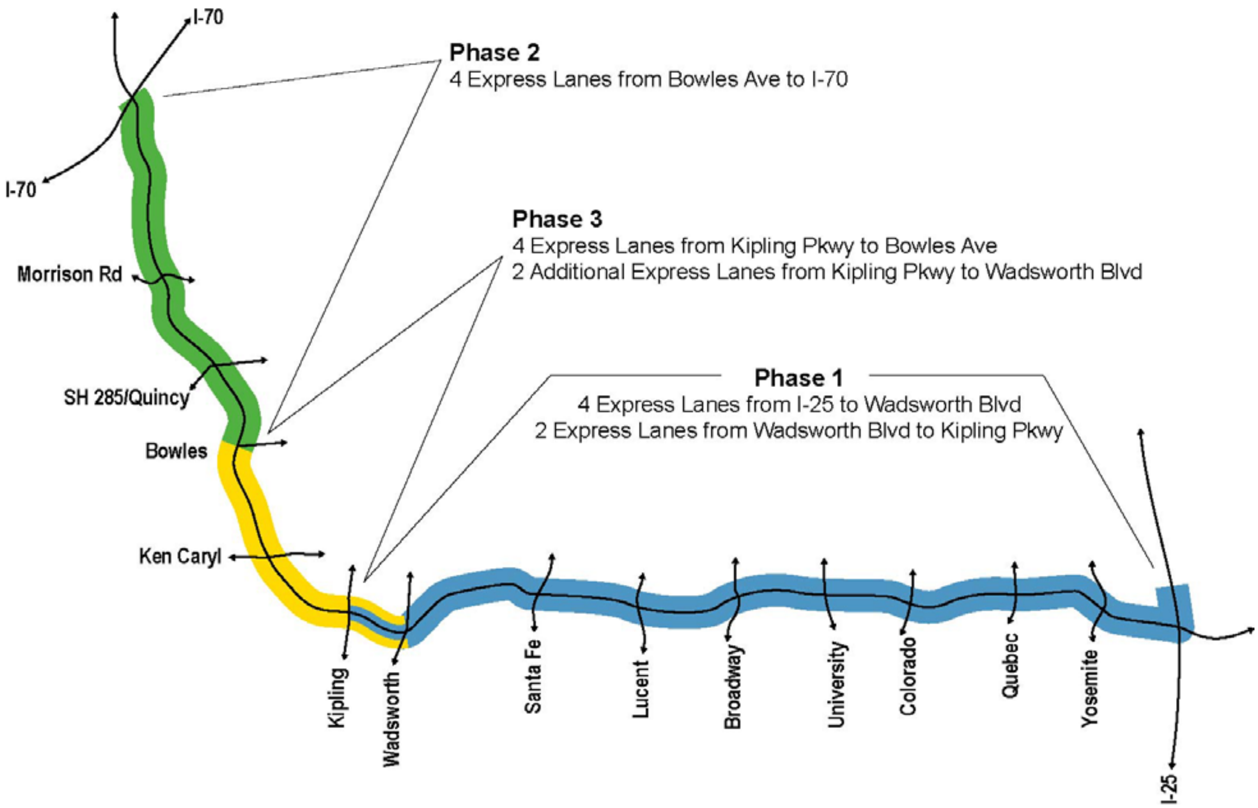


Figure 11.2
Potential Phasing Plan



Phase 1 would construct a four-lane barrier-separated express lane facility between Wadsworth Boulevard and I-25. A single lane in each direction, buffer-separated, would be constructed from Kipling Parkway to Wadsworth Boulevard.

Implementation is dependent on the alternative being selected as the preferred alternative in the C-470 EA and on obtaining a FONSI. Section 11.2, describes the steps necessary for the C-470 express lanes to advance to reality.

Phase 2 would construct a four-lane barrier-separated express lane facility from Bowles Avenue to I-70. Consideration should be given to constructing two express lanes from Bowles Avenue to Morrison Road initially as a short-term solution, due to the anticipated congestion in that segment.

Based on a continued 1.5 percent annual growth rate beyond 2025, Phase 2 could be warranted as early as 2030. This more aggressive growth scenario represents the earliest tolls would be warranted. Using a less conservative growth rate of 1 percent, this section would not be worth considering for express lanes until around 2040. It is anticipated that a two-lane alternative could be warranted in this segment within 15 years if the CTE wished to pursue this type of facility.

Phase 3 is questionable from a warrant standpoint, but if warranted, would construct two express lanes in each direction from Kipling Parkway to Bowles Avenue. Two additional express lanes would be constructed from Kipling Parkway to Wadsworth Boulevard, to complete the four–lane facility from I-25 to I-70.

Based on a continued 1.5 percent annual growth rate beyond 2025, Phase 3 could be warranted by 2050. This more aggressive growth scenario represents the earliest tolls would be warranted. Using a less conservative growth rate of 1 percent, this segment would not be worth considering until around 2070.

These estimates assume existing laneage and capacity. With the corridor approaching full build out at 2010, the anticipated growth rate beyond 2025 would be expected to be more consistent with the conservative 1 percent rate. This analysis assumes a preferred four-lane barrier-separated section due to the reliability and safety benefits.

Based on the on timing of phased implementation, much of the corridor will likely not be feasible for some time. One strategy that the CTE has been investigating to accelerate implementation is a regional toll system concept. Under this concept, tollways in the Denver region could be physically connected to one other; this is important not only from a system connectivity perspective but also from a funding perspective. The CTE has envisioned a system toll concept in which toll revenue from other more successful toll corridors is leveraged to assist adjacent corridors that may need additional funding. Even if express lanes in corridors other than C-470 are not implemented, it is conceivable that the eastern segment could supplement the other less feasible western and southwestern sections. Should such a concept be further developed and advanced, it is possible that Phases 2 and 3 could be accelerated.

11.2 IMPLEMENTATION STEPS

11.2.1 Carry Express Lanes Alternative Forward into EA

The initial step in implementing Phase 1 is to carry the alternative forward into the C-470 EA for consideration with other alternatives. If the C-470 express lane alternative is chosen as the preferred alternative and a FONSI is determined, the funding package for the alternative would then be developed.

11.2.2 Complete Funding Package

CTE must complete the funding package and identify the source of all funds to pay for 100 percent of the project costs. Sources must meet TABOR/Enterprise guidelines, and supplemental funding must go through the regional planning process, as appropriate.

11.2.3 Amend RTP to Include Express Lanes Alternative

After the funding package is completed, the C-470 express lane alternative must be amended into the DRCOG RTP. This process would require that a funding source be identified, all affected parties issue support for the project, air quality standards are met, and the DRCOG board members approve of the project.

11.2.4 Issue Design Build Contract

Under a pre-development agreement between the CTE and F&F Infrastructure for constructing express lanes along C-470, F&F Infrastructure has the first right of refusal to design and construct the facility. A design-build contract would be used to minimize the design and construction timeline allowing for an earlier facility opening date.

11.2.5 T&R Study

Before issuing bonds, either the CTE or the design-build contractor would complete an investment grade T&R Study. This study is often referred as a Finance Grade or Investment Grade study. This analysis is specifically intended to be sufficiently detailed and comprehensive to possibly be used in support of project financing. It is anticipated that it would take between 6 and 12 months to perform the T&R study, including procuring the consultant and reviewing period.

11.2.6 Bonding

Once the T&R Study is completed, the detailed financial plan, bond rating, and bond sales would be completed. This process is anticipated to take more than 12 months to complete. It is assumed that the CTE would issue the bonds necessary for construction.

11.2.7 Construction

Once bonds are issued, construction could begin.

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