COLORADO HIGHWAY 71

(Limon north to Colorado/Nebraska state line)

TRUCK FREIGHT DIVERSION FEASIBILITY STUDY

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REVISION RECORD		
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2	November 2019	Corrections per TAG Members Correct Benefit/Cost Analysis Chapter and Appendix
3	May 2020	Revisions per CDOT Final Review and Executive Summary Consistency

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ACRONYM LISTING

BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
BNSF	Burlington Northern Santa Fe Railroad
CBC	Concrete Box Culvert
CDOT	Colorado Department of Transportation
CR	County Road
CSG	Concrete Slab and Girder
DOT	Department of Transportation
ETPR	Eastern Transportation Planning Region
FAST	Funding Advancements for Surface Transportation
HEA	Heartland Expressway Association
ISTEA	Intermodal Surface Transportation Efficiency Act
LOSS	Level of Safety Service
MAP-21	Moving Ahead for Progress in the 21st Century Act
MM	Mile Marker
MP	Milepost
NPS	Non-Project Specific
O&M	Operations and Maintenance
P2P	Ports to Plains
PDO	Property Damage Only
PEL	Planning Environmental Linkages Study
PMP	Project Management Plan
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SH	State Highway
SOW	Scope of Work
SSM	Steel Stringer - Metal Plank Deck
TEA-21	Transportation Equity Act for the 21st Century
TTS	Treated Timber Stringer
UFRTPR	Upper Front Range Transportation Planning Region
UPRR	Union Pacific Railroad
VHT	Vehicle Hours Traveled
VMT	Vehicle Miles Traveled
WGCK	Welded Girder Continuous and Composite

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1.0 INTRODUCTION

Accommodating rapid growth in freight movements across the State of Colorado and the rest of the United States presents a challenge to CDOT and other Departments of Transportation (DOTs) across the nation. Recognizing this fact, the Funding Advancements for Surface Transportation (FAST) Act included specific requirements and a funding program to address the issue of freight transportation. Prior to the FAST Act, Moving Ahead for Progress in the 21st Century ACT (MAP-21), Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), Intermodal Surface Transportation Efficiency Act (ISTEA), and Transportation Equity Act for the 21st Century (TEA-21) all addressed freight by designating “high priority” corridors. CO 71 from Limon to the Colorado-Nebraska State Line is included as a segment of the Heartland Expressway Corridor, one of three “high priority” corridors that make up the Ports to Plains (P2P) Alliance.

The P2P Corridor stretches from Laredo, Texas, to Montana’s northern border with Canada. It enters Colorado near Campo, Colorado, through US 287. It connects with CO 71 at Limon, part of the Heartland Expressway, and continues north to the Colorado-Nebraska State Line. The P2P Trade Corridor also includes I-70 from Limon west to Denver and the Heartland Expressway includes I-76 from Denver east to Brush. Improvements in Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming are impacting the flow of travel, funneling freight into Colorado. At some point much of that traffic is ending up on I-25 and other north-south highways, contributing to congestion problems across the Front Range and throughout the Denver metropolitan area. This routing proves to be inefficient for the trucking industry and a burden on Colorado’s economy as freight traffic and commuters both waste time and fuel in stop-and-go traffic.

There has been considerable investment in the P2P Corridor as CDOT and other DOTs have completed various highway improvement projects to improve safety, provide alternatives to other congested corridors through major metropolitan areas, and help increase trade between the United States, Mexico, and Canada. In Colorado, the US 287/US 40 Corridor is a “Super Two” typical section with full-width lanes and shoulders. CO 71 is the only segment of the P2P Corridor in Colorado that remains unimproved. Evidence indicates truck routing decisions are responsive to completed improvements along the P2P Corridor.

2.0 STUDY CONTEXT

CO 71 is an important link serving the Eastern Plains of Colorado and designated as part of the P2P Corridor. It serves as a vital connection between I-70 and I-76, linking the towns of Brush and Limon. Economic development, municipal, and advocacy group officials throughout the corridor confer regularly to identify needs, discuss trends, and further coordination efforts.

2.1 STUDY LOCATION

This Freight Diversion Feasibility Study (the Study) focuses along the CO 71 corridor from Milepost (MP) 102 in Limon, Colorado, north to MP 232 at the Colorado-Nebraska state line, including the Town of Limon, Town of Brush, Lincoln County, Washington County, Morgan County, and Weld County. Figure 1 shows a corridor map detailing the location of the Study. The limits of analysis include US 24 from MP 304 in Colorado Springs, Colorado, to MP 377 in Limon and its connection to CO 71 via US 40.

2.2 CONNECTIVITY

CO 71 provides several important connections in eastern Colorado. While outside the study area, CO 71's southern terminus is at US 350 southeast of La Junta, CO. Traveling north, CO 71 intersects with SH 10 near Haley, US 50 at Rocky Ford, SH 96 at Ordway, and SH 94 at Punkin Center.

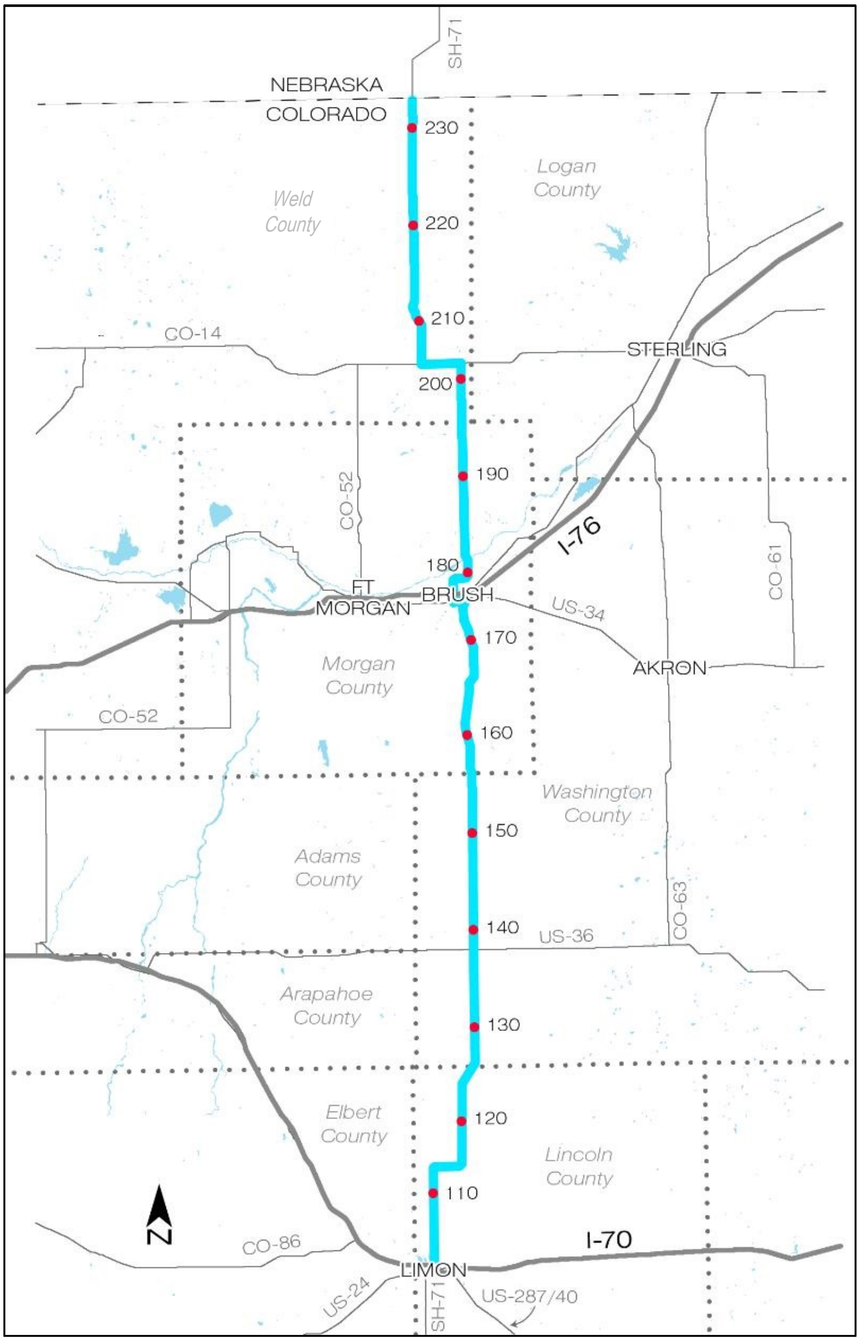

Figure 1: CO 71 Study Corridor

The study area begins at Limon, CO, where CO 71 intersects with US 287, US 24, and I-70. Traveling north, CO 71 intersects with US 36 in Last Chance, US 34 and I-76 in Brush, SH 14 near Stoneham, and the study area ends at the Colorado-Nebraska state line. The corridor continues north to I-80 at Kimball, Nebraska, continuing as NE 71 to Scottsbluff and eventually South Dakota. Numerous county roads also intersect with CO 71 throughout its 224-mile corridor in Colorado.

On a national scale, the CO 71 corridor serves a larger purpose as a link in the P2P corridor which spans across nine states. Within the US, the P2P corridor starts from Laredo, Texas at the US-Mexico border, and moves up to the port of Raymond, Montana at the US-Canada border. On an even broader scale, the P2P roadways extend south to the ports of Mazatlán, Mexico and north to Fort McMurray in Alberta, Canada.

2.3 PURPOSE

As freight movements across Colorado and the United States continue to grow at a rapid pace, accommodating trucks on existing facilities presents a challenge to both CDOT and other DOTs across the nation. The intent of this study to is analyze corridor freight movements and the feasibility of diverting current and future trucking traffic onto the CO 71/US24 corridor, thereby relieving existing and future congestion through the I-25 corridor on the front range.

The goals of this analysis are to:

- Identify the types and cost of improvement to CO 71 that will draw additional truck traffic
- Determine the potential economic benefit to the trucking industry and local economies, and
- Develop funding options and implementation scenarios.

2.4 OBJECTIVES

The Study area limit travels along the CO 71 Corridor from Milepost (MP) 102 in Limon, Colorado, to the MP 232 at the Colorado-Nebraska State Line, as shown in Figure 1. The limits of analysis include US 24 from MP 304 in Colorado Springs, Colorado, to MP 377 in Limon and its connection to CO 71 via US 40. Modeling limits are much broader due to the regionalism of the P2P and extend from Mexico to Canada with emphasis on the area from Amarillo, Texas, to Scottsbluff, Nebraska, and Douglas, Wyoming. Modeling will consider major traffic movements with concentrated effort throughout Colorado from I-25 to its eastern border.

The study includes:

- Inventory and document current freight truck movement throughout the CO 71 Corridor;
- Inventory and document current roadway conditions;
- Conduct stakeholder coordination and outreach;
- Develop potential improvements;
- Model and analyze impact of improvements on truck movement;
- Develop cost estimates;
- Identify improvements; and
- Produce a final report with an associated implementation plan.

For the CO 71 study, the team has coordinated with CDOT to identify participants for a Technical Advisory Group (TAG). This group will meet several times during the Study. There was one general stakeholder meeting, with representatives from the corridor, as well as attending meetings with both the Eastern Transportation Planning Region (ETPR) and the Upper Front Range Transportation Planning Region (UFR TPR)

3.0 CURRENT CONDITIONS

3.1 ENVIRONMENTAL RESOURCES SCAN

The Environmental Scan Technical Report identified environmental resources and environmentally sensitive areas within the study area. It is comprised of readily available data and field survey information. The purpose of the scan report was to:

- Develop a more thorough understanding of the existing uses and conditions of the corridor; and
- Identify sensitive environmental resources early in the planning process.

The intent of the scan report was not to identify specific impacts to sources. Rather, the collected information is to be used in subsequent study phases to avoid and minimize impacts to resources. If a recommended package of improvements receives funding at some point in the future, the results will be carried forward at that time into project development, additional environmental review, project design, construction, maintenance, and operations.

Data collection to identify the existing resources in the study area was conducted during the summer of 2017 using readily available resources including evaluation of any previously completed reports and studies, existing resources, maps, data, and a limited windshield review of the resources adjacent to the existing roadway.

Data was reviewed from the following agencies:

- City of Brush;
- Colorado Department of Public Health and Environment (CDPHE);
- Colorado Department of Labor and Employment (CDLE);
- CDOT;
- Colorado Division of Water Resources (DWR);
- Colorado Parks and Wildlife (CPW);
- Federal Emergency Management Agency (FEMA);
- Lincoln County;
- Morgan County;
- National Parks Service (NPS);
- State Historic Preservation Office (SHPO);
- Town of Limon;
- US Environmental Protection Agency (EPA);
- US Fish and Wildlife Service (USFWS);
- US Department of Agriculture (USDA);
- US Geological Survey (USGS);
- Washington County; and
- Weld County.

The Environmental Resources Scan is included as Appendix A.

3.2 TRAVEL SPEEDS

Travel speeds along the CO 71 corridor vary from 35 mph (in cities and at several sharp curves) to 65 mph (long, flat, straight distances). For most the corridor, the posted speed limit is 65 mph. Travel speed and additional information, including secondary speed limits, truck restrictions, and roadway designations are included as Appendix B.

3.3 HORIZONTAL AND VERTICAL CHALLENGES

Horizontal Challenges

About 10 miles north of Limon, CO 71 has two sharp, 90-degree curves at Lincoln County Road 3T near the Cedar Point Wind Farm, as shown in Figure 2. These curves represent challenges for freight haulers as they may encounter difficulties navigating this section of highway with oversized loads. Two similar curves are present along CO 71 immediately north of Brush at Morgan County Road U and near Stoneham at SH 14. These curves all require drastic speed reductions to navigate, especially for oversized loads.

Additional horizontal challenges exist for oversized loads as CO 71 travels through the City of Brush. There are two intersections requiring additional 90-degree turns within City limits.

The CO 71 bridge over the South Platte River has no shoulders, posing another issue for freight haulers with oversized loads. The 0.2-mile long structure is located just south of Snyder, north of Morgan County Road W.

Figure 2: 90-Degree Curves Near Cedar Point Wind Farm

Vertical Challenges

There are limited vertical challenges along CO 71. Immediately south of the City of Brush, a BNSF structure crosses over CO 71. The structure has a posted height of 15' 3", posing a potential risk to oversized loads. There are also several locations along the CO 71 corridor with rolling hills which pose sight distance challenges.

Table 1 - Horizontal and Vertical Challenges

MILEMARKER	NEAREST ROAD	ISSUE
112	Lincoln CR 3T	Road grade may pose sight distance challenges
113	Lincoln CR 3T	Two 90-degree curves
138	US 36	Night time visibility concerns
165	Morgan CR U	Two 90-degree curves
174	US 34	Vertical restrictions from BNSF structure
181.5	Morgan CR W	Platte River Bridge has no shoulder (0.2-mile bridge)
189	Morgan CR DD/EE	Road grade may pose sight distance challenges
211	Pawnee National Grasslands	Canyons, ditches, flooded areas with no shoulder
228	Weld CR 128	Road grade may pose sight distance challenges

3.4 CRASH DATA/LEVEL OF SAFETY SERVICE (LOSS)

A summary of crashes, detailing the crash type(s), severity, location, weather and lighting conditions, road conditions, contributing factors, and other information is included as Appendix C. This data was collected through CDOT's DiExSys Roadway Safety System from 2012-2016.

In an overview of crash records from the last five-year period, there were a total of three fatal, 56 injury, 143 property damage only (PDO). A higher density of crashes is found in the towns along CO 71, including Limon (14), Last Chance (14) and Brush (32). Notably, of the 32 crashes in Brush, nearly half (12) were broadside incidents. Also of note, around MM 211-212, near the rolling hills north of Stoneham, nine crashes were recorded. Of those nine, over half (5) were overturned vehicles; which may infer that vehicles have difficulty navigating the rolling terrain in this section of CO 71.

3.5 BRIDGES AND OTHER MAJOR STRUCTURES

There are 12 bridges and other major structures along the CO 71 corridor within the study area. Table 2 details each of the structures.

Table 2 - Bridges and Other Major Structures along CO 71

MILEMARKER	IDENTIFIER CODE	TYPE	RATING	FEATURE INTERSECTED	LOCATION
102.33	G-22-B	WGCK	69.9	I-70 ML	N Edge of Limon, CO 71
105.531	G-22-BQ	CBC	99.4	Lake Creek	2.9 Mi N of Limon, CO 71
106.255	G-22-BP	CBC	98.4	Draw	4 Mi N of Limon, CO 71
106.783	G-22-BO	CBC	98.4	Draw	4.2 Mi N of Limon, CO 71
111.533	G-22-BV	CBC	97	Arickaree River	9 Mi N of Limon, CO 71
117.341	G-22-BS	CBC	100	Draw	14.7 Mi N of Limon, CO 71
118.272	G-22-AZ	CBC	99.8	Draw	15 Mi N of Limon, CO 71
120.931	G-22-BW	CBC	96.6	Draw	18.3 Mi N of Limon, CO 71
139.431	E-22-J	CSG	90.7	W. Fork Plum Bush Creek	1.4 Mi NO of Jct US 36/CO 71
147.636	E-22-A	CSG	91.4	Beaver Creek	9.6 Mi NO of Jct US 36/CO 71
165.715	D-22-C	TTS	70.9	Big Beaver Creek	27.6 Mi NO of Jct US 36/CO 71
174.257	C-22-AR	SSM	NA	BNSF RR	36.1 Mi NO of Jct US 36

3.6 TRUCK AMENITIES

There are several locations providing truck amenities (i.e. fuel, repair shops, food, Wi-Fi, etc.) along the length of the study area. Table 3 provides a listing of those along CO 71 as well as the community it serves.

Table 3 - Truck Amenities along CO 71

CITY	AMENITY NAME	LOCATION (APPROXIMATE)
Brush	Acorn Travel Plaza	I-76, Exit 90A
	Tomahawk Truck Stop	I-76, Exit 90B
	Pacific Pride	I-76, Exit 90
	Love’s Travel Stop	I-76, Exit 89
Limon	Flying J	I-70, Exit 359
	TA Limon	I-70, Exit 359

3.7 MAJOR UTILITY LINES

Several major utility lines cross CO 71 along the length of the study area. Table 4 below details the utility lines and their respective locations.

Table 4 - Major Utility Lines along CO 71

NAME	OWNER	UTILITY
White Cliffs Pipeline	Western Gas	Crude Oil
Magellan	Midstream Partners	Petroleum
Wattenberg	DCP Midstream	HGL
Interstate	Cheyenne Plains Pipeline	
Overland Pass	Oneok	HGL
Gary Substation	Western Area Power Admin.	Electric
Woodrow Substation	Western Area Power Admin.	Electric
Last Chance Substation	Western Area Power Admin.	Electric
Big Sandy Substation	Western Area Power Admin.	Electric
Pipeline (z)	Pony Express Pipeline	Natural Gas

3.8 RAILROADS

Three different railroads cross CO 71 at three separate locations along the study area.

Burlington Northern Santa Fe (BNSF), generally follows I-76 to the west and US 34 to the east, travels through the Town of Brush crossing CO 71 just south of US 34. BNSF splits into two corridors in Brush with the southern branch continuing east along US 34 in BNSF Right-of-Way (ROW) until it crosses the Colorado-Kansas state line. Amtrak travels along this corridor as well. The northern branch travels several miles to the northeast along I-76 before transitioning to Union Pacific Railroad (UPRR) right-of-way ROW.

A spur line, originating at the BNSF/UPRR transition, crosses CO 71 about 5 miles north of Brush.

The third CO 71 crossing occurs about 1.5 miles south of the eastern intersection with SH 14.

In addition, south of the study area near Limon, the UPRR generally follows I-70 to the west and US 287 to the south and east. Additionally, the Kyle Railroad travels from Limon east into North Central Kansas.

3.9 WEIGH STATIONS

There is one weigh station along CO 71. Located in Limon along I-70 at mile marker 359. Trucks traveling along CO 71 access the weight station by turning west just north of Lincoln County Road 3G.

4.0 ULTIMATE VISION

In planning for future travel demand and anticipated growth in freight traffic, the ultimate vision should account for the long-term goals of the CO 71 corridor, including the stakeholders, towns within the corridor, and Ports to Plains Alliance. Each of these groups play a critical part in helping to shape CO 71 as not only a trucking route, but as a destination for pick-ups/drop-offs of freight goods, potential truck stops, and other potential destinations along the corridor. The possibility to attract certain industries and businesses, such as energy and agriculture, may draw additional traffic to the corridor, as well.

As discussed during meetings with the CO 71 Technical Advisory Group, the long-term vision for CO 71 should be flexible/phase-able to accommodate potential capacity growth. With a long-term vision of CO 71 as a four-lane highway, whether with a center turn lane (expressway) or a divided highway (i.e. future interstate), the corridor would be able to accommodate a higher volume of traffic and serve as a stronger connector for the freight industry and general vehicular travel. Therefore, a phased approach (i.e. add shoulders, passing lanes, etc. to expand the pavement and improve the safety/design speed as funds are available) to a 4-lane expressway is the recommended vision.

Based on the Highway Capacity Manual (2010 edition) (HCM 2010), the capacity of a four-lane divided highway with a free-flow speed of 70-75 miles per hour is 2,400 passenger-cars per hour per lane. Thus, a four-lane divided highway could hold up to 9,600 passenger-cars per hour. The capacity would decrease slightly with trucking traffic, as one freight vehicle is equal to roughly two passenger vehicles (HCM 2010).

Beyond the traffic volumes, improvements along CO 71 should consider the value to economic growth and the region's development. As a corridor connecting three major interstates (I-70, I-76, I-80), this highway provides a valuable link between Eastern plains communities and interstate travel. Currently, CO 71 is the final section to be improved within Colorado. As other neighboring DOTs improve their respective links of the P2P, CO 71 may need to meet a certain standard if it continues to be utilized by freight and trucking industries.

As an example of improvements drawing additional traffic, the TAG discussed US 287/US 40. Along the US 287/US 40 corridor, from Limon to the Oklahoma state line, improvements were made to include full-width lanes and shoulders starting in 2002 – making the corridor a Super Two highway. With construction completed in 2012, the improved US 287 corridor saw an increase in traffic volumes, growing at a rate higher than the state's average growth rate, as well as a higher growth rate than the CO 71 and US 385 corridors. As shown in Figure 3, volumes from CDOT's OTIS database compare AADT over the past 15 years for CO 71, US 385, and US 287. Although there may be additional factors in the increased growth rate on US 287, the data shows that over the past 15 years, traffic volumes have remained stagnant for CO 71 and US 385, while volumes on US 287 increased about 15% over a 5-year period. Statewide DVMT and Truck DVMT is shown for comparing growth. Truck DVMT is not available at the individual highway level. The growth rate comparison is shown in Table 5.

Table 5: Growth Rate Comparison for Statewide, CO 71, US 287, and US 385

	5-Year Growth (2012-2017)	15-Year Growth (2002-2017)
Statewide (All DVMT)	16%	24%
Statewide (Truck DVMT)	11%	9%
CO 71 (Total AADT)	9%	-9%

US 287 (Total AADT)	15%	30%
US 385 (Total AADT)	-7%	-10%

(Data Source: CDOT OTIS)

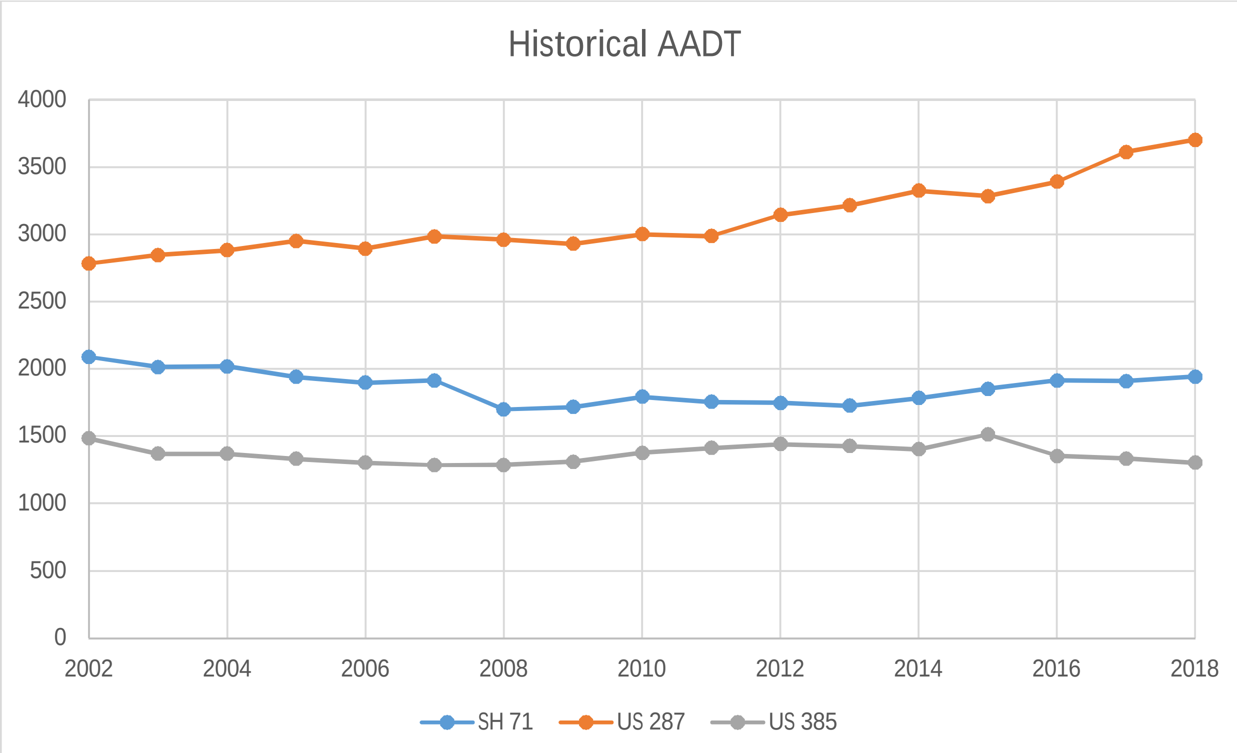

Figure 3: AADT Comparison for CO 71, US 287, and US 385

5.0 PROPOSED IMPROVEMENTS

As congestion on the I-25 corridor through the front range in Colorado continues to increase with growing vehicular and truck traffic, providing an alternative freight route in Colorado may relieve some of this congestion. A key component of the CO 71 study is to explore potential improvements to the CO 71 corridor, and what effect these improvements may have on truck travel in the I-25 corridor.

A super two highway is defined as a two-lane highway with passing lanes and climbing lanes, sometimes with partial or full-width shoulders. Such a facility serves as a two-lane highway but with more improvements and features than a standard two-lane highway, with the likely long-term goal of converting into either a freeway or four-lane highway, should the traffic volumes arise. For the CO 71 study, several options for roadway improvements and enhancements are explored, including the super two and four-lane divided highway. For this study, passing and climbing lane length is undefined; these specific lengths will be defined during project design and may depend on location-specific characteristics.

As funding opportunities are identified, improvements on the CO 71 corridor will be phased in to provide full/partial shoulders, passing lanes, and climbing lanes as identified. This phased approach will build toward the ultimate vision, and help in improving the corridor over several phases. Areas of highest safety concern will be prioritized first, as these sections can help improve the safety for truckers as well as all roadway users. Through this approach, interim improvements can build upon each other to lead into the overall goal of serving a higher-quality roadway for freight traffic, as well as general vehicular traffic.

5.1 IMPROVEMENT SCENARIOS

The following scenarios outline and illustrate some of the potential improvements to the CO 71 corridor. While some cross sections may be more fitting for certain sections of the corridor, it is also possible for CDOT to phase improvements based upon travel demand, anticipated traffic, and funding sources.

Super Two Alternative

In this standard cross-section, the two-lane highway has 8-foot shoulders to accommodate some width of trucks or passenger vehicles. While an 8-foot shoulder is acceptable for passenger vehicles, trucks typically prefer a 10-foot shoulder. Added shoulders, even a partial shoulder, would improve visibility for vehicles in taller grasslands, as well as reduce the likelihood of vehicles catching fire from stopping over grasses.

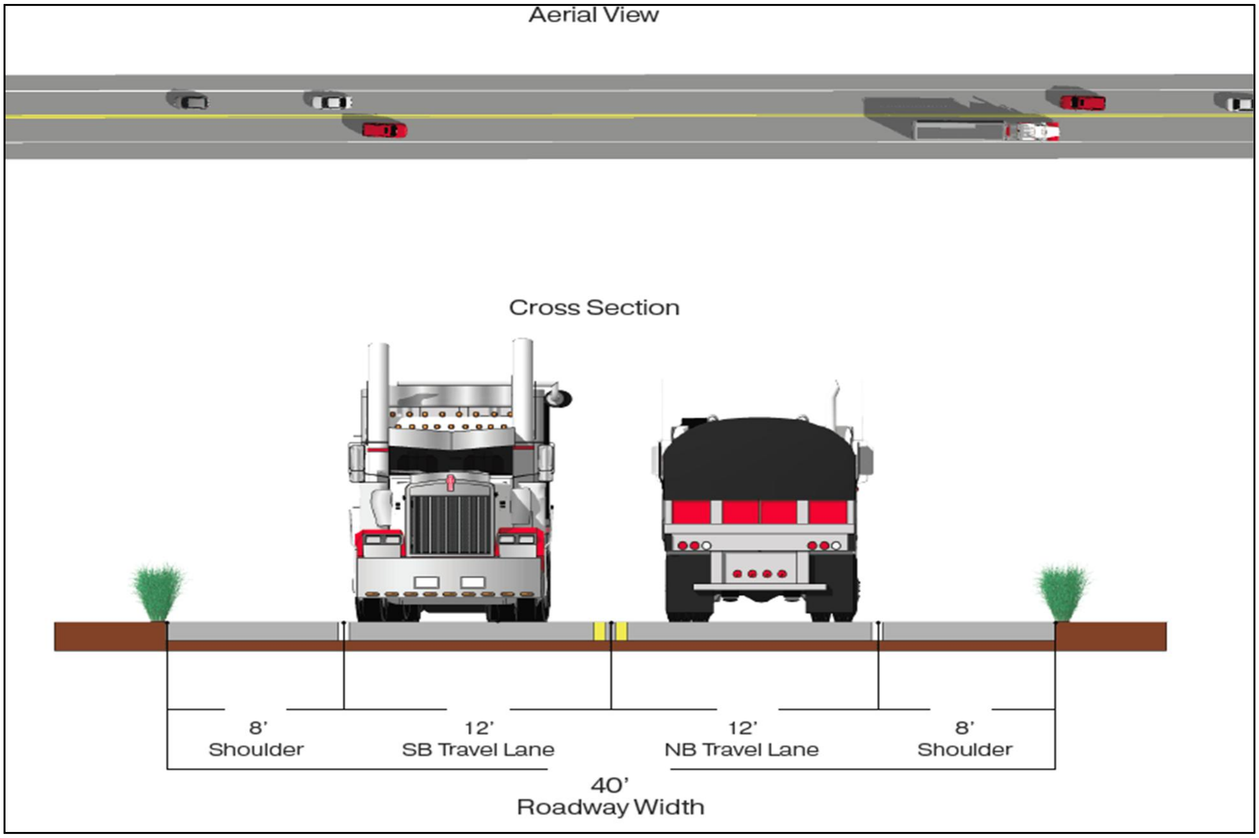

Figure 4: Super Two Alternative

Super Two with Passing Lanes Alternative

Building on the basic super two cross section, this alternative includes space for a 12-foot passing lane. This full-width passing lane is not only wide enough to accommodate passenger vehicles, but could also accommodate a truck. Passing lanes help reduce the likelihood of head-on collisions on two-lane roads.

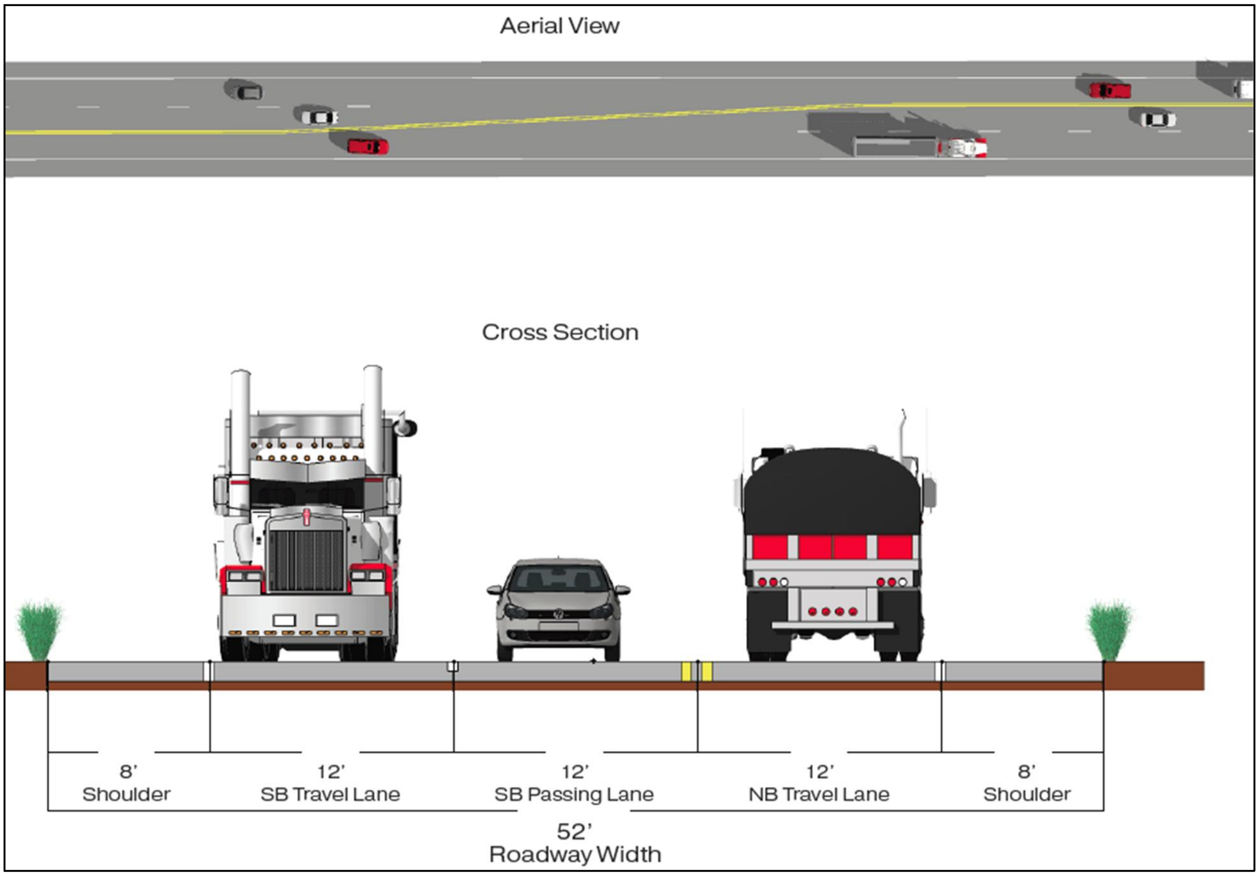

Figure 5: Super Two with Passing Lanes Alternative

Super Two with Center Turn Lane Alternative

In this alternative a center turn lane is provided to accommodate left-turning vehicles without obstructing thru movements. This may help increase vehicular flow if a section of road has multiple left-turn access points. This alternative is best suited for lower-speed locations.

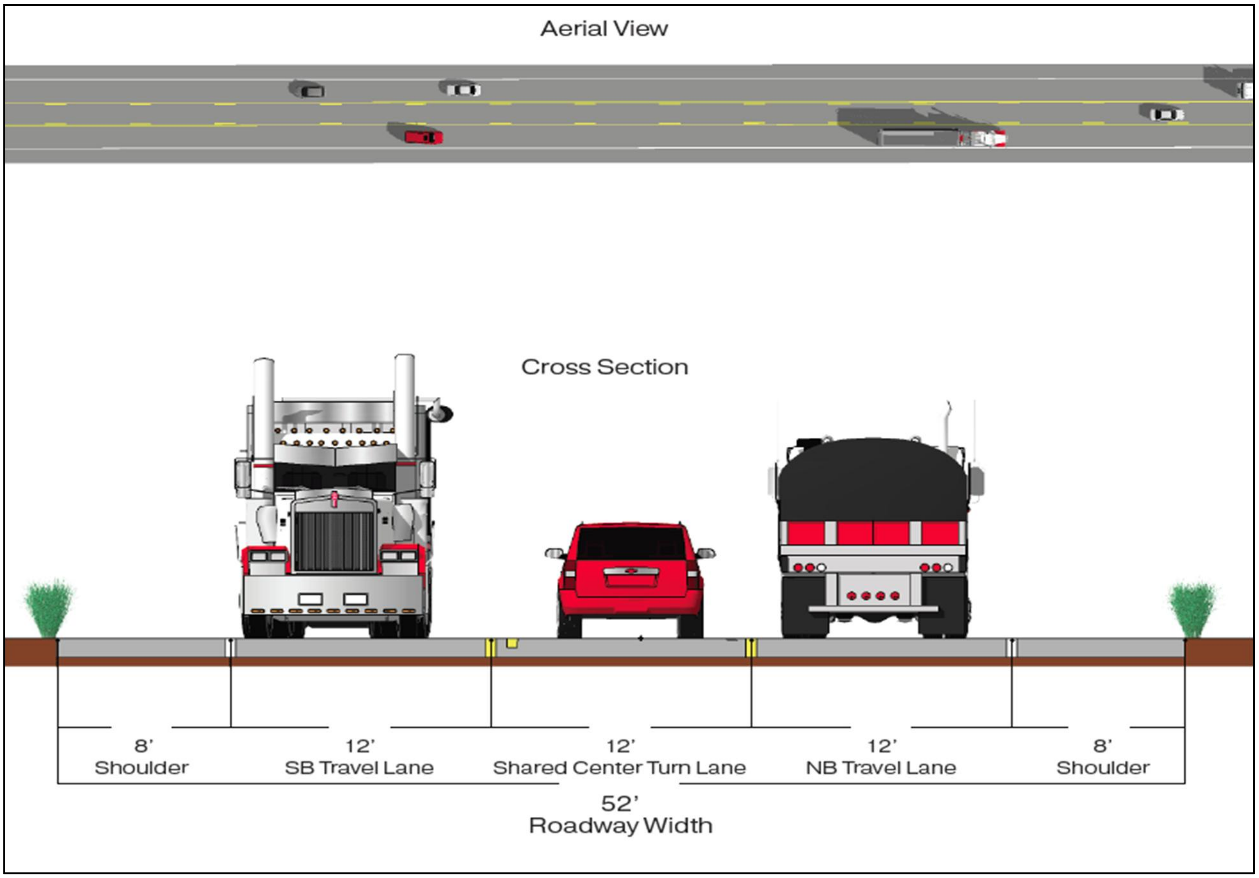

Figure 6: Super Two with Center Turn Lane Alternative

Multi-Lane with Center Turn Lane Alternative

A multi-lane with shared center turn lane has a dedicated passing lane for each direction of traffic, full shoulders, and shared center turn lane. One of the advantages in to this alternative is that the existing centerline and roadway can be maintained, with shoulders and the additional lanes phased in. This cross-section provides a safer corridor for passing vehicles, as well as dedicated space for left-turns.

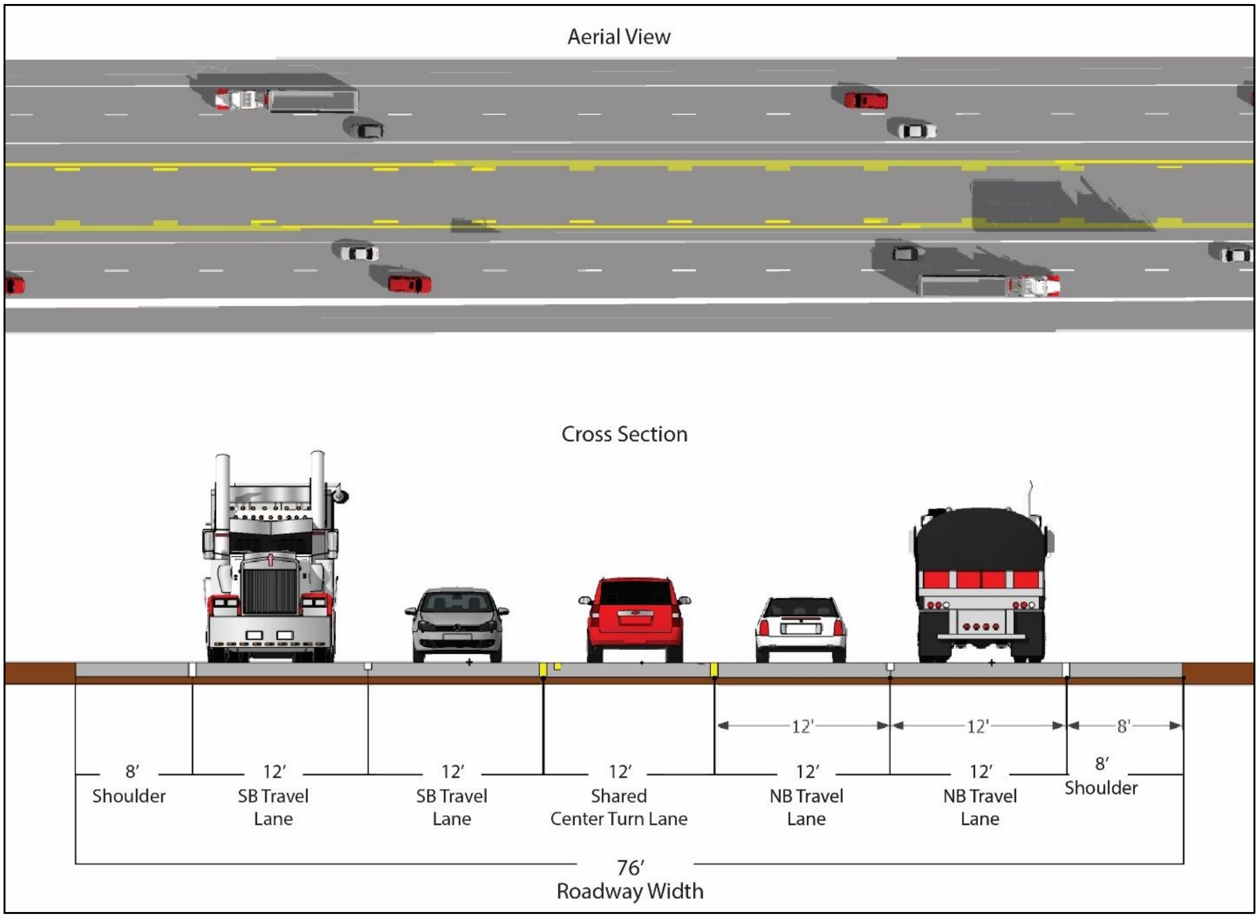

Figure 7: Multi-Lane with Center Turn Lane Alternative

Four-Lane Divided Highway Alternative

The four-lane divided highway has a dedicated passing lane each direction of traffic, shoulders, and an unpaved, separating median. This cross-section not only provides a safe alternative by removing head-on collisions, but also has the highest vehicle capacity.

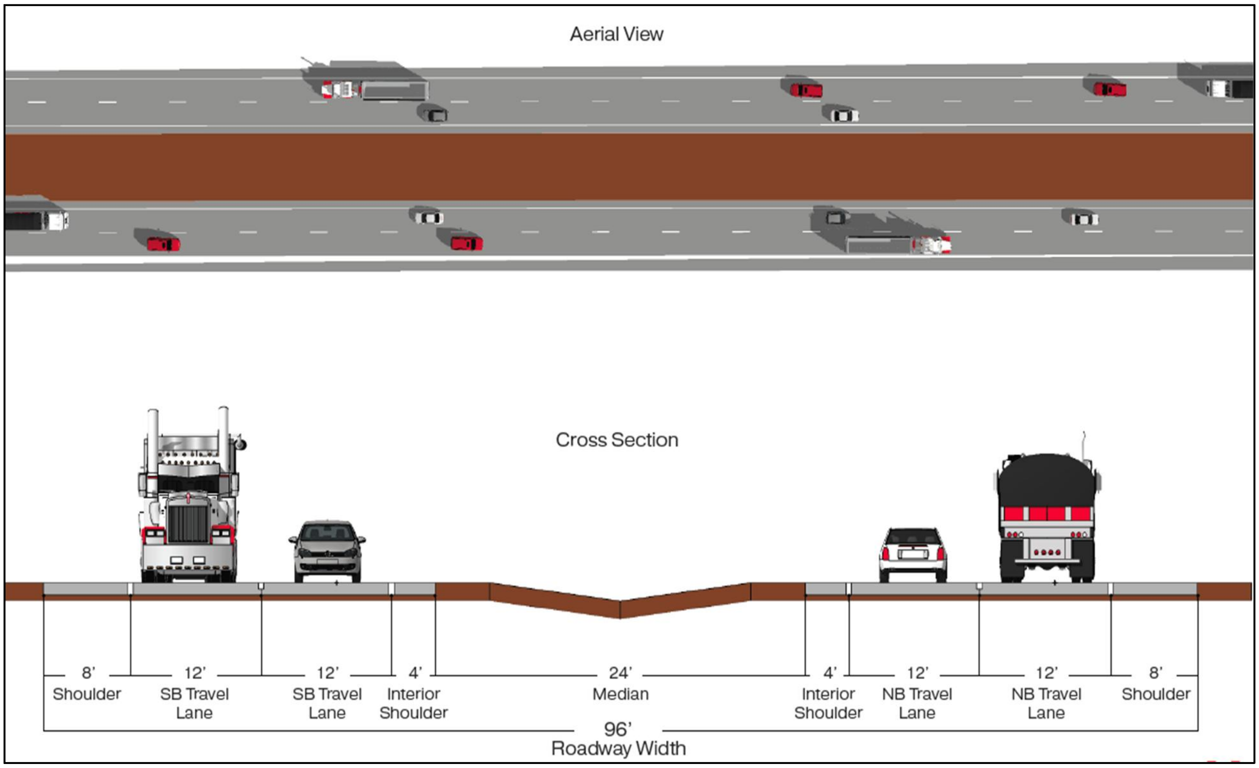

Figure 8: Four-Lane Divided Highway Alternative

6.0 TRUCK FREIGHT MODEL

The truck freight diversion model was developed to study the existing truck volumes in the CO 71 corridor, as well as analyze potential outcomes using future growth rates, potential improvements to the corridor, and any effects on diverting truck traffic from competing freight corridors. This comprehensive model incorporates data from existing truck data collected by CDOT, select field traffic counts along the corridor, the CDOT Colorado statewide travel demand model, the National Highway Planning Network model, and the most recent Freight Analysis Framework (V4.3) truck commodity flow data. For a complete detailed report on the truck freight model methodology, model components, and results, please see Appendixes D and J.

6.1 DATA INPUTS

For the CO 71 truck freight model, only multi-unit trucks (MUTs) are modeled. This helps in providing a high-end estimate of trucking volumes and behaviors along the corridor, as well as competing and complementary highways. Traffic volumes from both CDOT's OTIS database and field traffic counts were validated to provide a more accurate MUT estimate. This data set includes over 130 CDOT counts throughout the state and CO 71 corridor, 30 counts in Nebraska and Wyoming, and project specific field counts obtained along the CO 71 study area.

CDOT's Colorado Statewide Travel Demand Model zone system was utilized for the study in-state, while county-level zones were used for modeling outside of Colorado. Some additional detail in the zone system was added for the CO 71 corridor. For additional detail and maps of the zone system, please see the full travel demand modeling report in Appendix D.

6.2 MODELING METHODOLOGY

One of the primary goals in this freight analysis study is to determine if, and what, roadway improvements to CO 71 would attract truck drivers off the heavily congested I-25 front-range corridor of Colorado. Within the traffic model, sufficient sensitivity is provided to reflect improvements on CO 71, as well as potential congestion on I-25. To this end, several tests were run to establish a level playing field for a reliable national truck model that captures the north-south traffic flows through Colorado. The intent is to provide an average "time to traverse" the I-25 and CO 71 corridors, including both short truck trips within Colorado and longer distance trips that may start and end outside Colorado boundaries. The travel time directly correlates with how the model assigns truck traffic to specific roads. Assuming congestion is heavy enough on the I-25 corridor, and a trucker did not need to make any stops on the front range, this truck driver will be more inclined to drive CO 71 to save time to their destination.

Because of a lack of congestion on CO 71, improvements will not improve travel time through the corridor. However, there are qualitative benefits and driver comfort aspects that can increase a highway's usage. Because there are not approved methods for modeling qualitative improvements, increased travel speeds serve as the proxy in the model.

Existing Conditions and 2040 Baseline Conditions – 65 mph

In the existing baseline condition, truck speeds were modeled at 65 mph on the CO 71 corridor. There are some minor slowing areas, particularly through the towns along the corridor, but for the most part trucks were modeled traveling at 65 mph. This scenario also reflects the future year no-build improvements, in which no improvements are made to the corridor.

Improved Super Two Facility – 70 mph

To simulate proposed improvements along CO 71, the travel demand model in the improved super two condition modeled truck travel at 70 mph, with slowing through towns. Improvements to the corridor, such as wider shoulders, added passing and climbing lanes, and full width lanes provide additional driver comfort and potentially higher speeds.

Four-Lane Divided Highway – 75 mph and 80 mph

In simulating the ultimate long-term vision of a four-lane divided highway, the model set truck speeds of 75 mph and 80 mph. These higher speeds are intended to illustrate a more free-flowing capacity of traffic, given the nature of a divided highway, the increased level of driver comfort, and provide a speed sensitivity analysis.

Front Range Congestion on I-25 – Reduced Speeds by 7% and 10%

To simulate congested traffic conditions on I-25 through the front range, two separate speed reductions were applied to I-25 and its parallel roadways - 7% and 10%. The 10% speed reduction provides an upper-level estimate of congestion growth's impact on truck travel, while the 7% speed reduction provides a realistic-value in predicting truck traffic patterns, given that truckers may operate outside of peak traffic periods (such as late nights and weekends).

Select Link Analysis

Select link analysis was conducted to better understand the patterns of the truck markets active in the CO 71 corridor. Select link analysis provides information of where traffic comes from and goes to when it is crosses selected points of the road system. The resulting graphics show the coverage, magnitude and influence of each highway. Figure 9 shows the select link traffic for CO 71; as shown, much of the traffic movements are in the north-south direction and tend to be neighboring states to Colorado. Figure 10 shows the select link analysis for I-25, which highlight a broader spread of traffic flow patterns, including trips both north-south and east-west, as well as origins/destinations in farther states.

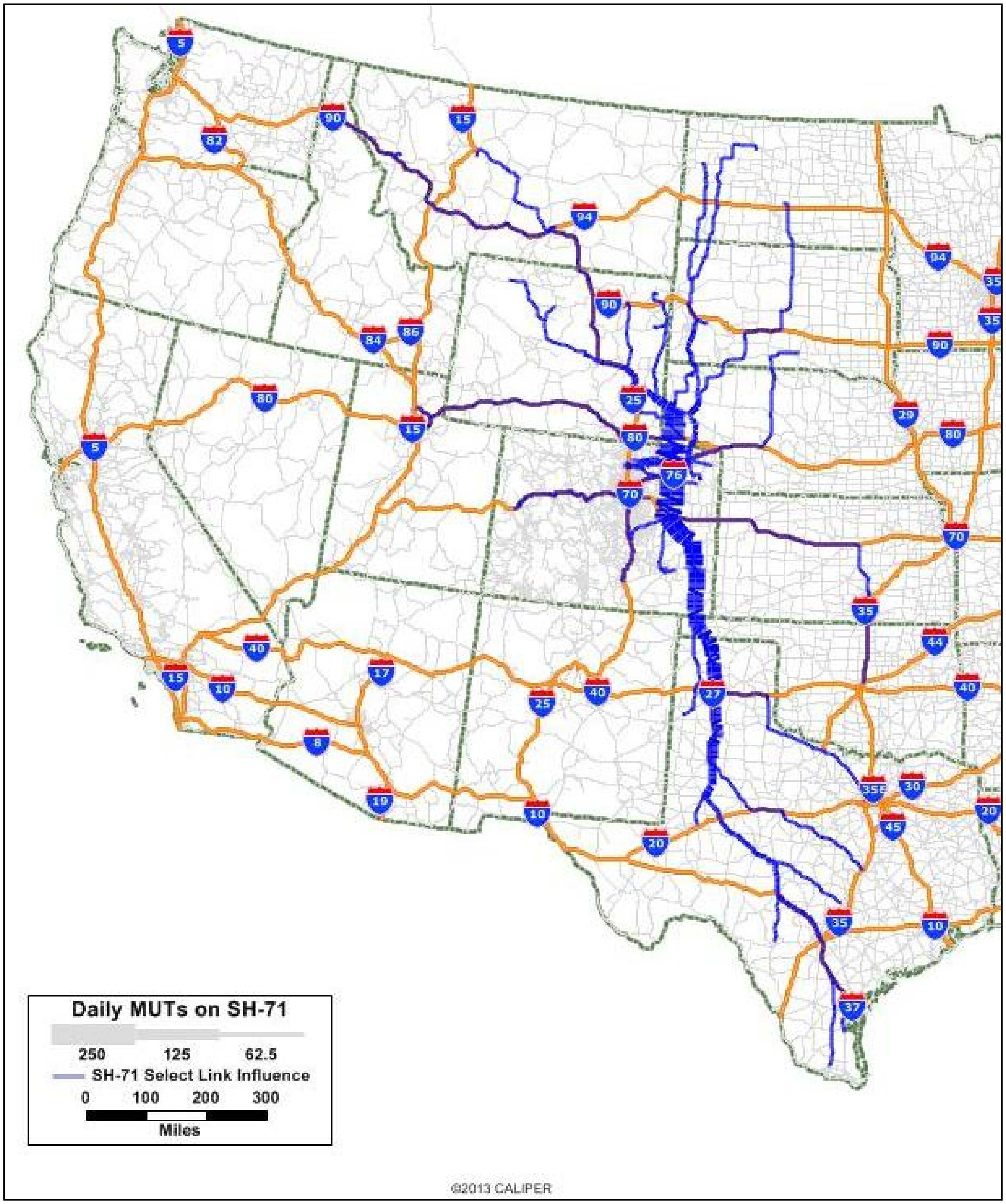

Figure 9: CO 71 MUT Select Link Traffic with the Interstate System

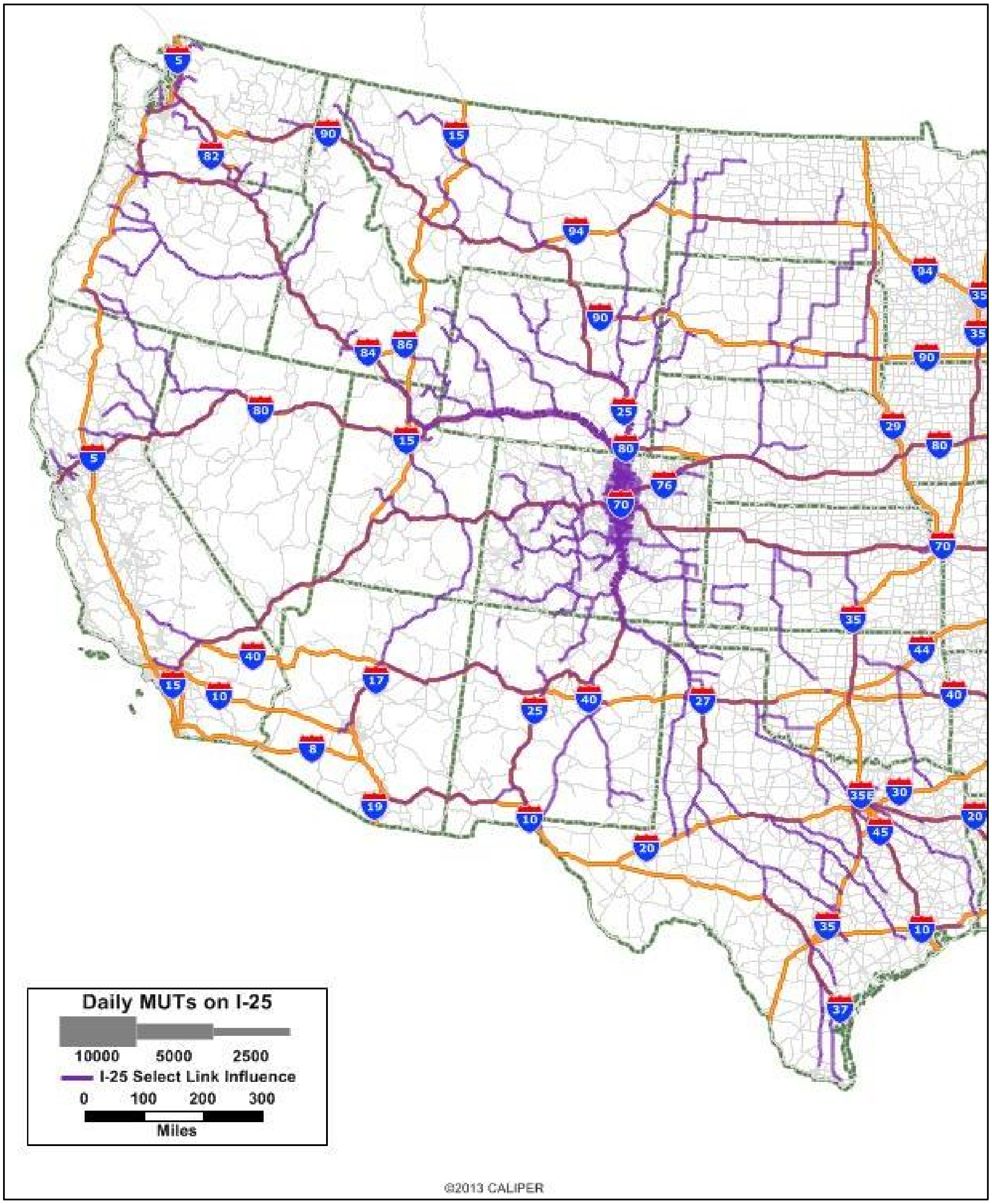

Figure 10: I-25 MUT Select Link Traffic with the Interstate System

Corridor Segmentation

In evaluating the travel patterns along the CO 71 corridor, three distinct segments were established to help differentiate truck travel patterns and prioritize improvements. In studying trip behaviors and major diversion points crossing CO 71, it was decided that the major roadway crossings along CO 71 would provide a most natural break in corridor segmentation. These three logical segments include:

- SH-71: Segment 1 – Nebraska State Line to SH-14 in Colorado
- SH-71: Segment 2 – SH-14 to I-76 (Brush, CO)
- SH-71: Segment 3 – Brush to I-70 (Limon, CO)

The highway segments that formed I-25 in the extended study area were also divided into three logical segments:

- I-25: Segment 2 – Wyoming State Line to US-36
- I-25: Segment 3 – US-36 to 470 (South)
- I-25: Segment 4 – 470 (South) to US24 in Colorado Springs.

These segments are shown in Figure 11. The establishment of the study segments allows for calculation and reporting of a centerline road length, drive time in minutes, and average speed to traverse.

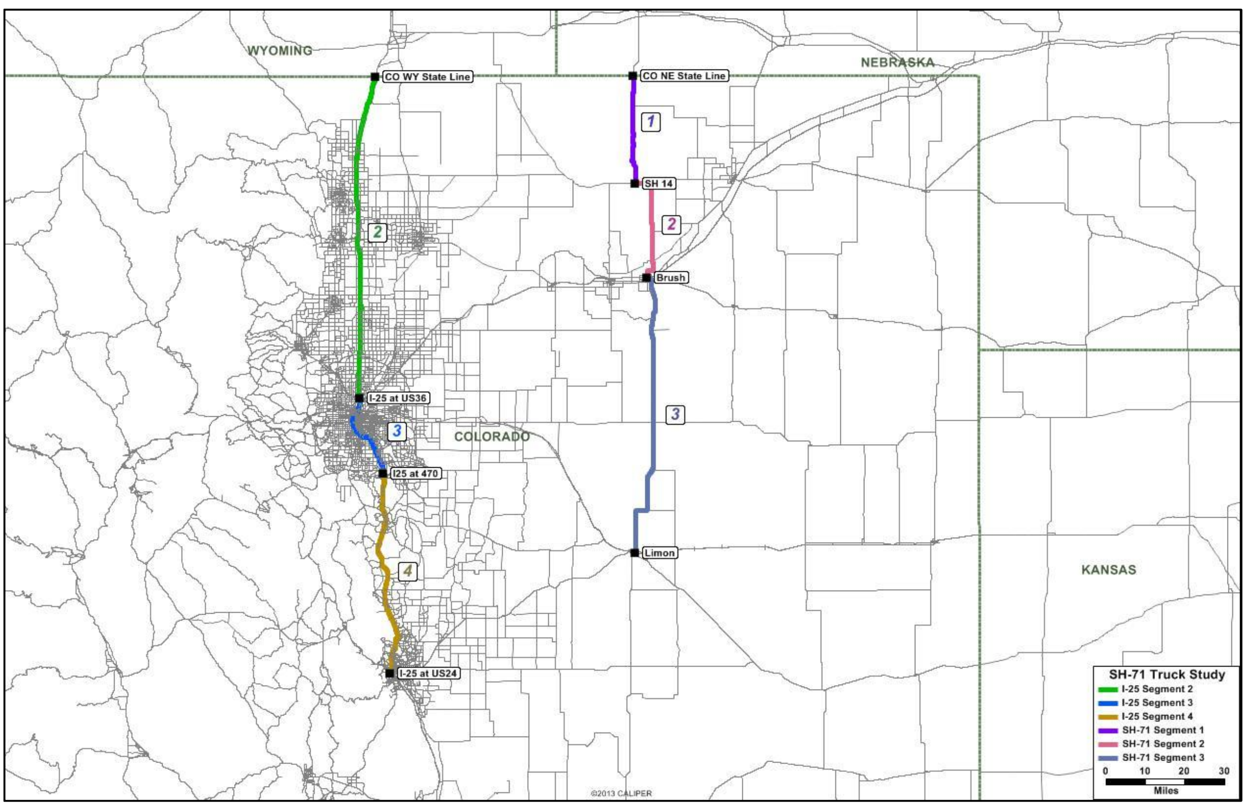

Figure 11: CO 71 Reporting Segments

6.3 TRUCK DIVERSION MODELING RESULTS

As discussed in the Methodology section, the travel demand model determines truck travel routes based on travel time. Inputs include congestion on the front range and potential improvements to the CO 71 corridor. The Table 6 provides a summary of the travel demand modeling results for the CO 71 corridor. This includes modeling the CO 71 corridor in its no-build (65 mph), super two (70 mph), and four-lane divided highway (75 and 80 mph) scenarios, and congestion on I-25 is modeled as no congestion (no speed factor), congestion with off-peak travel (7% speed reduction), and travel during congestion (10% speed reduction). Additionally, scenario combinations of CO 71 speed increases and front range speed decreases are modeled. Appendix J includes detailed results for each scenario and trip travel time tables.

Highlights from the modeling results are:

- Of the three segments, Segment 3 experiences the largest increase in truck traffic from proposed improvements on the CO 71 corridor. This is the segment between Limon and Brush, which also connects I-70 and I-76.
- As speed increases to 75 and 80 mph, CO 71 truck volume growth tends to increase at a slower rate; therefore, making “diminishing returns” and suggesting the travel time savings is reduced.
- In the most congested scenario (10% speed reduction), the volume of additional trucks on CO 71 in the 75-80 mph scenario is approximately 1100 trucks.
- Truck VMT reduction on I-25 is about 5-6% with super two improvements on CO 71, and about 7-9% VMT reduction with a four-lane divided highway on CO 71.

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Table 6: Truck Freight Diversion Modeling Summary

2040 Average Weekday MUT Traffic on SH-71

No Speed Factor

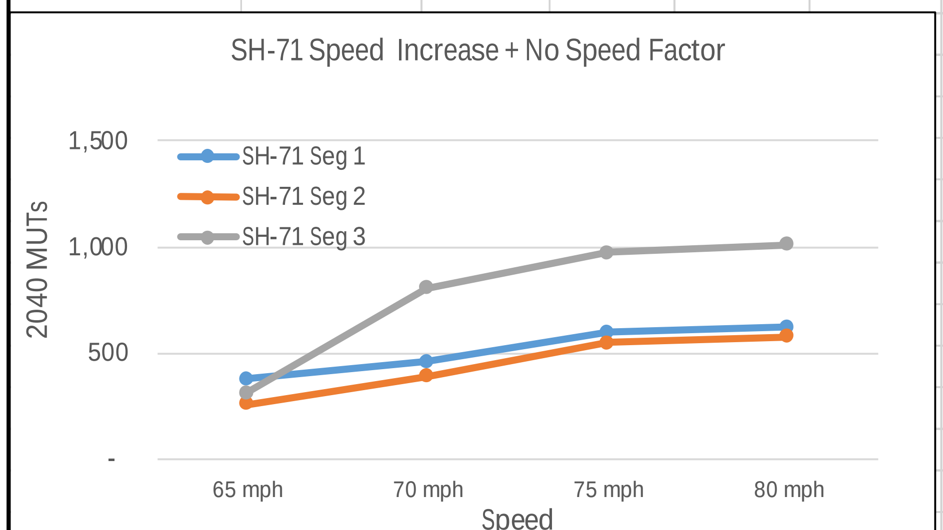
Segment	Miles	65 mph	70 mph	75 mph	80 mph
SH-71 Seg 1	27	377	460	597	623
SH-71 Seg 2	29	259	389	551	577
SH-71 Seg 3	74	311	809	974	1,013
All Segs	131	313	642	801	835
VMT Change in the Front Range			-1.3%	-2.4%	-2.8%

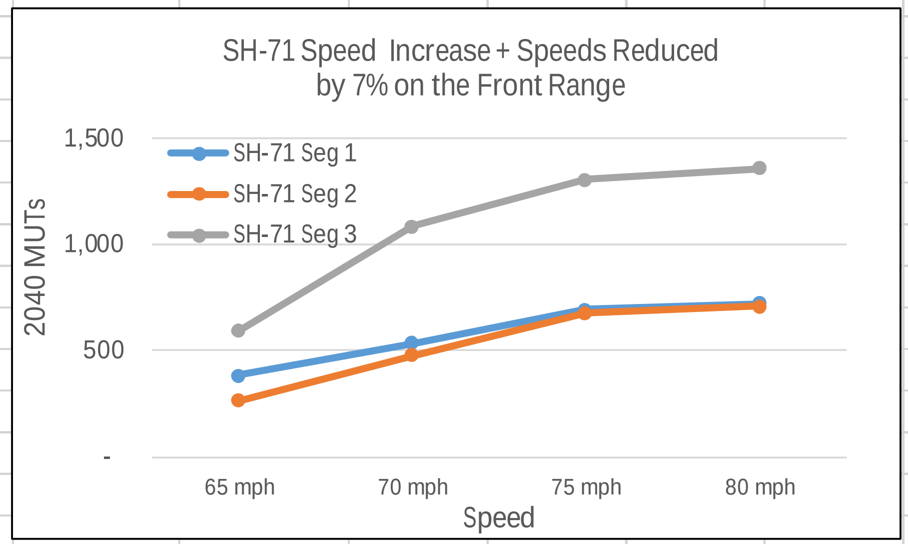
Speeds reduced by 7% in the Front Range

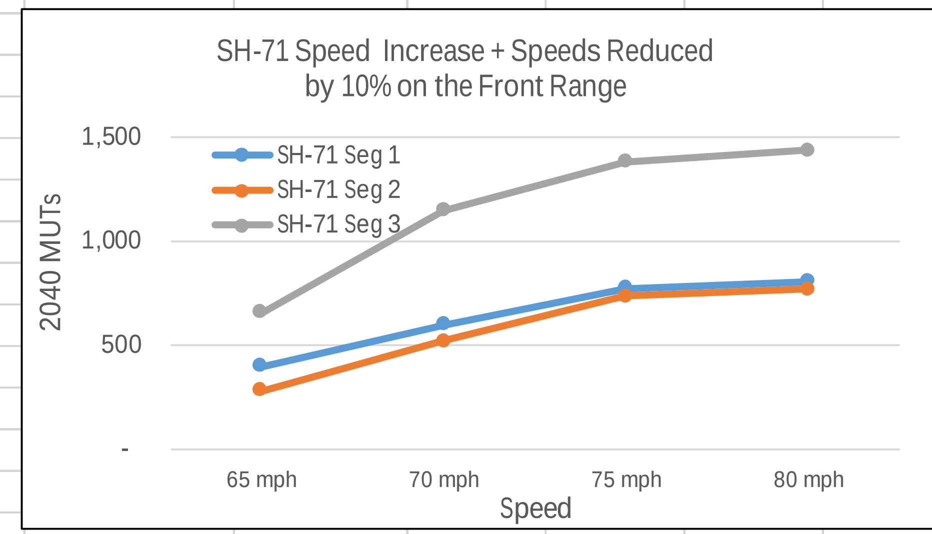
Segment	Miles	65 mph	70 mph	75 mph	80 mph
SH-71 Seg 1	27	384	534	693	723
SH-71 Seg 2	29	266	479	679	711
SH-71 Seg 3	74	593	1,085	1,307	1,360
All Segs	131	476	835	1,039	1,082
VMT Change in the Front Range			-4.8%	-6.2%	-6.5%

Speeds reduced by 10% in the Front Range

Segment	Miles	65 mph	70 mph	75 mph	80 mph
SH-71 Seg 1	27	397	596	773	807
SH-71 Seg 2	29	280	518	734	769
SH-71 Seg 3	74	655	1,146	1,381	1,436
All Segs	131	518	891	1,110	1,156
VMT Change in the Front Range			-6.9%	-8.9%	-9.7%







No Speed Factor

Diff in MUT	65-70 mph	70-75 mph	75-80 mph
SH-71 Seg 1	83	137	26
SH-71 Seg 2	130	162	26
SH-71 Seg 3	498	166	39
All Segs	329	159	34

% Diff in MUT	65-70 mph	70-75 mph	75-80 mph
SH-71 Seg 1	22%	30%	4%
SH-71 Seg 2	50%	42%	5%
SH-71 Seg 3	160%	20%	4%
All Segs	105%	25%	4%

Speeds reduced by 7% in the Front Range

Diff in MUT	65-70 mph	70-75 mph	75-80 mph
SH-71 Seg 1	150	159	30
SH-71 Seg 2	213	200	32
SH-71 Seg 3	492	222	52
All Segs	358	204	43

% Diff in MUT	65-70 mph	70-75 mph	75-80 mph
SH-71 Seg 1	39%	30%	4%
SH-71 Seg 2	80%	42%	5%
SH-71 Seg 3	83%	20%	4%
All Segs	75%	24%	4%

Speeds reduced by 10% in the Front Range

Diff in MUT	65-70 mph	70-75 mph	75-80 mph
SH-71 Seg 1	199	178	34
SH-71 Seg 2	238	216	35
SH-71 Seg 3	491	235	55
All Segs	374	219	46

% Diff in MUT	65-70 mph	70-75 mph	75-80 mph
SH-71 Seg 1	50%	30%	4%
SH-71 Seg 2	85%	42%	5%
SH-71 Seg 3	75%	20%	4%
All Segs	72%	25%	4%

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7.0 STAKEHOLDER OUTREACH

Stakeholder Outreach during the CO 71 study proved invaluable to the freight modeling process, as well as development of alternatives and proposed improvements. Each organization brought a unique perspective of the corridor, representing the Ports to Plains alliance, towns along the corridor (Limon, Brush), Eastern Transportation Planning Region, Upper Front Range Transportation Planning Region, Department of Agriculture, Pro15, Colorado Motor Carriers Association, CDOT Freight Advisory Council and members of the community. Meetings were held with each group of stakeholders, where the project team presented an overview of CO 71 project and solicited feedback on areas of concern, challenges along the corridor, future opportunities, and general thoughts on the corridor. A copy of materials distributed during the stakeholder meeting are included in Appendix E.

7.1 TECHNICAL ADVISORY GROUP

A Technical Advisory Group (TAG) was created for the CO 71 project to provide better insights and input from select stakeholders and subject-matter experts along the corridor. This group continued meeting during the study, and included CDOT leadership, public works directors, town managers, and policy organization leadership. Members of the TAG group are shown below in Table 7; these members were active within the TAG at the time of the study.

Table 7: Technical Advisory Group (TAG) Committee Members

Name	Organization	Title
Kathy Gilliland	CDOT	Transportation Commissioner
Steven Hofmeister	CDOT	Transportation Commissioner
Heather Paddock	CDOT	Region 4 Transportation Director
Dale Colerick	City of Brush	Director of Public Works
Rick Yost	CMCA	
Gary Beedy	ETPR	ETP Co-Chair / Transportation Commissioner
Gary Ensign	Lincoln County	County Administrator
Bruce Bass	Morgan County	Director of Public Works
Joe Kiely	Ports to Plains	Vice President
Cathy Shull	Pro 15	Executive Director
Monty Torres	Town of Brush	Town Manager
Greg Tacha	Town of Limon	Town Manager
Jim Flesher	Weld County	Transportation Planner

Copies of materials distributed during the TAG meetings are included in Appendix F.

7.2 FREIGHT INTERCEPT SURVEY

A Freight Intercept Survey was used to gain a more comprehensive understanding of truck driver behavior and their route selection process. This was intended to help inform CDOT improvements on I-25, CO 71, and US 385

Survey locations included:

- Amarillo, TX;
- Brush, CO;
- Cheyenne, WY;
- Cheyenne Wells, CO;
- Douglas, WY;
- Dumas, TX;
- Lamar, CO;
- Limon, CO;
- Pueblo, CO;
- Scottsbluff, NE;
- Sidney, NE; and
- Trinidad, CO.

The survey received 542 survey responses, of which 372 were deemed valid. A valid survey was determined through a responding driver's route. If the driver was traveling along I-25, CO 71, or US 385 for at least some part of their route, the response was deemed valid. If another primary route(s) was/were identified (i.e. I-70, US 50, SH 10), the response deemed invalid and not used in any survey conclusions. A copy of the survey methodology, questions and responses in included in Appendix G.

8.0 IMPLEMENTATION PLAN

With growth and increased freight traffic along the CO 71 corridor, coupled with added congestion on the I-25 corridor through Colorado, the potential for implementing improvements to CO 71 stands to leverage challenges into opportunities. These opportunities can help implement short- and long-term transportation improvements that betters safety and builds toward the ultimate vision. Implementing these improvements will require coordination between CDOT and its partners on the CO 71 corridor to identify and prioritize improvements and to obtain funding. This Freight Diversion Feasibility Study includes the potential projects that will help in improving CO 71 as a freight corridor and provide an alternative for truck freight and the congestion on the I-25 corridor and Front Range.

The list of projects can be implemented separately, in tandem, or along with other yet to be identified opportunities. For instance, it may be cost effective to add shoulders or passing lanes during an overlay or reconstruction, bridge replacements can be constructed to accommodate future widening, or intersection improvements can be coordinated and developed along with new business or residential development. Maintaining a list of projects will provide CDOT with information to help make these kinds of project connections.

8.1 COST ESTIMATES

Cost estimates were developed for the potential CO 71 improvement components of adding shoulders, adding passing lanes, and adding travel lanes. The estimates are based on current market conditions and bracket the cost with low- and high-cost likelihoods. Details of these cost estimates can be found in Appendix H, Potential Project Cost Estimating.

8.2 IDENTIFIED PROJECTS

Recommended projects for the CO 71 corridor can be found in Table 8. These projects were identified by CDOT, stakeholders, and through a safety analysis of the corridor. Note, the projects are in Segment 3, Brush to Limon, as that was determined to have the highest potential for increased truck travel. The list is not prioritized, and represents a snapshot of today's needs. CDOT is developing criteria based process to prioritize and select the projects outside the realms of this study that can be used to continually evaluate proposed improvements.

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Table 8: Recommended Projects

Project Number	County	MP From	MP To	Concern	Description	Category
1	Lincoln	101.97	103.64	Highway alignment through Limon	Realign highway to go around Limon	Other
2	Lincoln	102	108	Pavement condition	Resurfacing	Maintenance
3	Lincoln	102.3	102.3	Bridge condition	Minor repairs to G-22-BB	Maintenance
4	Lincoln	107.5	108.3	Wet weather off road crashes	Mill and overlay	Safety
5	Lincoln	108.3	111.2	Wet weather off road crashes	Mill, overlay, add shoulders	Safety
6	Lincoln	108.5	110.5	Passing/climbing opportunities	Northbound climbing lane 108.5-109.2 combined with north and southbound passing lane 109.75-110.5	Traffic
7	Lincoln	111.5	112.1	Climbing opportunity	Northbound climbing lane	Traffic
8	Lincoln	112.3	113	Crashes on curves	High friction surface treatment, widen shoulders, add rumble strips, enhanced pavement markings, signage, and delineation	Safety
9	Lincoln	112.3	113	Crashes on curves	Reconstruct roadway to 65 mph standard	Safety
10	Lincoln	114.9	115.9	Crashes on curves	High friction surface treatment, widen shoulders, add rumble strips, enhanced pavement markings, signage, and delineation	Safety
11	Lincoln	114.9	115.9	Crashes on curves	Reconstruct roadway to 65 mph standard	Safety
12	Lincoln	119.5	120.3	Passing opportunities	North and southbound passing lanes	Traffic
13	Lincoln/Washington	125.15	126	Passing/climbing opportunities	Northbound passing lane 125.15-125.9, southbound passing/climbing lane 125.3-126.0	Traffic
14	Washington	130.4	130.9	Climbing opportunity	Southbound climbing lane	Traffic
15	Washington	132.3	133.75	Passing/climbing opportunities	Southbound climbing (132.3-133.0) and passing (133.0-133.75) lane	Traffic
16	Washington	138.01	138.01	Intersection safety	Intersection improvement (US 36)	Safety
17	Lincoln/Washington	101.97	138.01	Highway geometry continuity	Mill, overlay, add shoulders (gap projects)	Maintenance
18	Lincoln/Washington	118	135.7	Snow fence condition	Replace existing snow fence (see remarks for detailed locations)	Safety
19	Washington	139.43	139.43	Narrow bridge	Widen or replace E-22-J (over West Fork Plum Bush Creek)	Bridge
20	Washington	140.15	140.9	Passing opportunities	Northbound passing lane	Traffic
21	Washington	140.9	140.9	Steep embankment near culvert	Extend culvert 071D140990BL at both ends and flatten embankment to traversable slopes	Maintenance
22	Washington	147.64	147.64	Narrow bridge	Widen or replace E-22-A (over Beaver Creek)	Bridge
23	Washington	147.65	147.85	Crashes on curves	High friction surface treatment, widen shoulders, add rumble strips, enhanced pavement markings, signage, and delineation	Safety
24	Washington	147.65	147.85	Crashes on curves	Reconstruct roadway to 65 mph standard	Safety
25	Washington	149.2	149.95	Passing opportunities	North and southbound passing lanes	Traffic
26	Washington/Morgan	153.44	173.52	Narrow roadway	Pavement rehabilitation and add shoulders	Safety
27	Morgan	156.3	156.6	Pavement condition in curve	Mill and overlay, add shoulders with rumble strips, enhanced pavement markings, signage, and delineation	Safety

Project Number	County	MP From	MP To	Concern	Description	Category
28	Morgan	157.1	157.85	Passing opportunities	North and southbound passing lanes	Traffic
29	Morgan	158.94	159.27	Crashes on curves	Mill and overlay, add shoulders with rumble strips, enhanced pavement markings, signage, and delineation	Safety
30	Morgan	161.42	164.42	Pavement condition, off road crashes	Mill and overlay, add shoulders with rumble strips. Enhanced pavement markings, signage, and delineation in curves	Safety
31	Morgan	165.25	166.45	Vehicles encountering pavement drop off	Mill and overlay, add shoulders with rumble strips. Enhanced pavement markings, signage, and delineation in curves	Safety
32	Morgan	165.25	166.45	Advisory curve warning	Reconstruct roadway to 65 mph standard	Safety
33	Morgan	165.72	165.72	Narrow bridge	Widen or replace D-22-C (over Big Beaver Creek)	Bridge
34	Morgan	166.28	167.3	Pavement condition	Mill and overlay	Maintenance
35	Morgan	170.5	171.25	Passing opportunities	Southbound passing lane	Traffic
36	Morgan	171.63	172.5	Crashes on curves	Add shoulders with rumble strips. Enhanced pavement markings, signage, and delineation in curves	Safety
37	Morgan	171.85	171.85	Concrete culvert age	Replace structure 071D171970BR	Maintenance
38	Morgan	172.75	172.75	Concrete culvert age	Replace structure 071D172870BR	Maintenance
39	Morgan	173.52	173.52	Intersection sight distance	Intersection sight distance improvements	Safety
40	Washington/Morgan	138.01	174.36	Highway geometry continuity	Mill, overlay, add shoulders (gap projects)	Maintenance
41	Morgan	174.36	178	Highway alignment through Brush	Realign highway to go around Brush	Other
42	Multiple	124	173	ROW fence condition	Replace existing ROW fence (see remarks for detailed locations)	Maintenance

8.2.1 Funding Opportunities

Full buildout of CO 71 with the long-term vision detailed through this Plan is estimated to cost in the range of $371 million to $507 million (2019 dollars). While the full cost is beyond current funding, CDOT and its partners will benefit from obtaining available funds to incrementally improve the highway. These funds are generally included in specific programs with detailed uses and restrictions. Details regarding these potential funding programs, their uses, potential restriction(s), and applicability to CO 71 are included in Table 9.

Table 9: Potential Funding Opportunities

FUNDING PROGRAM	USES AND RESTRICTIONS	CO 71 APPLICABILITY	APPLICATION PROCESS
CDOT Region Priority Program (RPP) Funds	RPP is a flexible funding source allowing for a wide variety of projects of importance to be funded in each CDOT Region.	Can be used for any of the improvements identified through this Plan	CDOT, in consultation with the UFRTPR and ETPR, allocates the RPP funds. The project/corridor will need to be identified in the TPR's Plans prior to any potential application
CDOT Transportation Safety Grants	For use on identified locations requiring safety improvements that provide projects, services, programs, and strategies that are intended to reduce the number of deaths and serious injuries resulting from traffic crashes.	Potential for any of the Safety Category projects	Various funding programs. Process dependent upon program.
CDOT Surface Treatment	Exclusively for resurfacing projects; cannot be used for widening or other improvements	Combine with RPP or other funding sources for the surface treatment component of a project	No application required as highways are identified through the Surface Treatment Management Program
Legislative Funds	Recently, SB18-001, SB17-267, and SB 19-262 have increased CDOT's funding. Uses and restrictions are included in bill language, and CO 71 has been included in lists for using these funds.	Can be used for many of the improvements identified through this Plan	TBD

FUNDING PROGRAM	USES AND RESTRICTIONS	CO 71 APPLICABILITY	APPLICATION PROCESS
Federal Freight Program	National Highway Freight Program (NHFP) projects must be in the state Freight Investment Plan (FIP) and contribute to efficient goods movement on the National Highway Freight Network (NHFN).	CO 71 is not on the NHFN or FIP, therefor ineligible. Segments of CO 71 are in the Freight Plan, Appendix C – Future Freight Investment Areas.	The selection of NHFP projects is done by CDOT in collaboration with the Freight Advisory Council.
Federal Grants	The Nationally Significant Freight and Highway Projects (INFRA) program provides Federal financial assistance to highway and freight projects of national or regional significance	Can be used for many of the improvements identified through this Plan. State/local match required in the past will need to be identified.	Annual NOFO announcements include application requirements.

8.3 BENEFIT-COST ANALYSIS

A benefit-cost analysis (BCA) was conducted on the proposed CO 71 improvement alternatives to assess whether the projected benefits of the project merit the expense. The BCA framework looks at project benefits and costs from a national perspective, capturing the net welfare change created by a project, including cost savings and increases in welfare (benefits), as well as disbenefits where costs can be identified (e.g., project capital costs), and welfare reductions where some groups are expected to be made worse off because of the proposed project. The national freight travel demand model that produced the key inputs to this BCA (VMT & VHT) necessitated this perspective.

The BCA framework involves defining a Base Case or "No Build" Case, which is compared to the "Build" Case, where the project is built as proposed. In the case of this project, two alternative Build Cases are considered: the "Shoulders with Passing Lanes" (S/PL) scenario, in which passing lanes and shoulders are added to CO 71, and the "Four-Lane Divided Highway" (4LDH) scenario, in which the road is converted to four full lanes. This BCA also conducts a sensitivity test on the S/PL scenario, considering the impacts if future volume forecasts are lower than projected by the model.

The benefits measured in this BCA reflect travel time savings from trucks traveling at faster speeds and bypassing the Denver-area congestion on I-25, and crash reduction from the implementation of the highway improvements. The BCA also measures the change in emissions and vehicle operating costs because of changes in vehicle miles traveled; however, for this project these manifest as disbenefits because VMT is expected to rise relative to the baseline under both build alternatives. These benefits and disbenefits are compared to the costs of each project alternative, including both upfront capital costs and expected increases in annual operating and maintenance (O&M) and periodic rehabilitation and repair (R&R) costs. Based on historical expenditures, the average annual cost per lane mile for certain types of O&M are provided in Table 10.

Table 10: O&M Costs per Lane Mile, 2019$s

Type of O&M	Cost per Lane Mile
Pavement Preservation	$1,163
Signs / Striping	$681
Bridges	$88
Snow Removal	$513
Total Costs	$2,445

These costs are applied to 262 miles of new lanes for 4LDH, for an average annual O&M cost of $640,500. For the S/PL, annual O&M costs are expected to average $120,700. This is based on the following assumptions:

- There will be 26 miles of new passing lanes and 105 new miles of shoulder. However, because the new shoulders will be two-thirds the width of a traditional lane, their maintenance costs are proportionally less as well, such that it is as if there are only 70 new full lane miles.
- Only pavement preservation and snow removal costs are applied to the S/PL lane miles.
- Because snow removal on shoulders is only completed at the end of an event, it is expected to be 25 percent of the full per lane mile cost.

Total estimated O&M costs for each scenario are presented in Table 11 in undiscounted and discounted terms.

Table 11: Estimated Project O&M Costs, 2019$s

	Total Cost		Average Annual Cost	
Scenario	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
S/PL	$2,414,273	$607,569	$120,714	$30,378
4LDH	$12,810,458	$3,223,841	$640,523	$161,192

For a full summary of results, as well as details on the economic analysis, please see Appendix I, Benefit Cost Analysis. Across all scenarios, the S/PL outperforms the 4LDH scenario in terms of both benefits and costs. This is because the expansion of CO 71 to four lanes would result in higher capital improvement cost. In both alternatives, the increased vehicle operating costs and emissions from the additional VMT counteract the time-saving benefits, reducing the Benefit Cost Ratio (BCR).

A summary of benefits, costs, and metrics for each scenario can be found in Table 12. The total benefits over the course of the analysis period are projected to be $321 million for S/PL, $221 for the adjusted S/PL scenario, and $593 million for 4LDH. Cost estimates range from $170 million to $292 million for S/PL and from $410 million to $556 million for 4LDH.

While the benefits of the 4LDH scenario are higher than the S/PL scenario, the costs are higher too, resulting in a BCR of 1.07 to 1.45 – lower than the base S/PL scenario, but higher than the adjusted S/PL scenario. When NPV is considered, the 4LDH result of $37 million to $183 million outweighs each comparable cost category in both S/PL scenarios.

Table 12: Summary of Benefit Cost Analysis, 2019 $Millions, Present Value

	S/PL	S/PL - Adjusted	4LDH
Total Benefits	$321	$221	$593
Total Costs			
Low	$170	$170	$410
Medium	$231	$231	$483
High	$292	$292	$556
BCR			
Low	1.89	1.30	1.45
Medium	1.39	0.96	1.23
High	1.10	0.76	1.07
NPV			
Low	$151	$51	$183
Medium	$90	($10)	$110
High	$29	($71)	$37