I-70 Mountain Corridor PEIS Travel Demand Technical Report

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Section 1. Introduction

1.1 What's in this technical report?

This *I-70 Mountain Corridor PEIS Travel Demand Technical Report* summarizes the travel demand analysis provides for the I-70 Mountain Corridor Programmatic Environmental Impact Statement (PEIS). This information forms the foundation for identifying the transportation needs in the Corridor. **Chapter 1** of the PEIS documents the project purpose and need. This Technical Report references other technical reports that provide further details and are included as appendices as follows:

- Appendix A, Travel Model
- Appendix B, Ridership Survey
- Appendix C, 2035 Travel Demand
- Appendix D, 2050 Travel Demand
- Appendix E, I-70 Safety and Congestion Problem Areas

This *I-70 Mountain Corridor PEIS Travel Demand Technical Report* describes existing conditions and the processes and assumptions to project future conditions. The future conditions include forecasts for 2025, 2035, and 2050. In addition, this Technical Report includes detailed information about the performance measure results that demonstrate the purpose and need of the I-70 Mountain Corridor project.

This Technical Report is organized as follows:

- **Section 1**, Introduction
- **Section 2**, Existing Conditions
- **Section 3**, Forecast Years
- **Section 4,** Definition of Travel Demand
- **Section 5**, Major Assumptions for the Forecasts
- **Section 6**, Overall Process to Project Future Conditions
- **Section 7**, Development of the 2025 Travel Demand Model
- **Section 8**, Development of the 2035 Forecasts
- **Section 9**, Development of the 2050 Forecasts
- **Section 10**, Development and Major Assumptions of the Microsimulation Model
- **Section 11**, Forecast Results: Future Conditions
- **Section 12**, Summary and Application of Results

Section 2. Existing Conditions

2.1 Where is the Corridor?

The study Corridor shown on **Figure 1** includes I-70 from Glenwood Springs to C-470 and the surrounding transportation systems of Garfield, Pitkin, Eagle, Summit, Grand, Lake, Clear Creek, Park, Gilpin, and Jefferson Counties. The study Corridor is located within an even broader region, which forms the larger travel shed for analysis, shown on **Figure 2**. This broader region, shown in color and with a dark blue border, encompasses the area of western Colorado from Denver International Airport to the Utah Border, and from the Wyoming border to Pueblo. **Figure 2** shows the studied 144-mile section of I-70 highlighted in red and surrounded by a hashed band. The Front Range—the urbanized section of Colorado east of the foothills spanning from Pueblo in the south to Fort Collins in the north, includes all of the Denver metropolitan area—shown in shades of yellow and orange, with a brown border. The regions shown in the legend indicate different sources of model data.

2.2 What are the travel characteristics of the Corridor that make it unique?

The I-70 Mountain Corridor is linked in the national interstate highway system and is part of the only east-west interstate crossing Colorado. The Corridor provides for the movement of people, goods, and services across the state, and is a major corridor for access to many of Colorado's recreation and tourism destinations. Existing transportation congestion on the Corridor is degrading the accessibility of mountain travel for Colorado residents, tourists, and businesses. The population of Corridor communities is projected to more than double by 2035. Additionally, there are a high percentage of second homes in the Corridor. While the Denver metropolitan area is not within the Corridor, Denver residents are frequent users of the corridor and the Denver metropolitan area population is projected to experience extensive growth.

With the combined growth in Corridor users, travel demand in the Corridor is projected to continue increasing over the next 25 years and beyond. Tourism drives the Corridor-area economy, and is directly tied to Corridor travel demand and traffic patterns. Tourism and recreation travel are the primary sources of weekend congestion in the Corridor. Modeling recreational trips requires tying trips to what is drawing people to the Corridor, including ski slopes, trails, campsites, and resorts.

What makes this Corridor unique for travelers is the combination of several factors, including:

- Mountainous roadway driving challenges;
- Diverse types of weekday work trips and weekend recreation trips;
- Complex and growing travel demand resulting in hours of congestion; and
- Diverse seasonal influences of summer and winter attractions.

Travelers in the Corridor encounter changes in travel lanes from six lanes to four lanes, mountainous terrain with sharp curves and steep grades over six and seven percent, and winter driving conditions that may exceed driver expectations and experience.

In addition to highway characteristics, traffic flows are influenced by the actions of drivers and the performance of their vehicles. Driver characteristics considered include trip purpose, desired speed, vehicle following and lane-changing behavior, and vehicle occupancy (willingness to travel with other people). Important vehicle characteristics include the type of vehicle (passenger automobile, single-unit truck, combination-unit or semi-truck, recreational vehicle, or bus), acceleration characteristics, power-to-weight ratio, and size.

2.3 Who uses this Corridor?

People travel in the Corridor for many reasons. Because Corridor travel patterns are so complicated, the Corridor is divided into ten study segments with generally common travel characteristics. Each segment has a representative location or 'focal point" for evaluation purposes. For purposes of presentation in **Chapter 1**, these ten focal points are represented by five locations. **Figure 1** shows the ten study segments and the five representative focal points.

Figure 1. Segments and Focal Points for Reporting Travel Information

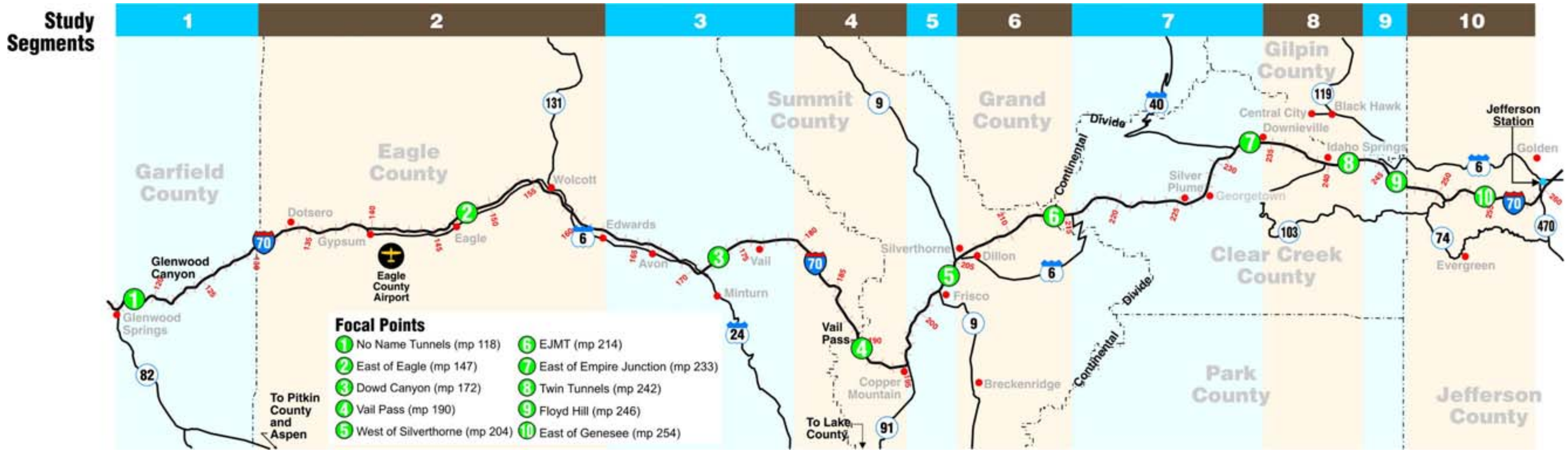
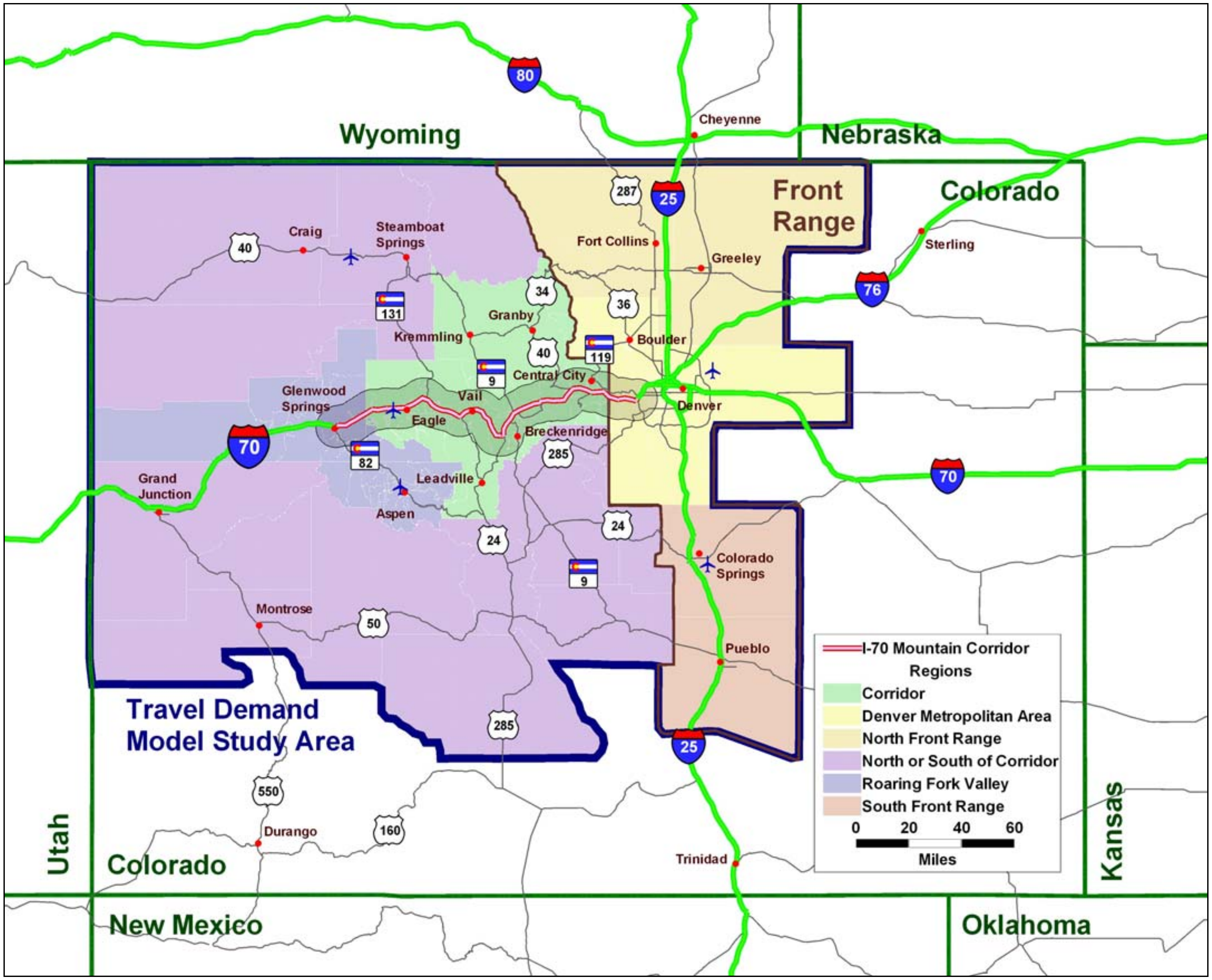


Figure 2. I-70 Travel Demand Model Study Area



2.3.1 Trip Purposes

Several types of trips made in the Corridor have common characteristics:

- Type of trip
- Origin and destination of trips
- Reason for travel
- Type of vehicle used
- Average number of passengers per vehicle

The purpose of each type of trip has certain characteristics that make it similar to some trips and different from others. Some of these characteristics include the income of the travelers, the type and location of the origin and destination, and the type of vehicle used.

The various types of trips and their inherent purposes have been captured in categories of "trip purposes." For the model development, trip purposes influence the value of time, willingness to consider other modes, and willingness to carpool.

The I-70 Mountain Corridor currently serves a variety of transportation users. Travelers include commuters, recreationalists, locals, intra- and interstate freight truckers, and others. Within these categories of users, the I-70 travel demand model considers several subcategories, resulting in the analysis of 21 types of trip purposes, listed below:

- **Commuters (Work Trips) –** Commuters (work trips) represent person trips to, from, or within the Corridor area, the Roaring Fork Valley, areas north and south of the Corridor, and the Front Range for purposes of employment. The patterns of work trips are related to commuting for work both within the Corridor and outside the Corridor. The vehicle occupancy for work trips (for the four income groups described below) is assumed to average 1.1 persons per vehicle, consistent with the Denver Regional Council of Governments travel demand model.

  Work trips are most prevalent on weekdays in the area between Eisenhower-Johnson Memorial Tunnels and East of Empire Junction: 41 percent (eastbound); followed by the area between East of Genesee and Floyd Hill: 31 percent and the West of Silverthorne area: 31 to 35 percent; the Vail Pass area: 27 to 30 percent; and Eagle County Line to Vail East Entrance (east of Dowd Canyon): 23 to 25 percent. The subcategories analyzed include:

  - Low-income home-based work trips
  - Middle-income home-based work trips
  - Upper-middle-income home-based work trips
  - High-income home-based work trips

  (Subcategory names correspond to those used in **Appendix A, Travel Model**.)

- **Recreationalists –** Recreationalists represent person trips for the purpose of recreation within or near the Corridor. The recreation purposes have an average occupancy of 2.6 persons per vehicle. They are divided into three main trip categories, listed below:

  - **Recreation - Day Trips –** These are day person trips by Denver metropolitan area residents traveling to and from the Corridor area for recreational purposes, and day recreation by Corridor-area residents.

    Day recreation trips are most prevalent and are the most common trip purpose in Clear Creek County: 46 to 48 percent; followed by Edwards to Vail East Entrance: just under 30 percent of all person trips made primarily by Eagle County residents; West of Silverthorne: 31 percent; and Jefferson County: about 25 percent of person trips. Subcategories include:

- Front Range Day Recreation trips (for example, skiing, hiking)
- Corridor Day Recreation trips (by residents, second home owners, and visitors)

- **Recreation - Stay Over Trips and Colorado Non-Work Trips –** These trips are primarily longer distance and overnight person trips by Coloradoans and out-of-state air visitors to recreation areas within the Corridor. These travelers may stay overnight at a resort or hotel, a second home in the Corridor area, or the home of a friend or relative. These trip purpose category includes overnight stays in the Corridor area and person trips to the Denver metropolitan area made by Corridor-area residents.

  Overnight recreation trips are most prevalent on weekends, in the Vail Pass area: highest percentage projected with 61 percent of westbound travelers and 56 percent of eastbound travelers, followed by the Edwards to Vail East Entrance: 38 percent, West of Silverthorne: 43 percent, Clear Creek County: 37 to 38 percent (second most common trip purpose), and Jefferson County: 22 percent. Subcategories include:

  - Corridor to Airport or Front Range trips
  - Stay Overnight Visiting Friends or Family trips
  - Stay Overnight at Hotel, Resort, or Forest trips
  - Stay Overnight at Second Home trips
  - Resort to Resort trips
  - Out-of-State Air Passenger trips

- **Gaming Trips –** These are person trips destined for gambling locations in Central City or Black Hawk that use I-70 for access.

  Gaming trips are most dominant in the Floyd Hill and Genesee area. The percent of gaming traffic on I-70 in the Mount Vernon Canyon area ranges from 17 percent on a Summer Thursday to 60 percent on a Winter Saturday

  Chapter 1 combined Day Recreation trips with Stay Over trips and Colorado Non-Work trips into the general category of "Recreation." The chapter considered Gaming trips separately.

- **Locals - Local Non-Work Trips –** These are person trips that include shopping, medical, and social person trips, and the "Non-Home-Based" person trips found in urban travel demand models. These types of trips indicate the importance of I-70 as the primary access for local travel between cities in the Corridor. Local Non-Work trips have an average occupancy of 1.7 persons.

  Local Non-work trips are most prevalent on weekdays in the Eagle County Line to Edwards area: 40 percent; followed by Edwards to Vail East Entrance: 36 percent; West of Silverthorne: 24 percent, Jefferson County: 22 percent; Vail Pass: about 13 percent; Loveland Pass Interchange to Downieville: 12 percent; and Silverthorne to Loveland Pass Interchange: 10 percent. Subcategories include:

  - Home-based non-work trips
  - Non-home based local trips

- **Other Trips** – This category includes trucks operating both locally and to or from outside the Corridor. The Other trip category also includes trips made by recreational vehicles and automobiles from external locations (for example, out of the Corridor area or out of state). Trucks are assumed to be occupied by a single driver. The model treats recreational vehicles and external auto trips as vehicle trips directly; that is, the model does not require an assumption about how many people are in either of these vehicle types. The sub-categories discussed in **Appendix A, Travel Model** are:

- Single-Unit Truck (for example, delivery van and buses) trips
- Single-Unit Truck Internal-External and Through trips
- Combination-Unit Truck (for example, semitrailer) trips
- Combination-Unit Truck Internal-External and Through trips
- Recreation Vehicle trips
- Out-of-State Automobile trips (Internal-External and Through trips)

Overall, the vehicle occupancy in the Corridor varies by location and day because the mix of trip purposes varies. On weekdays, work, local, and truck trips are the most common, and the average occupancy ranges from 1.45 to 1.65 persons per vehicle along the Corridor. There are more recreational trips on weekends, and because these trips have a higher occupancy, the average at different points in the Corridor ranges from 1.65 to 2.35 persons per vehicle.

2.3.2 Vehicle Types

The use of heavy vehicles—trucks, buses, and recreational vehicles—along the Corridor averages approximately ten percent, but varies substantially (three to 14 percent) by time of use (weekday use being generally greater) and by area along the Corridor. The interaction between heavy vehicle movements and congestion is important for several reasons:

- Most trucks or large recreational vehicles cannot go up or down the steep grades (up to seven percent) as fast as most passenger cars. The resulting variation of vehicle speeds on I-70 has safety implications, and slow-moving vehicles on grades take up the capacity of several passenger cars.
- For trucks delivering goods to customers within the Corridor area, there is no reasonable alternative to I-70, and trucker clients often control delivery times because most vending locations do not have adequate storage space.
- On steep two-lane segments, a truck passing a slower vehicle blocks all faster vehicles, causing congestion in both lanes.
- Other slow-moving vehicles on I-70 include recreational vehicles and buses. Depending on the distance from Denver, up to 5 percent of the vehicles on the Corridor are recreational vehicles.
- On weekends, truck and recreational vehicle use is most dominant in Garfield and Eagle counties: seven to eight percent, respectively. In the rest of the Corridor, truck and recreational vehicle use is about three to four percent of person trips.
- On summer weekdays, truck and recreational vehicle use is most dominant in Glenwood Canyon at 12 to 14 percent, followed by Clear Creek County at nine or ten percent, then Silverthorne to the Loveland Pass interchange with nine percent, and finally the Edwards to Vail East Entrance and Jefferson County segments tying with eight percent. (The fraction of heavy vehicles in Jefferson County represents a smaller percentage, but the greatest number of these vehicle trips in both directions combined.)

In summary, the travel patterns described above provide the need and challenges for developing strategies for making this range of slow-moving vehicle types compatible with general traffic on I-70.

2.3.3 How do traffic patterns differ between summer and winter?

Summer weekends have the greatest overall person trip volumes. Winter weekends represent peak demand during the winter, defined as the season from the Friday after Thanksgiving to April 15th. **Chapter 1** presented summer weekends as the typical weekend for several reasons:

- Summer weekends have greater daily volume than winter weekends.
- Summer weekends have more hours in a row of sustained peak volumes than winter weekends.
- There are more summer weekends (69 per year) than winter weekends (48 per year).

Because of these considerations, summer weekends offered a more representative description of weekend traffic and were used in **Chapter 1** of the PEIS for presentation. The detailed analysis included all model days and times, and that information was used in examining and evaluating the performance of alternatives.

In the eastern part of the Corridor, summer Thursdays have the lowest overall person trip volumes but on the western portion of the Corridor, summer Thursday and summer Friday represent peaks in overall person-trip volumes.

Below is a summary of major observations about traffic patterns regarding winter and summer weekend trips and weekday trips. **Figure 1** illustrates the locations highlighted in the following sections.

On winter weekends, congestion mostly occurs in the eastern portion of the Corridor—between Silverthorne and C-470—and during two pronounced rush hours—one in the morning and one in the evening. The timing of these peaks is related to skiers wanting to spend as much of the available daylight hours on the slopes as possible. The two peaks occur on both winter Saturdays and Sundays. The evening peak eastbound is more severe on Sundays because people who stayed overnight the whole weekend are returning with Sunday day skiers.

On summer weekends, congestion occurs in the eastern part of the Corridor, in Dowd Canyon, and over Vail Pass. In summer the duration and timing of activities varies greatly—from people who want to spend the whole day hiking to others who just want to spend an hour picnicking or shopping. Traffic volumes rise gradually in the morning, peaking around 11:00 AM westbound and 1:00 PM or 2:00 PM. eastbound, and gradually tapering off in the evening.

At present, there are no hours of congestion on summer or winter weekdays (including Fridays) because of the low volume of recreation trips on weekdays, and because the volume of work and local trips made by Corridor residents on weekdays is less than the volume of recreational trips made by all travelers on weekends. Because weekday travel is predominantly work and household trips, there is not as much of a difference between summer weekdays and winter weekdays as there is between summer weekends and winter weekends.

Analysis for the PEIS considered summer Thursday as the typical weekday because it is not generally affected by weekend recreation traffic the way Monday and Friday are. Summer Friday was examined separately because it is different from both typical weekdays and typical weekends. In the future, particularly as Eagle, Garfield, and Summit counties grow—and as second homes are converted to full-time homes—congestion is more severe on weekdays, with more Corridor residents making commuting and other trips. Future congestion occurs west of Vail, and between Frisco and Silverthorne, representing the urbanizing areas of Eagle and Summit counties. Garfield County continues to supply a good portion of Eagle County's workforce. (See **Section 4** of this Technical Report for more discussion of the days analyzed for the I-70 PEIS.)

2.4 What are the Corridor's safety statistics and problem areas?

Safety plays a strong role in the evaluation of Corridor mobility, accessibility, and congestion. In areas where safety issues currently exist, safety is considered inherent in the project needs. Evaluating the safety of travel in the Corridor requires considering factors such as roadway geography, weather, traffic volumes, and driver characteristics—each of which can contribute to increased crash rates. Areas meriting specific attention were identified by a weighted hazard index greater than zero, which indicates an above-average accident rate. (A weighted hazard index of zero indicates the accident rate is identical to the statewide average.) Weighted hazard indexes were calculated for interchanges and mainline sections between interchanges. Crashes reduce the flow of traffic and, therefore, increase delay within the Corridor. Further safety information can be found in the *I-70 Mountain Corridor PEIS Safety Technical Report* (CDOT, August 2010).

Mobility is greatly reduced in problem areas of steep grades combined with the limited ability to pass slow moving vehicles, particularly in times of heavy traffic conditions. For example, Vail Pass has grades of up to 7 percent, and between 9 percent and 12 percent of all vehicles are trucks, buses, or recreational vehicles, depending on the time of year and day. With only two lanes of roadway in each direction, these slow-moving vehicles greatly reduce the ability of faster vehicles to pass and create congestion when slow-moving vehicles pass other slow-moving vehicles.

Areas where existing roadway facilities result in congestion are typically located at sharp geometric curves, interchanges that have the potential to back traffic onto I-70, and steep grades that result in slow-moving vehicles. These congestion problem locations reduce the flow of traffic and increase congestion.

Figure 3 shows the problem areas of safety, mobility, and congestion.

Section 3. Analysis Years

3.1 For what analysis years are travel demand forecasts prepared?

The PEIS includes the work done for travel demand forecasts in the Corridor for the years 2025, 2035, and 2050. Initially, a 2025 travel demand model was developed at the start of the PEIS process in 2000. . To account for the updated population and employment forecasts—and to maintain a horizon year at least 20 years out—the 2025 forecasts were updated to 2035.

Forecasts for the long-term horizon of 2050 are prepared to identify and develop long-term solutions for the Corridor. To account for increasing variability of projecting into the future, the 2050 travel demand is estimated as a range.

3.2 Why is 2000 the base year of analysis?

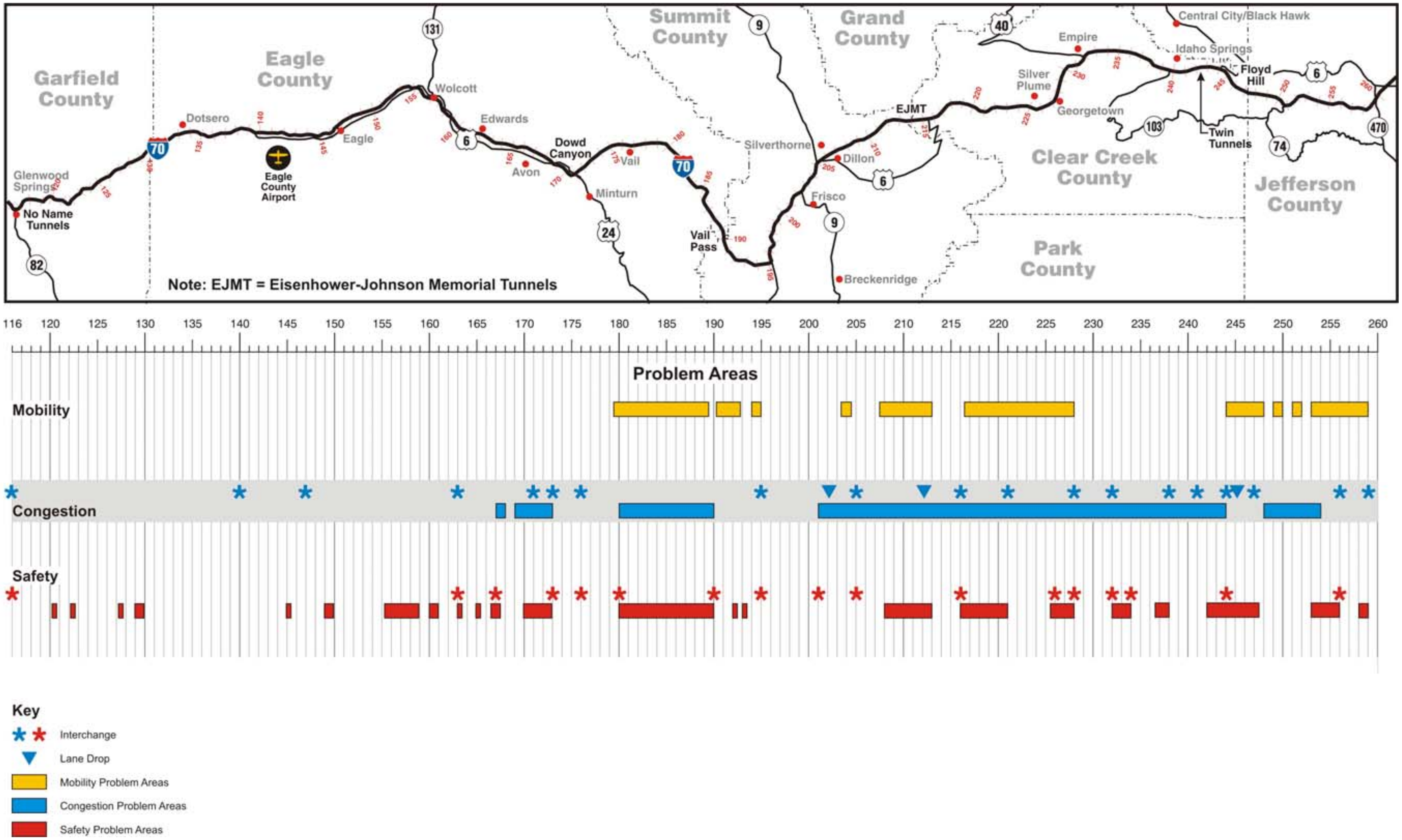
2000 is used for the base year of analysis because it represents a year with a large amount of travel and socio-economic data, including the 2000 US Census as well as the I-70 User Survey conducted by the project. At the time of model development beginning in 2000, the 2000 data set provided a complete snapshot of conditions in the Corridor, and it was used for calibration of the travel demand model. Furthermore, the 2000 data set on characteristics of the Corridor provides a base year for comparison purposes to future year scenarios.

2000 remains valid as a base year for the Tier 1 process of this document. During the passage of time for development of the PEIS, no major changes have taken place in the 144-mile Corridor that notably alter the snapshot of Corridor conditions provided by the year 2000. There have been no major or minor I-70 infrastructure improvements since 2000, and travel patterns and needs of Corridor users have not changed substantially. Confirmation of the travel demand model performance is provided by a comparison of the future trendline projected by the model with actual counts for 2008. The actual counts are below the model's projection for 2008, by an average of about 17% as shown in **Table 1**. This is a reasonable comparison given the economic conditions in the nation and the state of Colorado, and the circumstances of abnormally high petroleum prices during the year of 2008. As the economy rebounds, it is expected the demand for travel in the Corridor will again follow the trendline projected by the model to 2025, 2035, and 2050.

Table 1. Percent Difference Between Travel Model Projection Trend and Actual Volume Count for 2008

Location	Summer Thursday Eastbound	Summer Thursday Westbound	Summer Sunday Eastbound	Summer Sunday Westbound	Average Over Days and Directions
No Name	12%	16%	17%	14%	**15%**
Dowd Canyon	21%	21%	16%	15%	**18%**
Eisenhower-Johnson Memorial Tunnels	14%	17%	3%	21%	**14%**
Twin Tunnels	13%	19%	5%	14%	**13%**
West of C-470	19%	11%	49%	20%	**25%**
Average Over Locations	**16%**	**17%**	**18%**	**17%**	**17%**

Figure 3. Problem Areas for Safety, Mobility, and Congestion



Section 4. How is travel demand defined?

Travel demand is a prediction of the number of travelers projected to use the Corridor in the future. The Corridor serves a diversity of user types, vehicle types, and markets. Sometimes the term "travel pattern" is used to refer to the mix of the different types of travelers.

Travel demand for 2035 and for 2050 is presented for both typical weekday and weekend conditions. Typical conditions are defined by analyzing several representative days throughout the year establishing typical weekday and weekend travel demand volumes. Travel demand on some days throughout the year (for example, holiday weekends) is higher than typical conditions. The differences in travel patterns are reflected in the days used for analysis by the models.

4.1 For what days is travel demand modeled?

For the I-70 PEIS, demand is defined in terms of model days. Travel demand models for metropolitan areas typically use only one model day: an average weekday during the school year. For example, the Denver Regional Council of Governments' model uses only one model day. Because the traffic patterns in the I-70 Corridor are complicated by recreational travel, the PEIS uses five model days:

- Summer Thursday
- Summer Friday
- Summer Saturday
- Summer Sunday
- Winter Saturday

As discussed in **Section 2.3.3**, this analysis focuses primarily on summer because summer offered a more representative description of traffic. To represent typical peak days in each season—but not the worst traffic on holidays—summer days were represented by the average of the first two weeks in August, and typical winter Saturday volumes were calculated by averaging the volumes on the first two Saturdays in February. The definition of winter Saturday avoids including the Saturday during the Presidents' Day weekend.

For **Chapter 1** of the PEIS, these five model days were simplified to two "typical" days for summary purposes: a weekday and a weekend. The weekday corresponds to summer Thursday, or sometimes summer Friday in the western part of the Corridor, depending on which is more "typical." The typical weekend corresponds to summer Sunday because that day represents the greater daily volume compared to winter weekends, summer Sunday more hours in a row of sustained peak volumes, and there are more summer weekends (69 per year) than winter weekends (48 per year). (However, the peak-hour volume on winter Saturday is sometimes higher than that of summer Sunday.)

4.2 What is unmet demand?

The concept of unmet demand recognizes that the number of trips actually taken along the Corridor is related to the conditions of travel. The measurement of unmet demand is based on the desire to take a trip using the I-70 Mountain Corridor, but a decision is made by the traveler not to travel due to adverse conditions (that is, severe congestion).

Because unmet demand is an important issue in the I-70 Corridor, the travel demand model measures it. For purposes of this analysis, a "Baseline" travel demand forecast was developed. The "Baseline" for travel demand in the Corridor is a projection of the number of persons who desire to use the Corridor, not considering roadway congestion. As a standard planning forecast procedure to calculate desired demand, the year 2025 population, employment, and recreation forecasts were multiplied by the trip rates from the year 2000 to form the 2025 Baseline demand. In estimating the 2025 population forecasts, the State Demographer's socioeconomic model does not consider congestion on I-70 (or any other roadway) that might influence the number of trips made.

However, some people choose not to make some trips as congestion gets worse. The number of trips these people give up is the unmet demand. Because people give up making trips because of congestion the 2025 Baseline demand is an overestimate of the actual travel in 2025.

To determine unmet demand, CDOT experts familiar with the I-70 Corridor were asked about the worst travel times people would tolerate before they would reduce their trip-making. Their answers corresponded to an average speed of about 30 mph between Silverthorne and C-470. Therefore to calculate a demand level appropriate for the No Action Alternative, desired Baseline demand is iteratively reduced until 30 mph speeds are obtained over long segments, using the traffic microsimulator. (The segments used are from the Garfield/Eagle County Line to Vail East Entrance and from Silverthorne to C-470. The use of long segments means that speeds may be slower in some shorter sections and faster in others). Unmet demand is the difference between the desired Baseline demand and the calculated level of demand for No Action.

Accounting for unmet demand, travel times and congestion for the No Action Alternative are always the same or better than conditions with the Baseline demand, because the No Action demand is less than or equal to the Baseline demand.

Section 5.2 of this Technical Report and **Chapter 2** of the PEIS describe the elements of the transportation network included in the No Action Alternative.

4.3 What is induced demand?

Induced travel demand represents the idea that if a transportation system is improved and provides higher quality than existed previously, the system will attract additional users. Introducing additional capacity, either highway or transit, into the Corridor will influence unmet or suppressed travel demand and induce additional trips. Determining how much demand is induced by high-capacity alternatives uses a slightly different process. Because there is no high-capacity transit on I-70 now, CDOT conducted a Ridership Survey in 2000 to see how people would respond to different kinds of new transit. CDOT asked people:

- How often they travel on I-70 now
- Whether they would travel more
- How many more times they would travel if the transit concept shown during the survey were available

Statistical analysis then related the number of additional trips people would be willing to make to the average speeds with new transportation capacity in the Corridor. The data collected in 2000 remains valid as no major changes in transportation infrastructure have occurred since 2000. The Corridor serves the same market of users with the same I-70 infrastructure as was in place in 2000. These relationships were used to forecast additional travel under the various alternatives.

Appendix A, Travel Model, further describes how the model evaluates the influence of suppressed and induced travel demand.

Section 5. What are the major assumptions for the forecasts?

5.1 What growth is expected for the Corridor?

In 2008, the Colorado Department of Local Affairs released its socioeconomic county-level forecasts for 2035. For transportation planning purposes, Denver Regional Council of Governments allocated these forecasts to smaller geographic units (termed zones) for its member governments. Overall, the 2035 socioeconomic forecasts show continued growth in the Corridor and Denver metropolitan area. In the 10 years following 2025, Corridor population is expected to increase by 28 percent and Denver metropolitan area population by 15 percent. Because of the recreational opportunities in the Corridor that attract Front Range residents, Front Range population drives Corridor traffic levels as much as Corridor population. Colorado Department of Local Affairs also forecasts Corridor employment to increase 8 percent from 2025 to 2035 and Front Range employment to increase 6 percent.

Within the overall forecasted Corridor growth rates, there are important county-level differences in the distribution of growth. Considerably greater population growth occurs in the western part of the Corridor, while the eastern part of the Corridor is relatively stable. Garfield County experiences the greatest population growth—82 percent—from 2025 to 2035 among all nine Corridor counties. Eagle County follows with the second highest population growth at a 30 percent forecasted increase. During the same time period, Clear Creek County and Jefferson County are forecast to lose population.

A wide range of employment changes from 2025 to 2035 is expected among the Corridor counties. Park County employment is expected to be relatively flat from 2000 to 2025 and is forecast to more than triple by 2035. Garfield and Gilpin counties have the next greatest forecast employment increases, 42 percent over the ten years. At the other end of the range, both Eagle and Pitkin counties are forecast to lose 16 percent of their 2025 employment. In the Denver metropolitan area, employment is forecast to increase six percent from 2025 to 2035. These differential population and employment growth rates forecast for the Corridor and Denver metropolitan area counties influence localized traffic patterns on I-70.

Table 2 summarizes population and employment for the nine-county Corridor and for the Denver metropolitan area for each of the three years considered and provides average annual growth rates.

Table 2. Corridor and Denver Metropolitan Area Population and Employment Estimates for 2000, 2025, and 2035 Socioeconomic Estimate

	Socioeconomic Estimate			Average Annual Growth	
County	2000 (DOLA 2002)	2025 (DOLA 2002)	2035 (DOLA 2009)	2000–2025	2025–2035
Corridor Population	172,726	347,631	419,236	2.8%	1.9%
Corridor Employment	124,948	260,657	272,406	3.0%	0.4%
Denver Metropolitan Area Population	2,442,402	3,451,858	3,938,360	1.4%	1.3%
Denver Metropolitan Area Employment	1,367,174	1,972,984	2,354,538	1.5%	1.8%

Table 2 shows that population and employment growth for the Corridor counties slows after 2025. The Denver metropolitan area population is expected to have an average annual growth rate of 1.4 percent from 2000 to 2025 and 1.3 percent from 2025 to 2035. The Denver metropolitan area employment growth is expected to increase from an average rate of 1.5 percent from 2000 to 2025 to an average rate of 1.8 percent from 2025 to 2035. The Denver metropolitan area population and employment is an order of

magnitude (that is, roughly ten times) larger than the corresponding quantity for the Corridor. See **Appendix C, 2035 Travel Demand** for more detail on socioeconomic forecasts.

5.2 What are the No Action background network assumptions?

The No Action network in the travel demand model is the transportation network as it existed in 2000, plus those improvements that CDOT and others have made or committed to making. A project must be reasonably expected to be funded and constructed by 2025, to be included in the No Action network. The No Action network includes new and expanded roadways, new interchanges on I-70, and new park-n-Rides.

The No Action network includes the three new interchanges at Eagle Airport, Avon East Entrance (formerly Post Blvd.), and Eagle-Vail. The Avon East Entrance and Eagle-Vail interchanges have already been built. The Eagle Airport interchange is waiting for funding.

The new park-n-Rides to be constructed between 2000 and 2025 are located at the Hogback at the Morrison interchange (milepost 259), Silverthorne (milepost 205), Frisco (milepost 203), and Breckenridge. However, the travel demand model includes additional park-n-Rides because it assumes people board transit only at these locations. This assumption meant that park-n-Rides had to be provided in the western part of the Corridor—sometimes at locations where only a bus stop or informal park-n-Ride exists—to allow those residents the option of choosing transit. Further, the Hogback was not included in the 2025 travel demand model because no existing transit services stop there. The Hogback park-n-Ride has been constructed, and primarily serves drivers wishing to form carpools. **Section 6.1.1** and **Appendix A, Travel Model,** of this Technical Report describe transit access in more detail.

Roadway expansion projects in the No Action network for the travel demand model are:

- Widening SH 9 from two to four lanes between Breckenridge and Frisco (construction anticipated to be completed in fall 2010)
- Adding a westbound (northbound) climbing lane to U.S. 40 south of Berthoud Pass (completed)
- Widening U.S. 285 from two to four lanes between Bailey and Conifer (portions under construction)
- Constructing the Jefferson Parkway as a four-lane facility between I-70 (milepost 260) and US 36, including associated improvements to US 6 and SH 93 (included in Denver Regional Council of Governments travel demand model)
- Building the four-lane Central City Parkway from the Hidden Valley interchange (milepost 243) to Central City (completed)
- Building two bores of two lanes each for the Black Hawk Tunnel between the U.S. 6 interchange at the base of Floyd Hill (milepost 244) and SH 119 (see below)

When the I-70 PEIS forecasts were developed in 2003, the Black Hawk Tunnel was reasonably foreseeable as emerging as a component of the Preferred Alternative of the Gaming Area Access Environmental Impact Statement then being studied. The two studies were closely coordinated to ensure a consistent set of assumptions. After the Central City Business Improvement District sold bonds to build what is now known as the Central City Parkway, this roadway was added to the No Action network in July 2003. Completion of the Central City Parkway in November 2004 reduced the Black Hawk Tunnel's potential traffic market. Black Hawk patrons are willing to take the Central City Parkway and backtrack to Black Hawk. The Notice of Intent for the Gaming Area Access Environmental Impact Statement was withdrawn in 2010. However, the influence of the Black Hawk Tunnel is included in the 2035 travel demand forecasts, which are made by factoring in the 2025 forecasts.

In preparing the PEIS, the four-step travel demand model tested the sensitivity of the I-70 traffic forecasts to removal of the Black Hawk Tunnel. A sensitivity approach was used to initially understand the implications before running the model for all 22 alternatives. The resulting summary is that gaming traffic that would have used the Black Hawk Tunnel has the choice of either continuing on I-70 to the Central City Parkway, or returning to U.S. 6 through Clear Creek Canyon and continuing up SH 119. About 40 percent to 55 percent of gaming traffic formerly using the Black Hawk Tunnel switched to the Central City Parkway, depending on the day. Further, recreational traffic—primarily from Boulder and vicinity—that switched to US 6 when gaming traffic switched to I-70 will return to its original route of I-70 through Mount Vernon Canyon.

As a result of changing traffic patterns from the removal of the Black Hawk Tunnel, there will be more traffic on I-70 between the Central City Parkway interchange (milepost 243) and the U.S. 6 interchange (milepost 244). Additionally, there will be more traffic eastbound on U.S. 40 (the Frontage Road) from U.S. 6 to Beaver Brook because there is no ramp from westbound U.S. 6 to eastbound I-70. Finally, because construction of the Black Hawk Tunnel was assumed to include a third westbound I-70 lane from the current Floyd Hill lane drop to the Black Hawk Tunnel exit, there will be increased congestion down Floyd Hill as more traffic tries to make its way through fewer lanes. The sensitivity analysis demonstrated that this is a localized issue and does not affect Corridor-wide analysis of the alternatives. More detailed analysis of the traffic in this area and appropriate design solutions will be conducted during the Tier 2 processes.

In November 2004, voters approved the additional sales tax to help fund Regional Transportation District's FasTracks rail and bus expansion project. The travel forecasts in the 2025 model analysis did not reflect the FasTracks network, though the Transit and Combination Alternatives included a feeder bus system serving major stations in FasTracks corridors. Demand model runs made for the 2035 analysis showed that the change to FasTracks had little impact on transit ridership in the I-70 Corridor. Although travelers prefer rail to bus, the multiple stops on the West Corridor light rail line meant that Denver Metropolitan Area residents had slower access to I-70 transit at Jefferson Station. These two factors roughly offset each other.

Section 6. What is the Overall Process to Project Future Conditions?

6.1 What methods and tools were used to produce and analyze future travel conditions?

The following factors were used to complete the travel forecasts:

- A four-step travel demand model
- A traffic microsimulation model
- A socioeconomic factoring model
- A trend analysis

The four-step model estimates the amount of travel demand and the traffic microsimulation model estimates the amount of congestion. The travel demand model and the traffic model interact to make sure that when combined, the forecast traffic levels and congestion levels are reasonable.

The four-step travel demand model is used to forecast demands that occur in the year 2025. Demand in 2035 is forecast using a socioeconomic factoring model that assumes different segments of traffic grow differently as a result of population and employment growth forecasts. The 2050 demand forecast is made using trend analysis, as described in **Appendix D, 2050 Travel Demand**.

6.1.1 Four-Step Travel Demand Model

The type of travel demand model used in most urban areas, and for the I-70 PEIS, is called the "four-step process" because major components of the model attempt to answer the following four questions:

1. How many trips are there?
2. Where do the trips go?
3. Do people drive a car, or do they ride a train or bus?
4. What roads (or transit routes) do people use to get from here to there?

As part of the travel demand model, the entire study area is divided into smaller areas called zones. **Figure 2** shows the study area for the I-70 model. Because the I-70 model used about 750 zones, some of them could be small enough to represent a neighborhood in a resort town.

In the first step, the number of trips to and from each zone is estimated based on population and employment data or forecasts, using different average numbers of trips per day depending on household size, income, and the type of job. The I-70 travel demand model estimated recreational trips based on variables such as the area of a forest or wilderness, the number of campsites, the number of beds in a hotel or a resort, and the number of second homes.

In the second step, trip origins are linked to trip destinations based on how many trips are in a zone and how long it takes to go from zone to zone. Trips from an origin zone to other zones are distributed to nearby zones, and to far away zones if those zones attract a large number of trips. For example, travelers make short neighborhood trips for most purposes, but will make a long trip to a regional shopping mall for major shopping needs. Zones with more trips attract more trips from the zones around them. Zones that are farther apart do not get as many trips as zones that are closer together.

In the third step, the model considers the times and costs for each mode of travel (car, train, or bus), and compares them based on how important each mode is to people. Travel time might be divided up into parts such as time getting from the garage to the freeway or train station, time spent waiting for the train to arrive, time on the freeway or train, and time after leaving the freeway or train to get to the final destination. Similarly, costs might be divided into the costs for gas, parking, and the train ticket. How important each part of the trip is can be established by seeing what modes people choose or, as in the case of this study, where there is no Advanced Guideway System or train yet, asking people what they think they will do. If the modes offer competitive costs and travel time between the same origin and destination, the model predicts about the same number of trips for each mode. If one mode has lower costs or travel times than the other modes, it attracts the most trips.

In the final step, the model figures out how many cars will use a certain segment of road by putting all the trips from each origin and each destination on the fastest path. Because it takes longer to travel on a road when there are more cars on it, the fastest path may not be the fastest path once all the trips have been loaded. The model recalculates travel times and moves some of the trips to the paths that are now faster. The model keeps recalculating travel times and moving trips until the travel times and trips are consistent, and it does not have to move any more trips. **Appendix A, Travel Model** describes how the model considers the combination of times and costs when determining which transit path to use.

In performing each of these four steps to make a travel demand forecast, the model has to make many assumptions. To test the reliability of the assumptions , the model is run with current year data. The "forecast" of current year traffic is compared to actual counts, and adjustments are made to improve the match. This test showed the model produces reasonable results that are within accepted planning industry standards. **Section 7.2** provides further information on the validity of the model. Major assumptions of the I-70 travel demand model include the following:

- Researchers have observed that when new roads are built, there is more traffic on the roadway system overall than if the new road had not been built. In the I-70 travel demand model, projected trips vary by alternative. When transit or highway capacity is added, additional demand occurs to take advantage of the additional capacity. On the other hand, severe congestion causes demand to go unmet.
- As part of the I-70 travel demand model, a conversion is made from the daily trips that come out of the first step to the peak-hour trips that are needed to calculate peak-hour travel times during the fourth step. The percent of daily trips that happen during the peak hour is held constant across the forecast years and alternatives.
- The I-70 travel demand model chooses between alternate routes as a traveler would. As shown in **Figure 2**, the model covers a good portion of Colorado, including all the major roads in the shaded area. So while a lot of roads are included in the network, they are used only when congestion on I-70 is so bad that they become competitive.
- In running the fourth step for transit trips, the modeler looks at the forecasts and manually ensures that there are sufficient numbers of vehicles arriving with sufficient frequency for all passengers to have seats.

Appendix A, Travel Model describes in detail the many assumptions of the four-step model.

The I-70 travel demand model uses a software called TransCAD. There are other software packages that do four-step travel demand modeling, but TransCAD was chosen for I-70 for a number of reasons. First, because Denver Regional Council of Governments had adopted TransCAD, their model could be incorporated into the I-70 travel demand model. Second, TransCAD is based on a full Geographic Information System and is, therefore, more advanced than the TranPlan software used for the Roaring Fork Valley model, which includes Glenwood Springs and Aspen at the west end of the Corridor.

6.1.2 Socioeconomic Factoring Model

The four-step model could have been used to produce 2035 traffic forecasts. However, to do this, the State Demographer's 2035 population and employment forecasts at the county level would need to be split to the zone level. This process was time-consuming for the 2025 population and employment forecasts because all of the counties, cities, and towns in the Corridor needed to be consulted to make sure the divisions were reasonable. Often, individual cities and towns make quite optimistic growth assumptions for themselves, which, when added together, exceed the county total from the State Demographer. Therefore, a spreadsheet was used to factor the 2025 trip forecasts by the growth the State Demographer forecast in population and employment from 2025 to 2035.

This process began with the 2025 trip forecasts at each of the 10 focal points broken up by day, direction, and seven broad categories of trip purpose. For each focal point and trip purpose, a feeder area was identified that represented most of the origins or destinations of that type of trip. For example, winter Saturday day recreation (skiing) trips passing through the Twin Tunnels are most likely made by people coming from the Denver metropolitan area. Another example is that weekday work trips through Dowd Canyon are most likely commuters coming from Eagle and Garfield counties. Not many Summit County residents commute to jobs west of Dowd Canyon. **Appendix C, 2035 Travel Demand** provides detailed information on the feeder areas and other assumptions.

Most trip purposes grew in proportion to feeder area population. However, truck trips and trips from outside the model study area (see **Figure 2**) were assumed to grow in proportion to employment in the Corridor. Trucks come to the Corridor to deliver goods for sale and materials for manufacturing and to take finished goods out of the Corridor. Most people coming from outside the model study area are coming to the Corridor for recreation, which can be represented by employment at the resorts.

The 2035 spreadsheet keeps track of the different growth rates for the different focal points and trip purposes. In the end, the numbers of trips by purpose are added together to produce the overall 2035 trip forecast. That forecast is checked against the traffic microsimulation model to make sure that too many trips are not forecast when congestion is already severe, or else the forecast of trips is reduced. **Appendix C, 2035 Travel Demand** describes the 2035 socioeconomic forecasting model in more detail. FHWA, CDOT, and Denver Regional Council of Governments representatives reviewed this process and deemed it to be appropriate for this level of analysis.

6.1.3 Trend Analysis

Trend analysis examines data over time, finding a pattern or trend in the data, and using that trend to make a forecast for future years. Trend analysis can be done in a spreadsheet or in more complicated statistical software. For 2025 and 2035, travel was described as originating from population and employment. However, because no 2050 population and employment forecasts are available, the four-step model or the socioeconomic factoring model could not be used to develop the 2050 travel forecast. Instead, trend analysis was used.

Population and employment estimates for 2050 are not available to provide data for projecting travel demand. Therefore, for the 2050 analysis, only trend-based travel demand has been projected. A high and low estimate of 2050 travel demand was created using the 2035 forecasts as a foundation. Accounting for the potential uncertainties by using high and low estimates provides confidence in the 2050 travel demand forecasts. In the analysis of alternatives, both the high and low estimates are used to evaluate an alternative's ability to meet demand in 2050.

The low estimate assumes, at each location, the average annual amount of absolute travel growth between 2025 and 2035 continues to 2050 (a simple linear growth trend). For the high estimate, the average percentage travel growth rate during the 10-year period prior to 2035 was applied for each location (compounded growth). The annual growth rate for the high travel estimate varies from about 1 percent in the eastern portion of the Corridor to more than 3 percent in the western portion of the Corridor. See **Appendix D, 2050 Travel Demand** for more details of the 2050 travel demand forecasting process.

6.1.4 Summary of Travel Demand Forecasts

Complex travel patterns in the I-70 Corridor result from the collective decisions of travelers living in the Corridor, in the Front Range, and beyond. These decisions include whether to travel; why, where, and when to travel; who to travel with; and what mode and route to use. The methods to forecast travel for 2025, 2035, and 2050 reflect some of these decisions, depending on the supporting data available. **Table 3** shows which decisions are reflected in the models used for the different horizon years.

The four-step model used for the 2025 forecasts reflects the most decisions—all but the decision of which day of the week to travel. That is, the four-step model does not explicitly represent people who choose to cancel a trip on Saturday and take it during the week instead, for example. However, the four-step model implicitly represents switching travel days if it predicts unmet demand on one model day and induced demand on another. The socioeconomic factoring method considers the total number of trips, average vehicle occupancies, and transit shares. This method also reflects where travel demand increases by growing trips from 2025 levels based on population and employment growth in feeder areas. Trend analysis for 2050 was conducted for highway vehicle trips, highway person trips, and transit person trips. Therefore, the trend analysis reflects the total number of trips, the number of travelers per vehicle, and the transit share.

Table 3. Travel Decisions Reflected by Forecasting Methods

	Reflected in Model Forecasting Trips for		
Travel Decision	2025 (Four-Step Model)	2035 (Socioeconomic Factoring)	2050 (Trend Analysis)
Travel or not (number of trips)	√	√	√
Where to travel	√	√	
When to travel:			
Day of week	(implicit)		
Time of day	√		
Number of travelers	√	√	√
Mode choice	√	√	√
Route choice	√		

6.1.5 Traffic Microsimulation Model

The traffic microsimulation model keeps track of the lane and position of individual vehicles throughout the time being simulated, which for the I-70 PEIS is 5:00 AM through midnight. The model moves vehicles in accord with a driver's desired speed and desired distance from the vehicle in front of the driver. Both of these values are drawn from random numbers to reflect differences among drivers. This type of model is called "microscopic" or "microsimulation" because it considers vehicles individually. In contrast, TransCAD—which is "macroscopic"—uses a general relationship between traffic volumes and segment travel times.

TransCAD represents the roadway network as a kind of stick figure, and the traffic relationships are more analogous to water pressure in pipes. In the traffic microsimulation model, the number of lanes and the elevation of the highway are explicitly represented. The microsimulator can also represent acceleration and deceleration lanes for on-ramps and off-ramps, and traffic lights and stop signs at the end of off-ramps, unlike TransCAD.

The I-70 model process—which sends data back and forth between different software—was designed to take advantage of each software's strength. The four-step travel demand model is best at determining traffic volumes when given what travel times will be. The microsimulation model is best at determining travel times when given what demand will be. By using the two models together, consistent travel times and demand can be obtained.

Traffic microsimulation uses a software called VISSIM. VISSIM is a microscopic, time step and behavior-based simulation model developed to analyze the full range of functionally classified roadways and public transportation operations. VISSIM not only models integrated roadway networks found in a typical corridor but also various modes consisting of general-purpose traffic, buses, light rail, heavy rail, trucks, pedestrians, and bicyclists. VISSIM can also analyze a myriad of traffic conditions under constraints such as lane configuration, traffic composition, traffic signals, transit stops, etc., making it an invaluable tool for evaluating various alternatives, such as those analyzed in the I-70 PEIS, based on transportation engineering and planning measures of effectiveness.

Models in VISSIM can be designed to model any combination of surface street and freeway facilities, including most signal control and other operational strategies. VISSIM models provide a more detailed and focused output, both in tabular format and via animated graphics making well informed decisions possible.

VISSIM allows a smooth transition from a broader travel demand model macro-simulation level to a high detail micro-simulation level of analysis. The dynamic simulation module in VISSIM allows the analyst to input travel demand matrices generated in TransCAD into microsimulation with minimal effort.

One of the big advantages of VISSIM is that it provides the flexibility to control traffic operations (e.g., yield conditions) and vehicle paths within an intersection or interchange. VISSIM also allows the modeling of closely spaced intersections such as those found at some interchanges and numerous urban corridors. Another modeling advantage that VISSIM has is the fact that there are no limits to the size of the network, providing major flexibility in analyzing large corridors. VISSIM also allows users more flexibility in specifying where and what type of data is to be collected. Most models generate travel times for each link, which can be aggregated to determine travel time for a particular route. Within VISSIM, data collection such as travel time can be specified between any two points based on the analyst's requirements.

Another important aspect of data collection with VISSIM is that the data generated for various measures of effectiveness such as traffic density, travel time, queue lengths, and number of vehicles passing a point per hour are generated in a format that is user friendly and can be analyzed easily in spreadsheets such as Excel.

A similar program, called RAILSIM, was used to model the progress of transit vehicles between stations and to determine the station-to-station travel times. RAILSIM comes with a library of train and bus types for simulation based on vehicles in actual passenger service.

Section 7. Development of the 2025 Travel Demand Model

7.1 How was the model developed and what were its results?

The PEIS team developed the initial I-70 Mountain Corridor travel demand model to forecast 2025 projections. Because there is no existing Metropolitan Planning Organization travel demand model for the entire Corridor, or any other comprehensive models available, the team developed a new model by:

- Creating Corridor-specific traffic analysis zones;
- Collecting demographic, social-economic and recreation data; and
- Conducting a ridership survey.

The model combines weekday work trips and weekend recreational trips for summer and winter seasons, making it unique from other typical urban traffic models. The team worked extensively with technical specialists from FHWA, CDOT, Denver Regional Council of Governments, and local planning agencies throughout the model building process, to ensure that the data collected and the modeling process are within the reasonable range of expectations. A peer review panel consisting of experts from FHWA, Massachusetts Institute of Technology, University of California-Davis, Denver Regional Council of Governments, University of Colorado-Denver, Portland Metro, examined the accuracy of inputs and the reasonableness of outcomes from the model. An expert ridership surveying firm, Mark Bradley Research

& Consulting, and an expert model consultant, Cambridge Systematics, also reviewed the model. The peer review process concluded that the model was appropriate for this Corridor level study and for examining alternatives.

The I-70 model used the Denver Regional Council of Governments regional travel demand model and the Roaring Fork Valley model developed for CDOT's SH 82 studies. Highway networks from these two models were combined in a single line layer that also used Census highway files for roadways that were in the model study area but not included in the Denver Regional Council of Governments or RFV models. Zones were coded as to whether they were in the Denver Regional Council of Governments study area, the Roaring Fork Valley study area, the Corridor in between, or outside these areas. Average trip rates for Denver Regional Council of Governments zones were adjusted from the Denver Regional Council of Governments model because many of the trips leaving the Denver Regional Council of Governments study area (a separate trip purpose) are trips within the I-70 PEIS study area (see **Figure 2**). The same kinds of adjustments were made to the Roaring Fork Valley average trip rates. Average trip rates for the other areas were developed by comparing with the two existing models and adjusted as part of the calibration process.

The mode choice model (step three of the four-step process) was developed from answers to the I-70 Ridership Survey taken in 2000. (For more information about this survey, see **Appendix B, I-70 Ridership Survey**). Statistical methods were used to determine the tradeoffs travelers are willing to make between different times and costs of travel. These tradeoffs were calculated for 10 types of trips and are described in **Appendix A, Travel Model**.

7.2 What are the results of the calibration and validation, and what did the peer review conclude about the model?

For model calibration, the 2025 travel demand model forecasts 24-hour and peak period highway volumes for the year 2000, for five days. The five model days include summer Thursday, summer Friday, summer Saturday, Summer Sunday, and winter Saturday, as presented in **Section 4.1** of this Technical Report. **Section A.3** of **Appendix A, Travel Model**, summarizes the calibration process for the I-70 travel model and documents how well the model can predict existing travel patterns. Travel demand forecasts are compared against measurements including traffic counts and transit boarding records.

7.2.1 Traffic Count Calibration

Travel demand model highway volume estimates are conducted at selected CDOT Automated Traffic Recorder locations. Matching traffic counts is a typical criterion for determining whether the travel demand model is calibrated, particularly in an urban environment. Traffic counts for the Corridor are not as stable as in typical urban transportation networks. Corridor conditions that potentially modify the expected characteristics of the traffic counts include weather, snow conditions, crashes that block traffic, and holidays. In addition, trips estimated for the travel demand model need to correspond to trips estimated through independent processes such as ski market survey data. Nevertheless, this process represents an important measure that provides information concerning any potential bias present in the calibrated model.

Where the travel demand model and the counts differ by more than 2,000 vehicle trips by direction during one of the three periods, or 6,000 during the day, this difference is thought to represent normal model variation, and is generally less than 20 percent of capacity. Daily differences greater than 6,000 vehicles per day suggest that there may be a location-specific problem that needs adjustment in the model. At these locations, appropriate alterations were made during a post-model adjustment process.

Table 4 summarizes the results of the calibration process for each of the five model days by showing the range from the least difference and the greatest difference between volumes assigned for year 2000 by the travel model in comparison the observed traffic counts at seven CDOT Automated Traffic Recorder locations. The Automated Traffic Recorder locations are:

- No Name Tunnels
- East of Eagle
- Dowd Canyon
- Vail Pass
- Eisenhower-Johnson Memorial Tunnels
- Twin Tunnels
- East of Genesee

Figure 1 shows these locations. **Section A.3** of **Appendix A, Travel Model**, provides data for each model day at each Automated Traffic Recorder location.

Table 4. Summary of Year 2000 24-Hour Calibration Results
Comparison of Assigned Traffic Volumes and Automated Traffic Recorder counts

Model Day	Assigned Volume	Automated Traffic Recorder Count	Absolute Percent Difference
Summer Thursday Least Difference – Twin Tunnels	49,900	49,800	0%
Summer Thursday Greatest Difference – Vail Pass	19,900	25,900	23%
Summer Friday Least Difference – Dowd Canyon	44,200	47,900	8%
Summer Friday Greatest Difference – Eisenhower–Johnson Memorial Tunnels	36,700	45,700	20%
Summer Saturday Least Difference – Eisenhower–Johnson Memorial Tunnels	44,700	44,900	1%
Summer Saturday Greatest Difference – Vail Pass	28,500	25,300	13%
Summer Sunday Least Difference – East of Genesee	82,400	83,100	1%
Summer Sunday Greatest Difference – Vail Pass	31,100	27,400	14%
Winter Saturday Least Difference – Dowd Canyon	36,400	36,700	1%
Winter Saturday Greatest Difference – Vail Pass	23,000	17,900	28%

Summer Thursday – Little recreation traffic is expected during this day. The greatest model to count difference is in the area between Summit and Eagle counties using Vail Pass.

Summer Friday – Travel expected on summer Thursday and Friday is similar except for the addition of overnight trips, particularly in the afternoon and evening on Friday heading west from the Denver region and, to a much lesser extent (about one-third), from the mountains to Denver. The travel demand model is underestimating these trips from Denver to Vail in both directions. See **Peer Review Summary** below.

Summer Saturday – Travel expected on summer Saturday is dominated by travel from the Denver region for recreation to the Denver and Jefferson County Parks in Jefferson County, and overnight trips to the mountains. Because of the static nature of the traffic assignment routine within the travel demand model, it may be that some of the over-assignment shown at the Eisenhower-Johnson Memorial Tunnels is because trips are leaving in the AM and actually crossing the Eisenhower-Johnson Memorial Tunnels in the midday period.

Summer Sunday – Travel expected on summer Sunday is dominated by overnight recreation trips returning to the Denver region. The AM traffic is consistently being slightly under-simulated both eastbound and westbound.

Winter Saturday – Travel on winter Saturday is expected to include a large day skier demand from the Denver region that accesses the eight major resorts in the Corridor. There may be too much forecasted local traffic headed westbound through Vail from Summit County.

Peer Review Summary

The differences between modeled highway vehicle trips and observed trips are generally less than one-half lane of capacity of I-70 (this on average corresponds to about 8,500 vehicles per day). For this reason, because the main purpose for this model during the preparation of the PEIS is comparison of alternatives, the peer review team recommended the model be used, with its identified differences for this purpose.

7.2.2 Transit volume calibration by system

Table 5 summarizes transit calibration as a comparison between model daily system boardings and estimates based on information from each transit operator. (A boarding is one person getting onto one transit vehicle.) Generally, all of the private operators consider their ridership numbers proprietary, and count estimates for these systems were based on published schedules. Additional casino bus calibration was performed based on meeting the 20 percent mode choice for gaming patrons and the 30 percent mode choice for casino employees as identified in the *City of Black Hawk Transportation Plan* (City of Black Hawk, May 2000).

Mode choice for existing private operators (excluding the casino shuttles) is difficult to calibrate, given the very small number of transit operator trips (sometimes less than 100) out of millions of trips contained in the travel demand model. The Town of Vail Transit boardings are difficult to calibrate because of the short nature of bus trips there. Many of these bus trips are within a single zone of the travel demand model and do not show up in its transit forecasts. For this reason, **Table 5** shows the difference in total boardings for operators, excluding the Town of Vail and the private companies.

Calibration targets for transit boardings are not standardized within the transit modeling industry. For the PEIS, the criteria for 2000 calibration should be within 500 boardings if the count is below 1,000. If the count is more than 1,000 boardings, a model value within 30 percent of the estimated count is the recommended calibration criterion. Thirty percent is selected as a standard given more uncertainty in the ridership survey data, compared to highway survey data. 500 daily boardings represents 50 percent of the

1,000-boarding breakpoint, and this is thought appropriate for low-volume systems where small differences in boardings can represent relatively greater percentage differences. For routes exceeding these thresholds, post-model adjustment processes are made as appropriate.

Table 5. Transit Calibration Summary
Totals, Excluding Town of Vail and Private Corridor Operators

Model Day	Count	Model	Absolute Percent Difference
Summer Thursday	23,900	19,100	20%
Summer Friday	24,900	43,100	73%
Summer Saturday	27,400	21,900	20%
Summer Sunday	23,600	23,700	0%
Winter Saturday	35,000	36,600	4%

The model comes closest to predicting the actual number of boardings on summer Sunday, when the difference is about 100 boardings, followed by winter Saturday, when the difference is four percent. Both summer Sunday and winter Saturday experience high numbers of recreation trips. The model has an absolute difference of 20 percent from the counts on summer Thursday and summer Saturday, meeting the 30 percent threshold discussed above.

The difference between the model estimate and actual boardings on summer Friday is 73 percent. On this day, the model estimates the number of work and gaming trips on casino shuttles within five percent, but over-estimates the boardings for the Roaring Fork Transportation Authority (serving SH 82), ECO Transit in Eagle County, and Summit Stage. Reviewing the 2025 forecasts manually and adjusting the transit ridership forecasts on these systems downward to compensate for the model's tendency to over-estimate limits the impacts of this variability.

7.3 What are the results of sensitivity tests and what uncertainties are inherent in the forecasts?

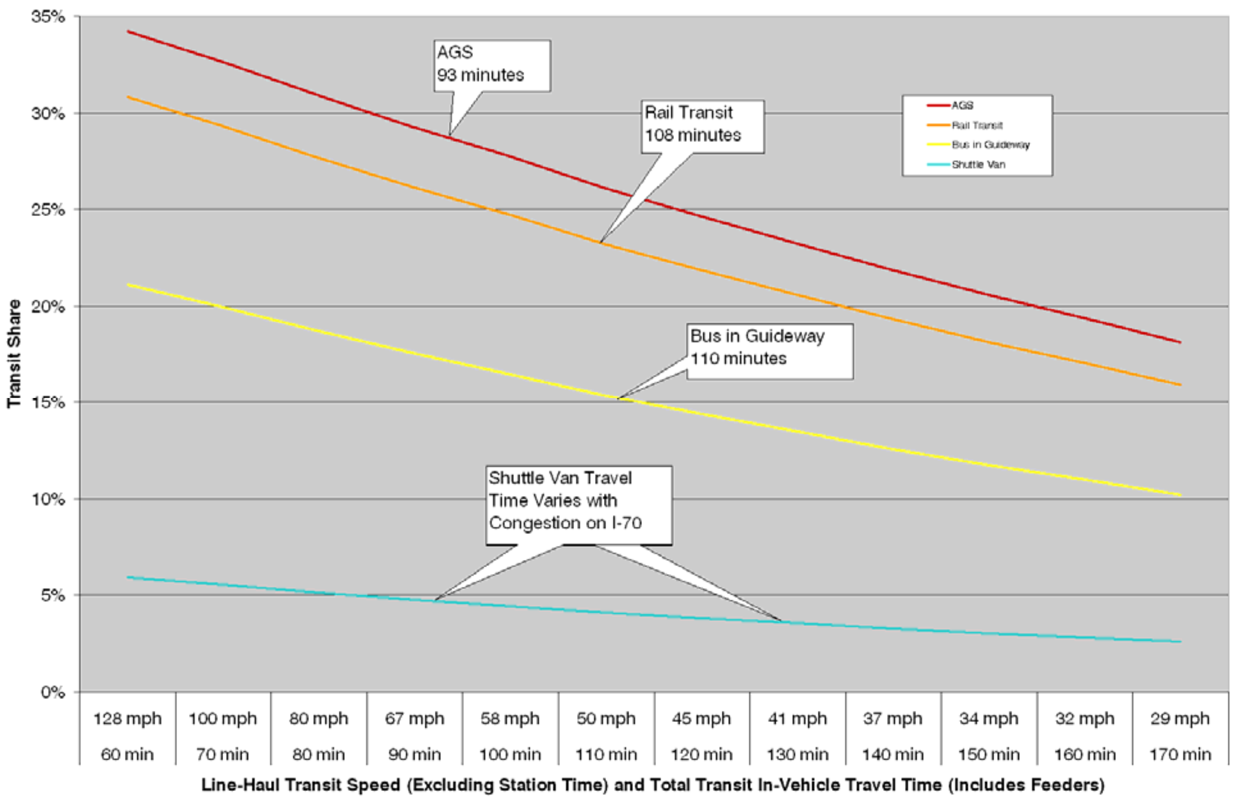
The term "sensitivity" refers to how much a model's forecast changes when inputs are changed. A sensitive model may change its forecast by the same percentage its inputs change, thus reflecting a cause and effect relationship. If a model's forecasts do not change much when the inputs change, that model is said to be insensitive. If such inputs are uncertain, that uncertainty does not show up in the forecast. Testing model sensitivity is an important way of gauging the uncertainty of a model.

The sensitivities of the mode choice model were tested most extensively because the PEIS alternatives would introduce new transit modes to the Corridor, and there is little direct experience to compare ridership forecasts against. The sensitivity tests considered a typical trip between El Rancho Station (near the I-70 interchange with SH 74, the Evergreen Parkway, at milepost 252) and Vail Lionshead. This transit trip involves a change at the Vail Transportation Center between the I-70 line-haul mode and a Town of Vail Transit bus to or from Lionshead.

The first sensitivity test looked at how the overall transit share of trips between these two places would change if the different modes could go at different speeds. **Figure 4** shows four curves for Advanced Guideway System, Rail Transit (the Rail part of Rail with Intermountain Connection), Bus in Guideway, and existing shuttle vans. These curves are for travel on a winter Saturday. Travel time is shown along the horizontal axis, and transit share decreases with increased travel time. **Figure 4** shows that highest use is on the Advanced Guideway System due to the shortest travel, with Rail a close second. Bus in Guideway is the third choice, with shuttle vans the least preferred. Call-outs on **Figure 4** show the actual speeds and travel times of the alternatives being evaluated in the PEIS. (The Dual-Mode and Diesel Buses have very similar travel times.)

If the Advanced Guideway System were able to reduce its travel time from just over 90 minutes to 60 minutes between El Rancho and Vail Lionshead, it would gain another 5 to 6 percent of the person trips between these two places. If the Advanced Guideway System took almost twice as long, it would lose about 10 percent of the person trips. With such a large range of travel times considered, the Advanced Guideway System share does not change dramatically. The results of the I-70 Ridership Survey suggest that travelers in the Corridor are not as sensitive to in-vehicle travel times as they are to other factors, such as access time, waiting time, and fare.

Figure 4. Sensitivity of Transit Share by Mode to In-Vehicle Time



Note: Shuttle vans are included in the No Action transportation network. No PEIS alternative proposes a change to shuttle van service.

Figure 5 is similar to **Figure 4** in that it shows the sensitivity of transit share to in-vehicle time on a winter Saturday. However**, Figure 5** breaks out the shares by trip purpose. **Figure 5** is for a Bus in Guideway, which represents the middle of the transit attractiveness scale. People going to and from second homes in the Corridor show a particular preference for Bus in Guideway, and for transit in general. Recall that because the buses being proposed and evaluated can make the trip between El Rancho and Lionshead in 110 minutes, they attract about 32 percent of people going to and from second homes. If the bus could make the trip in 60 minutes, it would attract about five percent or six percent more people, while if it took 170 minutes, it would lose six percent.

Out-of-State Air and Local Non-Work travelers have the flattest curves, indicating the least sensitivity to travel time. Air travelers have to deal with security lines and checking and claiming baggage, so the I-70 part of their trip may not be as great of a concern for them. Because Local Non-Work trips are often discretionary, travel time characteristics may not be that important to those making it. This observation is in contrast to valuable Work trips, which have a much steeper curve. Front Range Day Recreation travelers also have a steep curve, indicating they would like to participate in skiing or snowboarding as long as possible.

Figure 5. Sensitivity of Transit Share by Purpose to In-Vehicle Time

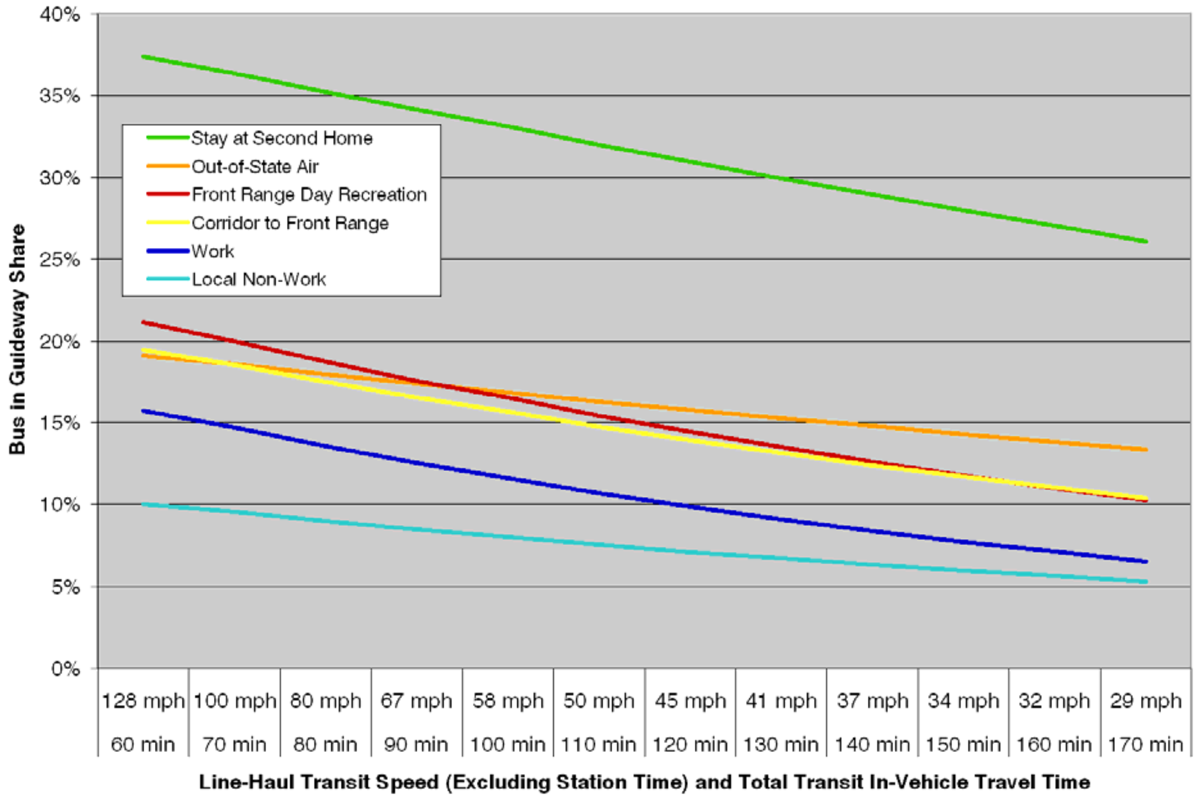
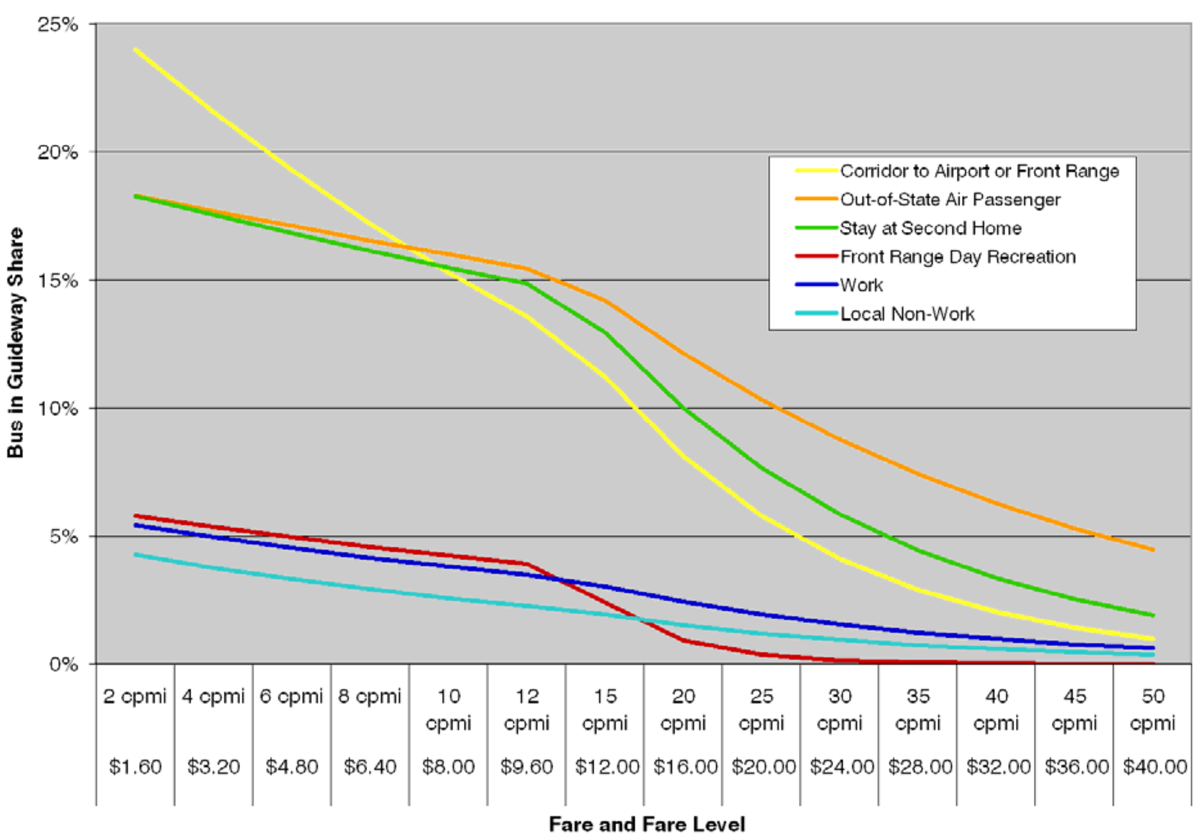


Figure 6 shows the sensitivity to fare by trip purpose. **Figure 6** is also for Bus in Guideway for a summer Saturday. For evaluating alternatives, the PEIS assumes a roughly 10-cent-per-mile fare level, meaning a trip between El Rancho and Vail would cost $8.00. (The ticket prices are actually calculated on a county-to-county basis for simplicity, rather than on a station-to-station basis. The El Rancho and Vail trip actually covers about 75 miles.) The curves show a kink in the middle because the horizontal axis changes from two-cents-per-mile ($1.60) steps on the left to five-cents-per-mile ($4.00) steps on the right.

Figure 6 shows that Corridor residents going to Denver International Airport and other Denver metropolitan area destinations are particularly sensitive to fare. By comparison, Work and Local Non-Work trips are relatively insensitive to fare. At 50 cents per mile (a $40.00 ticket), these purposes have just as small of transit shares as Corridor to Airport or Front Range trip-makers. But at lower fares, the Work and Local Non-Work shares remain low.

Front Range Day Recreation travelers show an interesting reaction to fare: they are less sensitive if the fare is under 12 cents per mile ($9.60 total), then become very sensitive to fare, then taper off again at higher fare levels, as shown in **Figure 6**. The I-70 Ridership Survey showed that these travelers do not mind fares under $10 very much, but are very unhappy about fares over $10. In fact, raising the fare from $5 to $10 for these people has about the same impact as raising the fare from $10 to $11! (By contrast, commuters did not show a different reaction if the fare was above or below $10.)

Figure 6. Sensitivity of Transit Share by Purpose to Fare



There are many sources of uncertainty in the travel demand model. Because the travel demand model depends on forecasts of population, employment, and recreation activity, its forecasts are only as good as those forecasts going in. Another source of uncertainty is getting a zone's development type classification right so that it can be given the correct average trips per day. For example, a zone currently classified may be suburban at 2025. With the second step of the model, average trip lengths and times are a source of uncertainty because there was not much data about these statistics to calibrate the model.

These are some sources of uncertainty related to adapting the I-70 Ridership Survey results into a mode choice model. First, to make the statistical methods applied to the I-70 Ridership Survey produce trustworthy results, assumptions about hourly earnings in the Corridor and Denver metropolitan area, and how much worse access times are than in-vehicle times were made. Second, because the I-70 Ridership Survey had to ask about people's intentions rather than past transit use, it is vulnerable to biases where people think the interviewer is advocating a particular mode and they change their response to support that supposed preference.

Another source of uncertainty in the mode choice model is the assumption that everyone gets to transit stations by driving. Because almost all of the Denver metropolitan area residents answering the 2000 Ridership Survey said they would get to the new transit system station by driving, it was decided to only model drive access to transit in the travel demand model. Transit systems in the Corridor do not have as developed a park-n-Ride network as there is in the Denver metropolitan area. Will the comparison the model makes for people who drive to transit in Eagle County or Summit County work for people who walk? The I-70 PEIS forecasts assume that driving or walking to transit stations are just as much, or as little, of an inconvenience.

The methods used for the travel demand forecasting for this project utilize the most up-to-date technology and widely accepted standards for transportation planning. However, as **Section 7.2** of this Technical Report showed, the travel demand model is not perfectly calibrated. This result is accepted practice for travel demand modeling. Trying to make the model match existing conditions too closely may not allow it to be responsive to the future changes it should reflect in its forecasts. Differences between model values and observed counts in the calibration are another source of uncertainty. Any model will have uncertainties inherent in trying to predict what travelers will do in the future.

While uncertainties associated with travel demand forecasting are inherent to the process, steps can be taken to limit the effect these uncertainties have on the decision-making and alternative selection process. Identifying and recognizing the uncertainties provides a better foundation for making comparative analyses of proposed alternatives. For this project, the following steps were taken to limit uncertainties in the forecasts:

- A peer review committee examined and commented on assumptions and data being used to develop the model. The committee convened four times as model components were being integrated.
- Forecasts from the model were reviewed and "post-model adjustments" were made to ensure that the forecasts as a whole were reasonable. Such adjustments are typical of the state of the practice and are documented in the administrative record of the PEIS.
- The model is used solely to compare alternatives, rather than make conclusions about absolute levels of travel volumes. Such a use is consistent with the objectives of a Tier 1 National Environmental Policy Act process.

Section 8. Development of the 2035 Forecasts

8.1 How were the 2035 forecasts developed?

The approach selected for the 2035 forecasts is a socioeconomically based process that, through factored modeling, estimates 2035 travel demands at the ten focal points in the Corridor shown in **Figure 1**, by considering the socioeconomic growth anticipated for relevant "feeder areas" associated with each of nine trip purposes (see **Appendix C, 2035 Travel Demand**). As described in **Section 6.1.2** of this Technical Report, some trip purposes grow in proportion to Department of Local Affairs population forecasts, while others grow in proportion to employment forecasts.

8.2 What are the conclusions of the methodology review?

Travel modeling experts at CDOT, FHWA, and Denver Regional Council of Governments reviewed the method for making the 2035 forecasts. The methodology review committee concluded the process was reasonable for purpose of a Tier 1 comparative evaluation and they agreed with the feeder area assumptions described in **Appendix C, 2035 Travel Demand**. One concern expressed was that the socioeconomic factoring method did not account for people who might change to alternative routes—such as US 50 and US 285—as I-70 became more congested. It was decided that these alternative route corridors would also see increased congestion as a result of population and employment growth in the counties they pass through; therefore, the proposed method would produce reasonable forecasts. Additional and more detailed modeling will be performed in Tier 2 processes.

8.3 What uncertainties are inherent in the 2035 forecasts?

Because the 2035 travel demand forecasts are factored from the 2025 travel demand forecasts, the 2035 forecasts are subject to the same uncertainties that the 2025 forecasts are. These uncertainties include internal rounding by the computer software and the choice of convergence criteria (how much is "close enough"?) for the various routines to implement the four-step process.

The 2035 travel forecasts are also subject to uncertainties related to the Department of Local Affairs population and employment forecasts. An attempt was made to test the potential sensitivity of the travel forecasts to different land use assumptions, but discussions with Denver Regional Council of Governments and the Corridor counties indicated that they were comfortable with the Department of Local Affairs forecasts and did not produce in dependent alternative forecasts.

Another source of uncertainty in the 2035 travel forecasts is related to the feeder area assumptions. For example, if another county should have been included in the feeder area, and that county grew at a rate faster than the counties included in the feeder area, then the forecasting process will underestimate the 2035 travel demand. Similar issues exist if a county that was left out grows at a slower rate than those that were included in the feeder area, or if the feeder area included a county it should not have.

A final source of uncertainty relates to the need to extend the bus guideway from its western termini assumed for the 2025 forecasts—Silverthorne eastbound and the Eisenhower-Johnson Memorial Tunnels westbound—to Eagle Airport because of increased congestion expected by 2035 in the rapidly growing Eagle and Summit counties. Having a dedicated bus guideway through areas of highway congestion would make transit more attractive, but the percent of people using the bus was effectively held constant from 2025. The PEIS assumes the whole bus guideway between Eagle Airport and C-470 (Jefferson Station) would be built in phases by 2050; however, what phases would be completed by 2035 were never established. For this reason, the effects of a more attractive transit service using a longer guideway could not be quantified for 2035.

Despite these uncertainties, the methodology review committee concluded that the socioeconomic procedure was the most appropriate to use because it makes use of all the available data (the 2035 population and employment forecasts) without needing to make many assumptions, each of which introduces additional uncertainty into the travel demand forecasts. The committee determined that this approach is consistent with the state of the practice for this time horizon.

Section 9. Development of the 2050 Forecasts

9.1 How were the 2050 forecasts developed?

In making the 2050 travel demand forecast, the desire was to produce a range of values to reflect potential uncertainty in the projection. Because 2050 socioeconomic forecasts are not available, the 2050 demand was estimated by extrapolating from the 2025 and 2035 travel demand levels, as described in **Section 6.1.3** of this Technical Report.

The high estimate uses exponential extrapolation, which assumes a constant growth rate from year to year. The low estimate uses linear extrapolation, which corresponds to the same increase in the number of trips occurring each year. Linear extrapolation, therefore, corresponds to a decreasing growth rate over time, since in calculating the growth rate, the numerator is the same each year while the denominator increases over time. As **Table 6** shows, the historical Corridor and Denver metropolitan area county population growth rates cover a wide range. The trip growth rates for the high estimate and for the first year (2035–2036) and last year (2049–2050) of the low estimate were examined and found to be well within the historical population growth rates.

Table 6. Comparison of Maximum and Minimum Annual Population and Trip Growth

Quantity	Minimum Annual Growth Rate	Maximum Annual Growth Rate
County Population: Denver Metropolitan Area (1880–2000)	-0.5%	11.6%
County Population: Corridor (1900–2000)	-10.5%	12.7%
Total Person Trips: 10 Focal Points (2035–2050)	0.5%	3.4%

9.2 What are the conclusions of the methodology review?

The same methodology review committee that was used for the 2035 forecasts reviewed the method for making the 2050 travel forecasts by trend analysis. The committee confirmed that no socio-economic forecasts were available beyond 2035. Therefore, the methodology review committee concluded that the trend analysis method is appropriate for comparative analysis in the Tier 1 process since data for a more refined approach were not available.

9.3 What uncertainties are inherent in the forecasts?

Because the 2050 forecasts are based on the trends in the 2025 and 2035 forecasts, the 2050 forecasts include all the sources of uncertainty from the earlier forecasts. Other uncertainties involve whether continuing a trend is appropriate:

- Is there enough water to support continued population growth in the Corridor and Front Range?
- Is there enough developable land to support additional housing and workplaces?
- Will global climate change alter the nature or attractiveness of recreation in the Corridor (for example, if ski resorts have shorter seasons)?
- Will enough petroleum be available to sustain travel patterns in the Corridor that predominantly rely on the private automobile, and to a lesser extent the diesel bus?

Because there is no consensus on the answers to these questions, they must remain as a source of uncertainty in the 2050 forecasts. However, developing a high and low estimate helps bound the range of uncertainty. Further, these uncertainties are typical of forecasts so far in the future. The range of forecasts developed for 2050 are appropriate for this level of analysis.

Section 10. Development and Major Assumptions of the Microsimulation Model

10.1 How was the microsimulation model developed?

The microsimulation model was developed consistently with FHWA guidelines for recommended use of traffic microsimulation software in transportation analyses. The guidelines recommend a seven-step process:

1. Identification of Study Purpose, Scope, and Approach
2. Data Collection and Preparation
3. Base Model Development
4. Error Checking
5. Calibration
6. Alternatives Analysis
7. Final Report and Technical Documentation

Simulation models are designed to mimic the behavior of traffic over time and space, to predict system performance. Simulation models include mathematical representations of real life traffic behavior in computer software. Simulation model runs are experiments performed in the laboratory rather than in the field.

Data collected for calibrating the traffic microsimulation model included data on speeds, capacities, and traffic composition. Colorado Department of Transportation Automated Traffic Recorders and numerous field observations provided data on speeds. Results of a Global Positioning System-based tracking study were examined but determined not to be useful because the readings seemed to indicate incident congestion, when the capacity of I-70 is reduced to one lane in one direction. Capacity information came from CDOT Automated Traffic Recorder readings during congested conditions and from field observations. Colorado Department of Transportation, the state Department of Revenue (which operates the truck weigh stations at Downieville), and field observations on six different days provided traffic composition data.

10.2 What are the assumptions of the microsimulation model?

As described in **Section 6.1.5** of this Technical Report, the microsimulation makes random draws of drivers' desired speeds and accelerating and braking characteristics. **Table 7** shows the random distribution of drivers' desired speeds by 5-mile-per-hour increments. Car drivers like to drive anywhere between 60 mph and 90 mph, while truck and recreational vehicle drivers want to go at 50 mph to 80 mph.

Table 7. Distribution of Desired Speeds for Cars, Trucks, and Recreational Vehicles

Vehicle Type	Percentage of Vehicles in Each Speed Range							
	50 to 54 mph	54 to 60 mph	60 to 65 mph	65 to 70 mph	70 to 75 mph	75 to 80 mph	80 to 85 mph	85 to 90 mph
Car	0%	0%	6%	9%	38%	38%	6%	3%
Truck and Recreational Vehicles	5%	16%	60%	6%	6%	7%	0%	0%

Desired acceleration and deceleration is also drawn from a random distribution—in this case a uniform distribution. **Table 8** shows the upper and lower endpoints of that distribution by vehicle type.

Table 8. Distribution of Desired Acceleration and Deceleration by Vehicle Type

	Maximum Acceleration (ft/s^2)		Maximum Deceleration (ft/s^2)	
Vehicle Type	Lower	Upper	Lower	Upper
Car	12.0	99.4	-24.6	-19.7
Single-Unit Truck	9.9	99.4	-19.7	-6.0
Semi	9.5	99.4	-19.7	-6.0
Low-Performance Recreational Vehicle	9.6	99.4	-19.7	-6.0
High-Performance Recreational Vehicle	11.2	99.4	-19.7	-6.0

Table 9 shows the percentage of vehicles belonging to each of the vehicle types simulated for the eastern part of the Corridor, and **Table 10** shows the percentage for the western part of the Corridor.

Table 9. Proportions of Volume between Silverthorne and C-470 by Vehicle Type and Model Day

Model Day	Winter Weekend	Summer Weekend	Summer Weekday
Direction	WB and EB	WB and EB	WB and EB
Car	93.0%	93.0%	91.0%
Single-Unit Truck	1.2%	2.0%	2.0%
Semi	1.8%	2.0%	4.0%
Low Performance Recreational Vehicle	0.7%	1.5%	2.0%
High Performance Recreational Vehicle	3.3%	1.5%	1.0%

Table 10. Proportion of Volume between Glenwood Springs and Eisenhower-Johnson Memorial Tunnels by Vehicle Type and Model Day

Model Day	Winter Weekend	Summer Weekend		Summer Weekday	
Direction	WB and EB	WB	EB	WB	EB
Car	93.0%	91.0%	93.5%	91.0%	93.0%
Single-Unit Truck	1.2%	2.0%	2.0%	2.0%	2.0%
Semi	1.8%	2.0%	1.5%	4.0%	2.0%
Low Performance Recreational Vehicle	0.7%	1.7%	1.0%	2.0%	1.5%
High Performance Recreational Vehicle	3.3%	3.3%	2.0%	1.0%	1.5%

Other assumptions of the traffic simulation model relate to how much of a gap drivers keep between themselves and the cars ahead, how far ahead drivers are able to look to see upcoming traffic conditions, drivers' reaction times, and how much space drivers want when changing lanes. **Appendix A, Travel Model** provides more details on the traffic simulation model.

10.3 What are the microsimulation model calibration and validation results?

Table 11 identifies the results of the 2000 calibration traffic simulation runs. The results have less delay than expected because the expectations are for the worst non-holiday travel times during the summer and winter seasons, whereas the 2000 traffic simulation runs used the model day volumes, which are based on more typical days.

Table 11. 2000 Travel Results from VISSIM

Critical Day	Direction	Expected Peak Hour Travel Time (minutes)	Achieved Peak Hour Travel Time (minutes)	Difference in Peak Hour Travel Time (minutes)
Summer Saturday	WB	70	63	7
Summer Sunday	EB	100	84	16
Winter Saturday	WB	85	75	10

10.4 What uncertainties are inherent in the forecasts?

The two main sources of uncertainty in the traffic microsimulation model are the limited amount of data for calibration and the fact that simulation is an inherently random process. While a large amount of traffic volume data was available for calibrating the travel demand model, in comparison, the amount of speed data was limited. Calibration of the traffic simulation model focused as much on matching observed capacities as matching observed speeds.

The word “simulation” implies that the software running it must make random draws to determine its input values. In the case of traffic simulation, random draws are made for when in an hour a vehicle departs and the other driver and vehicle characteristics mentioned in **Section 10.2** of this Technical Report. The draws used in the simulation are not truly random—a computer does not do the electronic equivalent of flipping coins or throwing darts—but are based on a complex mathematical procedure that generates a series of numbers that looks “random enough.” This mathematical procedure has to have a starting value, which is called the “seed.” Using the same seed lets you get the same sequence of “random” number values for testing different alternatives on an equal basis. But because different seeds would produce different results, the ideal procedure for modeling with simulation is to run multiple simulations and take the average. However, the large number of alternatives and model days in the I-70 PEIS did not allow for such an ideal, theoretical consideration. Uncertainties were limited in forecasting travel times by using the same random seed for each simulation to allow consistent comparisons across alternatives. Travel time and congestion forecasts were also reviewed for reasonableness and post-model adjustments were applied when warranted.

10.5 What are the conclusions of the methodology review?

A methodology review of the traffic simulation model focused on its use in estimating unmet demand. A panel of experts familiar with the I-70 Corridor reached consensus on a maximum travel time for a trip between C-470 and Silverthorne, after which people would stop traveling in the Corridor. This maximum travel time is equivalent to an average speed of 30 mph, and this speed threshold was also adopted for the western part of the Corridor.

Two FHWA staff members each independently conducted reviews of the sensitivity of unmet demand to congestion and concluded that the results of the model were reasonable.

Section 11. Forecast Results: Future Conditions

11.1 What performance measures were selected to demonstrate purpose and need and why?

Three performance measures were selected to demonstrate purpose and need:

- The need to increase capacity is measured by unmet demand.

  As stated in **Chapter 1** of the PEIS, there is insufficient capacity to accommodate the current and projected demand for person trips in the Corridor. Person trips are used to portray the future demand, rather than vehicle trips, so that all potential modes of travel are examined. Lack of capacity leads to slower travel times and congested conditions. It also means that person trip travel demand cannot be adequately accommodated. The inability to adequately accommodate person trip demand results in a need to increase person trip capacity.

- The need to improve mobility and accessibility is measured by peak-hour travel times.

  As stated in **Chapter 1** of the PEIS, mobility along the I-70 Mountain Corridor is defined as the ability to travel along the Corridor safely and efficiently in a reasonable amount of time. Mobility in this Corridor is directly affected by the mix of vehicle types, particularly slow moving vehicles (trucks, buses, and recreational vehicles) that make up about 10 percent of weekday traffic. Accessibility is related to mobility and is defined as the ability to access destinations served by the I-70 Mountain Corridor safely, conveniently, and in a reasonable amount of time. Currently, there are long travel times to traverse the Corridor or reach Corridor destinations during peak weekend conditions. Future increases in person trip demand will result in more congestion, more delay, and increased travel times for weekends and weekdays. Long travel times affect all types of Corridor users and result in a need to improve mobility and accessibility in the Corridor.

- The need to decrease congestion is measured by the duration of congestion.

  As stated in **Chapter 1** of the PEIS, severe congestion occurs on the Corridor during typical peak weekend conditions and is projected to worsen on weekends in the future and occur on weekdays. Congestion is defined by a poor Level of Service and is measured over the course of a day at a specific location by the number of hours at Level of Service F. Congestion can be caused by many factors including, but not limited to, deficient roadway geometrics, inadequate interchanges, slower-moving vehicles in areas of steep grades, unsafe conditions or actual crashes, or poor road conditions. Congestion is also affected by high vehicle volume. Existing and future travel delay, forecast to increase with higher person trip demand, results in a need to decrease congestion along the I-70 Mountain Corridor.

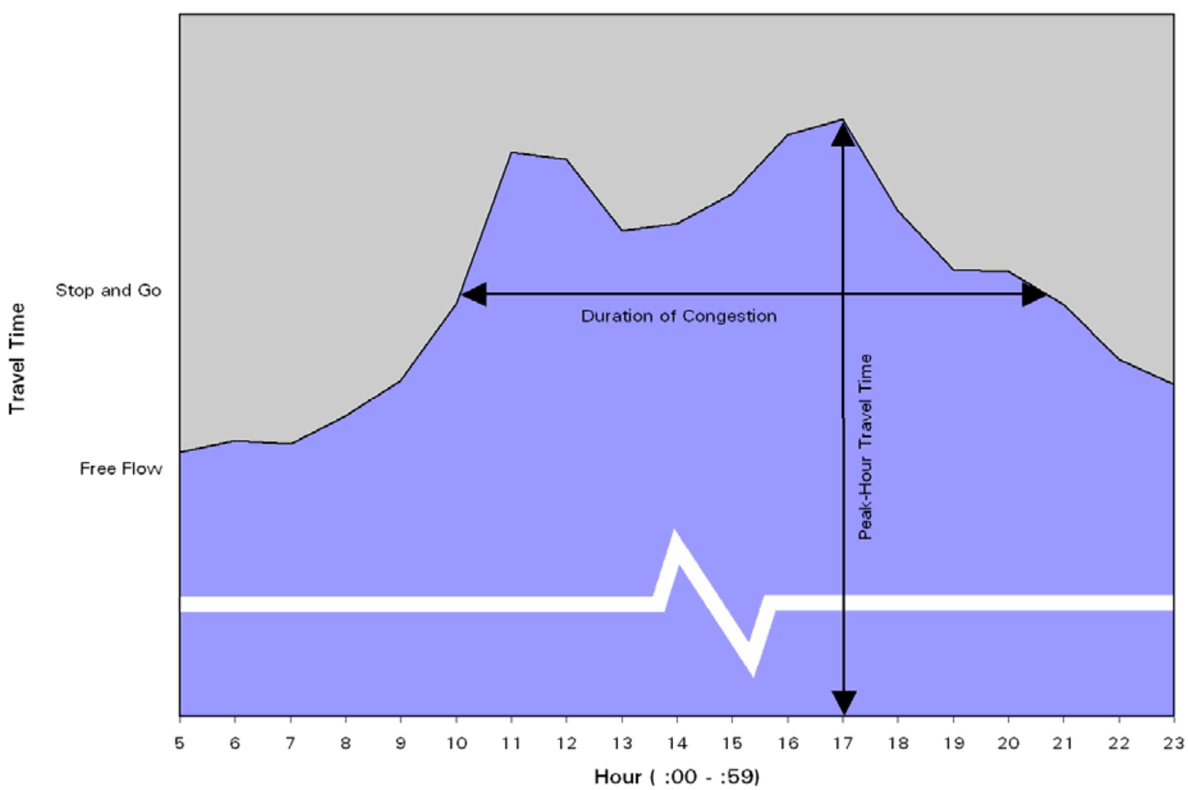
These performance measures are interrelated and provide different impressions of the overall traffic conditions in the Corridor. Peak-hour travel time was selected because it is familiar and intuitive to the public. However, peak-hour travel time does not tell the whole story of Corridor performance. The peak hour may be congested, but peak-hour travel time provides no information about congestion in the second busiest hour or other hours when many people may travel. For example, **Figure 7** shows a plot of how travel time may vary by hour of the day. In **Figure 7**, the vertical arrow to the highest point of the travel time curve indicates the peak-hour travel time. Another important consideration in the I-70 Corridor is how long it is congested or travel times are much greater than the free flow time. This measure is shown in **Figure 7** by the horizontal arrow, which is drawn at a threshold level of travel time, and called duration of congestion. (Technically, congestion is defined by density, which is the number of cars per lane mile, but relationships can be established between density and speed or travel time.)

Finally, because congestion in the I-70 Corridor is so severe that some people choose not to travel, another measure of performance is needed, which is unmet demand. Unmet demand is the number of trips desired to be made but not taken in the future because congestion then will be worse than it is today. Recall that the 2035 Baseline demand is defined as the 2035 population multiplied by the 2000 trip rates. The 2035 No Action demand is how many people would actually want to travel that year, excluding those who think the congestion is too bad. Therefore, unmet demand is the difference in demand between the Baseline demand level and the number of trips taken under the No Action Alternative.

The models described in **Section 6** of this Technical Report forecast each of these performance measures. The traffic microsimulation model forecasts include peak-hour travel time and the duration of congestion. The travel demand model working in conjunction with the traffic microsimulation model forecasts unmet demand. Establishing purpose and need is one of the applications of the models developed for the I-70 PEIS. **Chapter 1** of the PEIS and **Appendix E, I-70 Safety and Congestion Problem Areas** of this Technical Report identify the values of these performance measures.

Another model application is the evaluation of alternatives, which also uses these same three performance measures. However, note that with some high-capacity alternatives there will be induced demand—which results in more people being able to make desired trips—instead of unmet demand—where people choose not to travel. Alternatives are evaluated in **Chapter 2** of the PEIS and in the *I-70 Mountain Corridor PEIS Transportation Analysis Technical Report* (CDOT, August 2010).

Figure 7. Relationship between Peak-Hour Travel Time and Duration of Congestion



11.2 What is the 2035 unmet demand?

Table 12 shows that the 2035 two-way unmet demand ranges from none to as much as 55,000 person trips, depending on the day and location. (**Chapter 1** of the PEIS presents statistics for one-way, peak direction unmet demand.) Because more people live in the eastern part of the Corridor, there are more trips and more congestion there. Therefore, there is also more unmet demand in the eastern part of the Corridor.

At the two westernmost focal points, the No Name Tunnels and East of Eagle, there is no unmet demand in the summer on Thursdays, Saturdays, or Sundays. The most unmet demand at those two places occurs on winter Saturday, but even that unmet demand is no more than 1,300 person trips.

Winter Saturday is also the worst day—in that the most unmet demand occurs then—for the four easternmost focal points. In the middle of the Corridor—Vail Pass through the Eisenhower-Johnson Memorial Tunnels—unmet demand is worst on summer Sunday. In Dowd Canyon, unmet demand is worst on summer Thursday (16,000 trips), followed closely by summer Friday (13,000 trips). The unmet demand at the Eisenhower-Johnson Memorial Tunnels on summer Friday—11,000 trips—is almost as bad as at Dowd Canyon, although these trips do not appear to be related, since there are only 1,500 unmade trips over Vail Pass.

On winter Saturday, unmet demand is most noticeable at the four focal points east of Empire Junction. The most unmet demand of any day occurs this day East of Genesee—people do not make 55,000 trips that are desired. These four focal points also have the greatest unmet demand on summer Sunday. On summer Saturday, the most noticeable unmet demand is at Floyd Hill (31,000 trips) and East of Genesee (42,000 trips). Because there is not more unmet demand further west on summer Saturday—there are only 14,000 trips desired but not made at the Twin Tunnels—much of this unmet demand may be associated with the gaming trip purpose.

Table 12. 2035 Two-Way Unmet Demand (Person Trips) by Day and Location

Location	Winter Saturday	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday
No Name Tunnels	800	0	300	0	0
East of Eagle	1,300	0	20	0	0
Dowd Canyon	600	16,000	13,000	30	1,700
Vail Pass	1,100	1,500	1,500	1,200	6,700
West of Silverthorne	14,000	6,800	N/C	7,800	16,000
Eisenhower–Johnson Memorial Tunnels	13,000	2,900	11,000	5,800	19,000
East of Empire	44,000	3,100	N/C	12,000	29,000
Twin Tunnels	48,000	2,500	N/C	14,000	30,000
Floyd Hill	54,000	1,400	N/C	31,000	26,000
West of C-470 (East of Genesee)	55,000	1,600	N/C	42,000	25,000

Note: N/C = not calculated.

11.3 What is the 2050 travel demand?

According to the 2050 travel demand estimates, the greatest travel demand occurs on summer Sunday at all focal points except for Dowd Canyon, where the most demand occurs on summer Friday. **Table 13** has the details of the range of travel demand at the 10 focal points on the five days examined. In 2000, the most person trips—125,000 of them—were found at Genesee on a summer Sunday. (Summer Saturday saw almost as many person trips, at 123,000.) In 2050, all ten focal points exceed this number on summer Sunday. As **Table 13** shows, 177,000 to 205,000 person trips are expected at the No Name Tunnels, while 478,000 to 490,000 trips are expected East of Genesee. Further, the East of Eagle and Dowd Canyon focal points exceed 175,000 trips on each of the five days studied in 2050. This result is not unexpected considering the level of population and employment growth forecasted for Eagle and Garfield counties, which is greater than those of other counties. The larger ranges of 2050 trips in the western end of the Corridor also reflect the greater potential for growth in Eagle and Garfield counties. The six easternmost focal points—from Copper Mountain east—also exceed 175,000 trips on winter Saturday and summer Saturday.

Table 13. 2050 Travel Demand (Two-Way Person Trips)

Location	Winter Saturday	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday
No Name Tunnels	104,000 – 120,000	96,300 – 111,000	124,000 – 140,000	122,000 – 141,000	177,000 – 205,000
East of Eagle	175,000 – 201,000	176,000 – 194,000	180,000 – 197,000	214,000 – 245,000	227,000 – 258,000
Dowd Canyon	194,000 – 209,000	194,000 – 206,000	217,000 – 226,000	184,000 – 196,000	206,000 – 218,000
Vail Pass	111,000 – 117,000	114,000 – 121,000	107,000 – 112,000	143,000 – 150,000	172,000 – 178,000
West of Silverthorne	174,000 – 181,000	162,000 – 169,000	N/C	199,000 – 207,000	227,000 – 234,000
Eisenhower–Johnson Memorial Tunnels	163,000 – 166,000	117,000 – 118,000	137,000 – 139,000	178,000 – 183,000	218,000 – 224,000
East of Empire	238,000 – 244,000	126,000 – 127,000	N/C	225,000 – 231,000	274,000 – 281,000
Twin Tunnels	253,000 – 260,000	141,000 – 143,000	N/C	243,000 – 249,000	283,000 – 291,000
Floyd Hill	379,000 – 389,000	213,000 – 215,000	N/C	386,000 – 396,000	411,000 – 422,000
West of C-470 (East of Genesee)	390,000 – 398,000	231,000 – 232,000	N/C	447,000 – 457,000	478,000 – 490,000

Note: *N/C = not calculated.*

11.4 What is the 2035 travel time and how is it defined?

In the eastern part of the Corridor in 2000, it takes about an hour to go either direction between Copper Mountain and C-470 in light traffic. On summer Thursday in 2035, it takes about 160 minutes to make the westbound trip from C-470 to Copper Mountain. Particularly congested segments are C-470 to Beaver Brook—which is affected by the backup on Floyd Hill where westbound I-70 drops from three lanes to two—where speeds would average 21 mph in the peak hour, and from Silverthorne to Copper Mountain, with an average speed of 14 mph. Eastbound travel on summer Sunday takes even longer—over 3 hours from Copper Mountain to C-470. On this day, the slowest section is from Copper Mountain to Hidden Valley, which takes 45 minutes in free-flow, but about 160 minutes—not quite four times as long—in the worst of the weekend congestion.

Table 14 shows the 2035 highway travel time by 10 study segments. (In **Chapter 1** of the PEIS, times on these individual segments are added to get travel times for two portions of the Corridor, for summary purposes.) Despite the increased volumes at the No Name Tunnels, travel times remain close to free-flow through Glenwood Canyon (Glenwood Springs to the Eagle/Garfield County Line) and only increase by a minute for summer Sunday eastbound.

In light traffic in 2000, it takes about an hour to go either direction between the Eagle/Garfield County Line and Copper Mountain. On a summer Sunday in 2035, it takes about double this time to make the trip eastbound. However, summer Friday is worse, when it takes about 150 minutes to make the trip westbound. On summer Friday, the travel time from Vail East Entrance to Edwards is three times the free-flow time, and travel time from Copper Mountain over Vail Pass is four times as much as it takes in light traffic.

In the eastern part of the Corridor in 2000, it takes about an hour to go either direction between Copper Mountain and
C-470 in light traffic. On summer Thursday in 2035, it takes about 160 minutes to make the westbound trip from C-470 to Copper Mountain. Particularly congested segments are C-470 to Beaver Brook—which is affected by the backup from the Floyd Hill lane drop—where speeds would average 21 mph in the peak hour, and from Silverthorne to Copper Mountain, with an average speed of 14 mph. Eastbound travel on summer Sunday takes even longer—over three hours from Copper Mountain to C-470. On this day, the slowest section is from Copper Mountain to Hidden Valley, which takes 45 minutes in free-flow, but about 160 minutes—not quite four times as long—in the worst of the weekend congestion.

Table 14. 2035 Highway Travel Time (Minutes)

Segment	Free-Flow	Summer Thursday Westbound	Summer Friday Westbound	Summer Sunday Eastbound
Glenwood Springs to Eagle/Garfield County Line	15	N/C	15	16
Eagle/Garfield County Line to Edwards	26	N/C	35	58
Edwards to Vail East Entrance	15	N/C	48	29
Vail East Entrance to Copper Mountain	16	N/C	70	31
Copper Mountain to Silverthorne	9	43	N/C	25
Silverthorne to Loveland Pass	11	11	N/C	53
Loveland Pass to Downieville	17	38	N/C	42
Downieville to Hidden Valley	8	18	N/C	43
Hidden Valley to Beaver Brook	5	12	N/C	6
Beaver Brook to C-470	12	35	N/C	17

Note: N/C = not calculated.

11.5 What is the 2035 congestion, and how is it defined?

Table 15 shows the 2035 hours of congestion eastbound for each of the 10 focal points on each of the five days examined. (**Chapter 1** of the PEIS formally defines congestion as traffic operating at Level of Service [LOS] F.) The No Name Tunnels and Floyd Hill are not predicted to have congestion on typical days. Traffic volumes are low at the No Name Tunnels, and where I-70 goes from two to three lanes at Floyd Hill. Congestion is the worst on summer Thursday East of Eagle (two hours) and in Dowd Canyon (12 hours), when low-vehicle-occupancy Work trips predominate. The most congestion occurs on summer Saturday at Vail Pass (one hour) and East of Empire (eight hours). West of Silverthorne has zero hours of congestion on summer Sunday and four hours on summer Saturday. The Eisenhower-Johnson Memorial Tunnels has the most congestion—six hours—on summer Thursday, again because of Work trips. The Twin Tunnels experience the most congestion on summer Sunday, though the other days are almost as bad. East of Genesee, there are two hours of congestion on both winter Saturday and summer Sunday—both days when large numbers of recreation trips return to the Denver metropolitan area.

Table 15. 2035 Eastbound Congestion (Hours of LOS F)

Location	Winter Saturday	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday
No Name Tunnels	0	0	0	0	0
East of Eagle	0	2	1	0	0
Dowd Canyon	0	12	2	0	0
Vail Pass	0	0	0	1	0
West of Silverthorne	0	0	0	4	0
Eisenhower–Johnson Memorial Tunnels	0	6	N/C	2	3
East of Empire	3	5	N/C	8	3
Twin Tunnels	9	9	N/C	7	10
Floyd Hill	0	0	N/C	0	0
West of C-470 (East of Genesee)	2	0	N/C	0	2

Note: N/C = not calculated.

Table 16 shows the 2035 westbound hours of congestion for the ten focal points and five days. The No Name Tunnels and West of Silverthorne are not expected to have congestion on any day. Three lanes are provided westbound, going uphill from Silverthorne to the Frisco/SH 9 interchange. As with eastbound hours of congestion, summer Thursday is the worst day for Dowd Canyon, with 11 hours of congestion, followed closely by summer Friday (ten hours). East of Eagle also has an hour of congestion on summer Thursday. Congestion is worst on summer Saturday over Vail Pass (six hours), at the Eisenhower-Johnson Memorial Tunnels (ten hours), and East of Genesee (15 hours), largely due to day and overnight recreational trips. The Eisenhower-Johnson Memorial Tunnels and East of Genesee also see almost as much congestion on summer Thursday. Winter Saturday is tied with summer Thursday for the most congested days at the Twin Tunnels and Floyd Hill.

Table 16. 2035 Westbound Congestion (Hours of LOS F)

Location	Winter Saturday	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday
No Name Tunnels	0	0	0	0	0
East of Eagle	0	1	0	0	0
Dowd Canyon	0	11	10	0	0
Vail Pass	0	0	0	6	2
West of Silverthorne	0	0	0	0	0
Eisenhower–Johnson Memorial Tunnels	1	9	N/C	10	0
East of Empire	1	3	N/C	0	2
Twin Tunnels	2	2	N/C	1	2
Floyd Hill	4	4	N/C	3	2
West of C-470 (East of Genesee)	3	12	N/C	15	2

Note: N/C = not calculated.

Section 12. Summary and Application of Results

The travel analyses summarized within this Technical Report provided the foundation for identifying and analyzing transportation problems to aid in the establishment of the project purpose and need and the comparison of alternatives. The methods used to produce the analyses were deemed appropriate to the level of analysis required for the Tier 1 phase of the I-70 PEIS and produced reasonable and justifiable results by which the Tier 1 alternatives for the 144-mile corridor could be compared. Due to the length of the Corridor, regional measures of effectiveness were analyzed to determine the potential comparative effectiveness of proposed regional improvements (that is, the Action Alternatives).

Subsequent phases (Tier 2) of the I-70 Corridor project will use the results of these analyses as starting points for more detailed transportation analyses as specific improvement phases are identified. Analyses of specific projects will include data gathered and produced as a part of this effort and additional, more detailed modeling concerning those specific locations and improvements.

Chapter 1 of the PEIS provides information on the application of the results of the transportation analyses pertaining to the establishment of project purpose and need. **Chapter 2** of the PEIS provides information on the application of the results pertaining to the comparison of alternatives. Greater detail on the alternatives screening process can also be found in the *I-70 Mountain Corridor PEIS Alternatives Development and Screening Technical Report* (CDOT, August 2010).

The appendices provide greater detail on many of the sections within this Technical Report.

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Appendices

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Introduction to Travel Demand Model Appendices

The I-70 Mountain Corridor PEIS project began in 2000. An initial effort was the development of a travel demand model for this project's 144-mile rural Corridor. The base calibration year for the model is 2000. The model was developed with a forecast year of 2025. In 2009, after the Collaborative Effort, CDOT updated the forecasts to 2035 to reflect the current 2035 long range transportation plans. This was accomplished using the 2025 travel model as a foundation. In addition, CDOT and stakeholders agreed that a long term horizon is needed and extended the purpose and need through 2050. The 2050 travel forecasts were developed and presented in a range, reflecting the uncertainties associated with long term forecasts.

Five appendices support this *I-70 Mountain Corridor PEIS Travel Demand Technical Report*:

- **Appendix A** provides documentation of the development of the 2025 Travel Demand Forecasting Model. This appendix includes an overview of the overall forecasting methodology and forecasting tools used to prepare the forecasts. It also includes documentation of the major assumptions, calibration, and validation results of the travel demand model. The calibration of the model was performed for 2000 data. The 2000 data remains valid for model calibration as no major changes in travel behavior or transportation infrastructure have occurred since 2000. The Corridor serves the same market of users with the same I-70 infrastructure as was in place in 2000.
- **Appendix B** provides documentation of the travel survey used to develop the ridership forecasts. It describes the advantages and disadvantages of the stated preference survey approach, the survey description, survey questionnaire, summary results of market segmentation, and application for model development. The survey was conducted in 2001. Because no major changes have occurred in the Corridor infrastructure or user types in the Corridor, the data remain valid and the most current regarding traveler preferences.
- **Appendix C** describes the method for developing 2035 travel forecasts. The documentation includes a description of the need for 2035 forecasts, the major assumptions supporting the 2035 forecasts, and the results. Attachments to Appendix C describe the technical review of the process and results, the development methodology, and the process to develop 2035 forecasts for the No Action Alternative. 2035 forecasts were prepared in 2009.
- **Appendix D** describes the method for preparing 2050 travel demand forecasts. The appendix describes the data available for the year 2050, uncertainties with the forecasts, and the method used to develop the 2050 forecast. The relationship to the performance measure of Year at Network Capacity is described, along with the travel forecast results. The 2050 forecasts were prepared in 2010.
- **Appendix E** describes the safety and travel demand characteristics of the Corridor, by major segment. Information on roadway deficiencies, safety issues, and travel patterns is documented for each major segment. This detailed data support the determination of safety and congestion problem areas. The base year data for the analysis is 2000. This year provides a valid snapshot of characteristics since no major changes in infrastructure on I-70 have been implemented since 2000, and the travel market of users remains the same. The roadway deficiencies, safety issues, and travel patterns documented in 2000 remain in place today.

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Appendix A
Travel Model

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Appendix A. Travel Model

The I-70 PEIS travel model system includes models that were created in three software platforms, as follows:

Travel Demand Model in TransCAD:
Consists of databases, mathematical relationships and algorithms, which when run as a set provide forecasts of travel use in the Corridor and beyond to an area defined in the north by Wyoming, south by Pueblo, east by Denver International Airport and Greeley, and west by Utah. This model forecasts five days in 2000 (calibration days) for this scenario and five days in 2025 (forecast days) for the various project alternatives. These five days can then be extrapolated to an entire year for 2000 or 2025, and from this information, travel performance analyses can be performed for each alternative for 2000 and 2025. (Such analyses are summarized in Chapter 2 and Appendix B.)

Traffic Simulation Model in VISSIM:
Consists of highway networks that provide various information on travel performance, including travel times, speeds, and queuing. For modeling purposes, the Corridor has been split into two parts, the western portion from Glenwood Springs to the Loveland Pass interchange and the eastern portion from Silverthorne to C-470. The travel demand is obtained from TransCAD through hourly trip matrices. These matrices create traffic flow on I-70 by specifying where the trips in each hour of the day are coming from and where they are going.

Transit Operations Simulation Model in RAILSIM
Consists of databases representing rail or bus guideway geometry, and a library of vehicles with different power, weight, propulsion, acceleration, and braking characteristics. Travel time and energy consumption data are obtained by tracking these vehicle characteristics through a simulated journey from end to end of the guideway.

The appendix summarizes the model assumptions both for 2000 and 2025. This appendix is organized by topic, rather than providing a minute-by-minute description of the combined I-70 PEIS Travel Model system.

Section A.1 provides a general description of how the travel model is structured. First, the economic supply and demand theory is described in the transportation context. Then more detailed descriptions of the capabilities of the three software platforms are given. The final part of **Section A.1** describes how the three software platforms relate to each other, giving particular attention to how the data flow between the model components.

Section A.2 describes the various assumptions behind the travel model system. The discussion of assumptions and input values makes up the majority of this appendix, and many topics are addressed:

- **Section A.2.1** describes the treatment of time, from annual summaries to second-by-second operational simulations.
- **Section A.2.2** describes various aspects of the roadway infrastructure.
- **Section A.2.3** describes existing transit services in the Corridor and those introduced by various alternatives.

- **Section A.2.4** discusses the socioeconomic data from which the travel demand forecasts are made.
- **Section A.2.5** describes trip generation, the first step of the four-step process.
- **Section A.2.6** describes how trip ends are associated with Corridor attractions.
- **Section A.2.7** discusses how the travel demand model determines the choice between the highway and transit modes.
- **Section A.2.8** discusses how the travel demand model assigns trips to specific routes.
- **Section A.2.9** describes how the traffic simulation model determines roadway performance from demand matrices.
- **Section A.2.10** discusses the estimation of mobile-source airborne emissions.

Section A.3 summarizes the calibration of the I-70 travel model, that is, how well the model can predict existing travel patterns. Travel demand forecasts are compared against measurements such as traffic counts and transit boarding records. Travel times and achieved flow rates can be used to assess the traffic simulation model.

A.1 Overview of Methodology

At its simplest conceptual level, the I-70 travel model uses the economic concepts of supply and demand to predict how many people want to travel where and when, and thus to determine the congestion associated with those travel patterns. This section gives a brief overview of the methods used to estimate travel volumes and performance of the transportation network.

A.1.1 Supply and Demand Equilibrium

The I-70 travel model system may be thought of conceptually as equilibrium between transportation supply and demand, as shown in **Figure A-1**. TransCAD® calculates travel demand. Given input sets of speeds—one set representing free-flow conditions and the other the congested condition of the peak hour or period—TransCAD produces hourly matrices of person and vehicle trips. The traffic simulation model in VISSIM uses vehicle trip matrices as inputs and serves as the supply simulator. The primary output obtained from VISSIM is a set of travel times for various segments of I-70 for different hours of the day. After these travel times are converted into a form TransCAD can use (average travel times during the congested period of a day), the two programs can be used sequentially to reach convergence between supply and demand (the desired equilibrium).

Interpretation of Supply and Demand

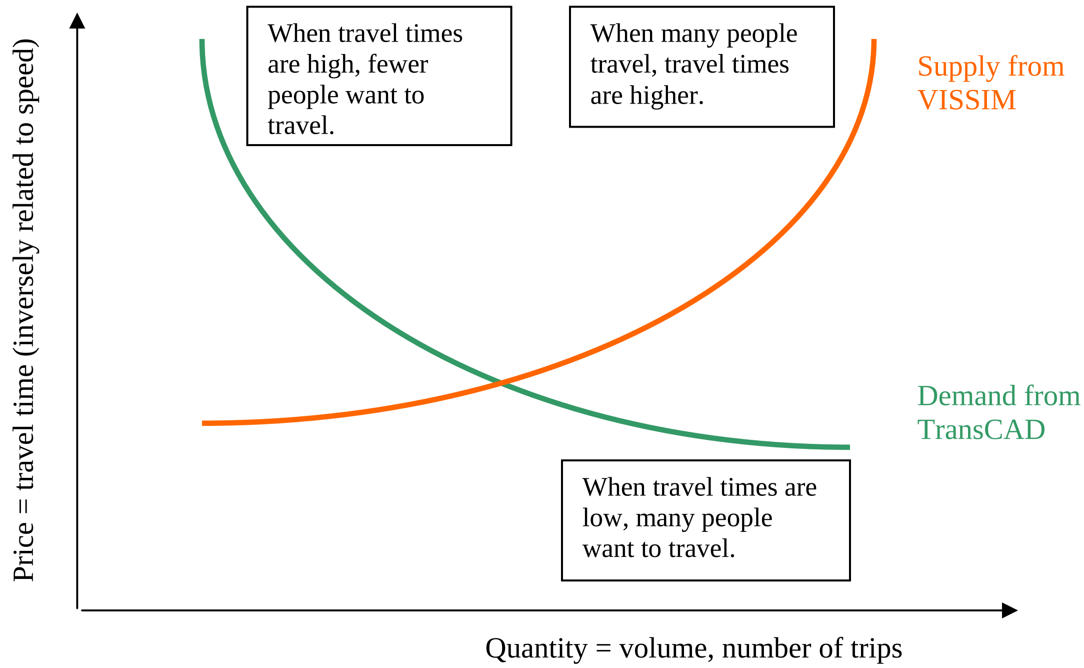
In the traditional economic context, demand is the relation showing what quantity of item consumers want to purchase at a given price. The supply relation reflects how much of that item a producer is willing to make at a given price or, alternatively, the price the producer needs to receive to recover the costs associated with producing a given quantity of an item. In the transportation context, the quantity of travel is the number of trips or perhaps the person miles traveled (PMT). The price is some measure of difficulty associated with traveling—usually the travel time required to make the trip. Distances, tolls, fares, and other costs may also make up the generalized price of travel.

As in the economic context, travel demand is a curve or relation expressing the number of trips people are likely to make when congestion is at a certain level. However, the analog of the producer is less obvious. While travel demand models predict the travel times and other conditions under a certain demand and network scenario, these models do not generally predict the decisions of transportation departments to provide additional infrastructure under various scenarios.

Transportation infrastructure has a limited capacity for movement. At low traffic levels, the facility is able to perform at roughly its free-flow speed. As traffic levels increase, travel times also increase because people get in each other's way and must negotiate right-of-way. The relationship between volume and travel times looks like a traditional supply curve in that the marginal cost of an extra unit of demand is greater than the average cost, resulting in increasing average costs with increasing travel volumes. That is, the transportation supply curve is concave upward, as shown in **Figure A-1**.

Of course, interactions on a transportation network are much more complicated than the economic model of one item in a single marketplace. Travelers desire to move from many dispersed origins and destinations. The transportation network consists of many facilities with different capacities. Travelers have different reasons or purposes for traveling, which affects their demand response. However, the economic metaphor provides a convenient way of thinking about transportation problems, which can then be generalized and given more detail using computers to track various calculations.

Figure A-1. Role of Software in Demand-Supply Equilibrium



Source: J.F. Sato and Associates

Convergence Process (Method of Successive Averages)

TransCAD and VISSIM each return one point. TransCAD returns quantity demanded given travel time. Conversely, VISSIM returns travel time given quantity demanded; therefore, the forecasting process must transfer data between the two modules until convergence in volumes and speeds is attained. This convergence represents the equilibrium point where the travel times (assumed by one module and output by the other) are consistent with the quantity of trips demanded (again, an output of one program and an input of the other).

The Method of Successive Averages (MSA) is one way to reach convergence in an iterative process, such as demand and supply equilibrium. The MSA has been proven to converge, although the convergence may be slow in certain cases. As the name suggests, the MSA works by assuming specific weights to average the variable of interest during the iterative process.

For example, if $\mathbf{y}_0$ represents the initial link travel times assumed by TransCAD, then the formula for these variables at iteration *n* is

$$\mathbf{y}_n = \frac{\mathbf{x}_n}{n+1} + \frac{n}{n+1}\mathbf{y}_{n-1}$$

where $\mathbf{x}_n$ is the solution (with elements corresponding to those of **y**) at the current iteration. That is, $\mathbf{x}_n$ is the set of travel times produced by VISSIM at iteration *n*. Note that the MSA formula indicates that the best strategy for convergence is not to take the current estimate of travel times, but to use information gained in all iterations of the solution.

Table A-1 shows a numerical example of the MSA process for a sample origin-destination (OD) pair. Because the initial guess of travel time underestimates the equilibrium travel time, in the initial loop the resulting demand overestimates the equilibrium quantity, leading to a large increase in travel time. The estimate of travel time input to TransCAD is increased in each of the next two loops, and the resulting demand decreases. At the end of loop 2, the travel time output by VISSIM is within 3 percent of the time input to TransCAD at the beginning of the loop, which is sufficiently close, so the algorithm stops. The equilibrium travel pattern in this example is, therefore, 4,200 trips taking 120 to 123 minutes each.

Table A-1. Example Applying the Method of Successive Averages

Loop	Input to TransCAD	TransCAD Output	VISSIM Output
0	y_0 = 80 min. (from DRCOG table)	D_0 = 5,000 trips	x_1 = 150 min.
1	$y_1 = ½\ y_0 + ½\ x_1$ = 115 min.	D_1 = 4,500 trips $< D_0$	x_2 = 130 min.
2	$y_2 = 2/3\ y_1 + 1/3\ x_2$ = 120 min.	D_2 = 4,200 trips $< D_1$	x_3 = 123 min. (Stop)

Note that with some manipulation, it can be seen that $\mathbf{y}_n$ is the simple average of $\mathbf{x}_n$ through $\mathbf{x}_1$ and $\mathbf{y}_0$. For example, for loop 2 in **Table A-1**,

$y_2 = 2/3\ y_1 + 1/3\ x_2 = 2/3\ [\ ½\ y_0 + ½\ x_1\ ] + 1/3\ x_2 = 1/3\ y_0 + 1/3\ x_1 + 1/3\ x_2$

A.1.2 The Demand Simulator: TransCAD®

Forecasts of various aspects of travel demand are made using TransCAD, a Geographic Information System and Transportation Planning (GIS-T) application. That is, TransCAD integrates specialized transportation models within the spatial representation context of GIS.

In 1999, the five Metropolitan Planning Organizations (MPOs), the Regional Transportation District (RTD), and an observer from The Colorado Department of Transportation's (CDOT's) Division of Transportation Development (DTD) met as the Colorado Model Users' Group to examine the latest developments in transportation modeling software. The Denver Regional Council of Governments (DRCOG) was the first to adopt TransCAD and is in the process of converting its regional modeling system to this platform. RTD and three of the MPOs, which often receive technical assistance from DRCOG, followed suit. DTD has also acquired a TransCAD license to review modeling efforts throughout the state.

TransCAD also includes a powerful scripting language that makes it possible to automate the I-70 travel demand model (the macro) and to convert data to formats more useful for display or input to other programs.

GIS Context

As a GIS application, TransCAD shares many features with other familiar GIS packages, such as ArcInfo™ and ArcView®. One important feature of a GIS is the ability to use latitude and longitude to accurately show physical features. GIS packages also share similar methods for storing data:

- Points or nodes represent single locations, such as intersections, park-and-ride facilities, and transit stops.
- Links or poly-lines connect a pair of points and may have intermediate shape points that provide additional detail without having to significantly increase the number of entities or records used to represent a particular feature. Links may represent sections of roadways, sidewalks, ways, rivers, and streams.
- Areas or polygons are two-dimensional features described by poly-line boundaries. Common features represented by areas include states and counties, city limits, census blocks, and zip codes. Transportation analysis zones (TAZs) are developed from these other types of areas for travel demand modeling purposes. Each area has a centroid, a representative point generally used to display certain attributes of the area.

However, TransCAD extends this representation system to include other entities that better reflect certain aspects unique to transportation planning:

- A route consists of an ordered series of links and optionally a set of points. This entity is useful for representing transit service, including stops and stations. A route can be used in a linear referencing system, where certain values (for example, passengers on board or pavement quality) can be related to their distance from the beginning of the route.
- A matrix can store two dimensionally oriented items, such as the number of trips or the travel time between pairs of zones.
- A highway or transit network is a special representation of a set of links that allows certain transportation problems (for example, finding the shortest path) to be solved very efficiently.

Numerical data in several formats can be associated with any above entity type. Different geographic features can also be overlaid to answer various questions, such as finding the sum of a point attribute contained in a particular area or finding what percentage of an area is within a certain distance of a route.

The Four-Step Process

The I-70 travel demand model forecasts highway and transit segment travel demand through an adaptation of the four-step process, the state-of-the-practice procedure for modeling travel demand in metropolitan regions. This type of model is increasingly being used for statewide demand modeling, especially in areas of complex travel demand, such as where there are multiple recreational trip purposes.

This process consists of four principal steps: (1) trip generation, (2) trip distribution, (3) mode split, and (4) highway and transit assignment.

1. Trip generation calculates the number of trips that go into and out of a set of small areas represented by TAZs based on socioeconomic zone information from a database. This information includes TAZ population, members’ households, employment, and various recreation trips.
2. Trips from one TAZ to another are then calculated in the trip distribution model. That is, trip ends forecast in the trip generation step are used with estimates of travel time between zone pairs to come up with an origin-destination set of trips.
3. In the mode split model, the number of trips from TAZ to TAZ are calculated by mode, either highway or one of several transit modes. Specifically, travel times and other factors are used to

calculate mode shares. The number of trips by a particular mode is determined by multiplying the total number of trips by the appropriate mode share.

4. Knowing the number of trips from one TAZ to another, in highway and transit assignment, the model determines which highway routes are used and which transit routes are used for each modal interchange. If the selected routes are then overly congested, the model can reduce the expected speed on the highway routes and then recalculate all of the model values to adjust the number of trips in and out of each TAZ, their distribution to other areas, their modes, and any potential new routes. The model can continue to do this until all parts of the model are using nearly the same values for travel time between small areas (the convergence criteria).

Specialized routines within TransCAD support each model step. The macro controls the order of executing these specialized routines and ensures that the correct input parameters are specified. Embedded in these model calculations are a set of assumptions concerning how the transit and highway networks are represented, the socioeconomic data by small area, how far people are willing to travel to other areas, the propensity to use transit, the propensity to drive compared to traveling as an automobile passenger, the choice of when to leave and arrive at each area, the choice of which day to make the trip, and the choice of season in which to make the trip. Other assumptions involve whether a new transit or improved highway system providing better service than today, leads to encouraging more trips in the future. Similarly, if traffic is worse in the future, the model also incorporates assumptions about the impact on growth in important socioeconomic variables, such as population and day skiers visiting the mountain resorts, and reduced trip rates.

A.1.3 The Highway Operations Simulator: VISSIM

VISSIM simulates traffic flow by moving “driver-vehicle-units” through a network. Various parameters and variables are used to match the performance of the model with the observed conditions in the study corridor. These parameters and variables can be grouped into the following categories:

- Physical characteristics of the I-70 VISSIM model
- Traffic compositions
- Vehicle performance characteristics
- Driving behavior parameters
- Simulation parameters

Appropriate sections of this appendix discuss these categories in more detail.

A.1.4 The Transit Operations Simulator: RAILSIM®

The RAILSIM 7 Train Performance Calculator (TPC) was used to model train performance of the four modal alternatives remaining after Level 3 screening to calculate travel time and energy consumption (the Rail with IMC alternative included both the main segment from Jefferson to Vail and the IMC from Vail to Eagle County Airport). This particular TPC has gained recognition within the industry as one of the most comprehensive simulators used today as a planning and costing tool.

During Level 2 screening, the 4 percent and 6 percent alignments were eliminated because of costs and conflicts with local land uses associated with long tunnels outside the I-70 right-of-way. During Level 3 screening, the only alignment tested was the Highway alignment, and the grades and curves of the existing I-70 roadway were input using the TPC’s Database Editor. The alignment was extended to the Eagle County Airport on the I-70 alignment for the Advanced Guideway System (AGS) and over the Intermountain Connector alignment for IMC. The TPC was used as a planning tool to perform the following tasks:

- Develop trip time predictions for the exclusive rail and bus guideway alignments (required to calculate operating costs and fleet size requirement analyses, a key part of capital costs)
- Predict energy consumption (kilowatt-hour (kWh) for electrical-powered trains and gallons for diesel-powered buses; kWh was also an input for sizing the electrical distribution system)

In summary, the TPC was used to generate detailed and highly accurate performance characteristics of trains and buses operating over a specified alignment. The performance data include time, distance, velocity, and acceleration on grades among the many types of output.

The TPC Report Generator function summarizes performance from the raw output files (numerous data points are recorded each second of the simulated run, typically one to two hours long). Text-based Train Summary Reports have been produced for each run. The report provides an overview of the selected TPC run(s), by station. It includes a header identifying the report and the geographic limits of the run; all option and parameter settings; station arrival and departure or pass times (for express runs) based on cumulative running time from the beginning of the run; and distance operated, average velocity (with and without station stops), peak power demand, and energy consumption for the End to End run. The TPC can also produce user-specified graphic plot reports.

RAILSIM 7 has an extensive library of rail equipment: 344 North American locomotives, 128 North American coaches, 64 North American multiple unit cars, 220 North American transit vehicles, 292 World Wide multiple unit cars, and 412 World Wide transit vehicles. With this roster to choose from, it was possible to select the best type of equipment available as a starting point for creation of custom-built train sets using the capability of the TPC to build user-defined rolling stock to meet the specific needs of the Corridor, most notably the grades up to 7 percent. AGS vehicles were defined as custom TPC rolling stock types, with specifications from the Colorado Maglev Project.

The terminals and stop patterns set in the TPC runs were those established as part of the overall study and refined in the development of the operating plan. See the operations descriptions in section 2.2 for the route structure used in the TPC runs. Appendix E provides details of the final operations plan.

A.1.5 Data Transfer Between Demand and Supply Simulators

A series of assumptions are made when translating the traffic volumes and travel times (or speeds) between the two modeling platforms (TransCAD and VISSIM). The goal is to simulate traffic second by second for the Corridor, accounting for the desires of the travelers, the attitudes of the drivers, the capabilities of the vehicles, and the congestion levels of the roadways.

Differences in Geographic Scope

Because TransCAD and VISSIM use different methods to examine transportation questions, they have different computational requirements. TransCAD is static and macroscopic; that is, it looks at aggregate flows. VISSIM is dynamic and microscopic; it looks at each vehicle individually. RAILSIM is also microscopic, and considers a single train or bus run.

It is difficult to make a model system work if, for example, TransCAD runs in 5 minutes but VISSIM takes two days or vice versa. Therefore, the problem size presented to each package is adjusted to obtain a better balance of computing time between the two software packages. Specifically, the geographic area examined by each program is different.

- TransCAD examines Utah to the Front Range, Wyoming to US 50; and major roads.
- VISSIM examines I-70, ramps, and intersecting roadways in two networks: (1) Glenwood Springs to Loveland Pass and (2) Silverthorne to C-470.
- RAILSIM examines an exclusive rail or bus transit guideway.

TransCAD performs a subarea assignment to generate compatible data for VISSIM. That is, an area layer is used to define the extents modeled by VISSIM. During the highway assignment procedure, TransCAD tracks the number of trips originating or terminating within the subarea, as well as the number of trips crossing the subarea boundary. This procedure produces trip matrices where the origins and destinations are defined in terms of the boundaries of the VISSIM networks instead of the TAZ centroids used by TransCAD.

Traffic was simulated in two areas, as shown above, called the Eastern Subarea and Western Subarea. A cordon line was drawn around each area that includes I-70 and its interchanges but cuts each access road to each interchange just to the north or south of each interchange. The cordon line matches the limits of each VISSIM network. At all points where the cordon line crosses a road, including I-70, a parking lot in VISSIM is used to feed traffic into or take it out of the network. Two general types of parking lots are used in VISSIM, "real parking lots" and "abstract zone connectors". The I-70 PEIS Traffic Simulation Model does not include any "real parking lots"; therefore, whenever the term parking lot is used, it refers to "abstract zone connectors." There are 29 such parking lots in the eastern network and 34 in the western one.

Overall travel desires are specified in the TransCAD model. During subarea assignment, TransCAD creates new trip tables for each period that indicates the number of trips between each pair of parking lots. A cordon line is drawn around I-70 between Glenwood Springs and C-470 to include each interchange but no parallel facilities (such as the frontage road or US 6). The TransCAD assignment for each of the four periods tracks the volume that crosses the cordon line. The resulting distribution that uses each interchange is assumed to be reasonable in relation to capacity unless a particular set of interchanges happens to be consistently over or under capacity. For example, this situation occurs at the set of interchanges between Dowd Junction and Edwards, and OD volumes are adjusted manually to give a better balance between these interchanges and Avon, Post Boulevard, and Eagle-Vail. These vehicle tables are later converted to hourly tables for traffic operations simulation.

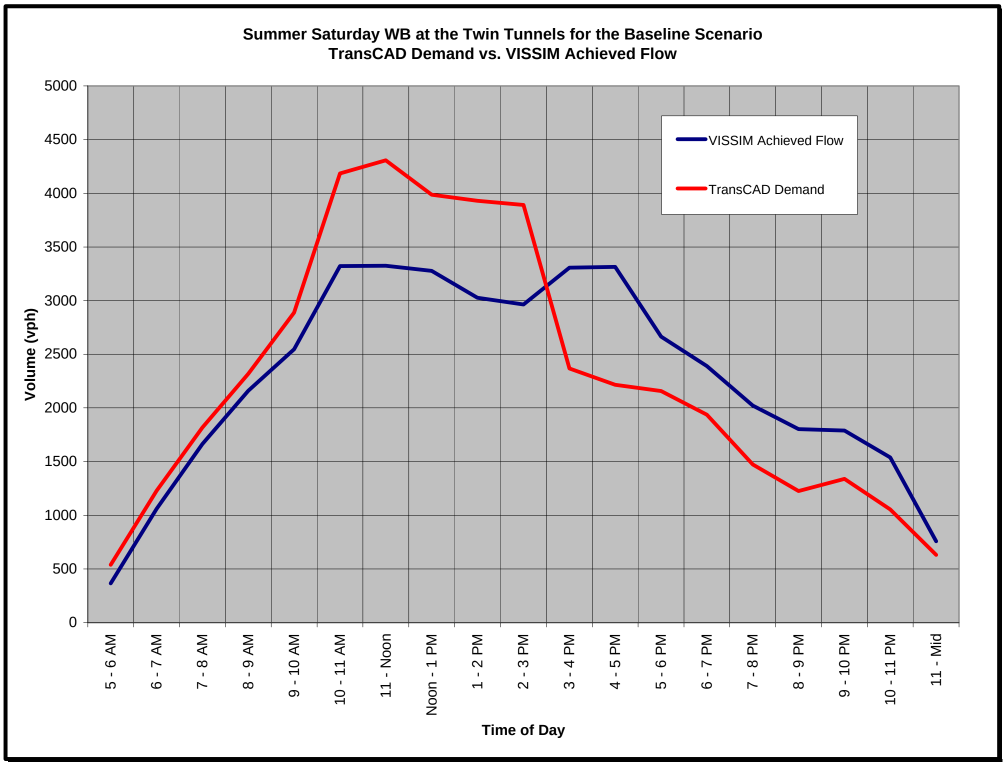
Differences in Variables and Treatment of Time

TransCAD uses a static treatment of time. The analyst is free to choose the time period to be evaluated—15 minutes, an hour, a day, a week, or any other duration. Variables, such as trip matrices (volumes) and capacities, are then defined in terms of this analysis interval. Attributes, such as link travel times, are assumed to be constant throughout the duration of the analysis interval because they are represented by a single database entry.

TransCAD uses a fluid-flow analogy for travel demand in networks. Link volumes are analogous to pressure in a pipe. Because only one analysis period is considered, any vehicle is essentially everywhere along its path at once. Further, capacity is treated as a link property rather than a hard constraint. That is, volume/capacity ratios greater than one are possible (if not common) with no obvious physical interpretation.

In contrast, VISSIM offers dynamic simulation. That is, time is explicitly considered and the attributes (such as position and speed) of each vehicle are recalculated during each simulated time step. This more detailed treatment of time allows VISSIM to reflect certain traffic phenomena, such as queues and shock waves. **Chart A-1** illustrates this difference between the two software platforms. The red line indicates the desired demand profile from TransCAD. When the hourly demand starts to exceed the capacity (around 10 AM), a queue starts to form in VISSIM. In later hours, the achieved flow exceeds the demand as the queue dissipates.

Chart A-1. Comparison of Desired Demand Predicted by TransCAD and Achieved Flow Predicted by VISSIM



The TransCAD demand model assumes four modeling periods per day, which range from 4 to 11 hours in length. Because VISSIM has the capability to calculate travel times for each simulated vehicle, these times must be aggregated in a way that is meaningful to TransCAD. That is, the aggregated time should be representative of the whole period. The choice of a simple average, the maximum, or a particular percentile of travel time is not obvious.

TransCAD uses free-flow speed for the noon and night periods during the winter model runs and only the night period during the summer. The other periods use congested time, which is calculated as the weighted average of the average hourly travel time weighted by hourly volume for the congested periods of the day, as reported in VISSIM.

Travel times are recalculated for each loop of the model run and introduced to TransCAD manually.

A.2 Assumptions

This section provides a much more detailed examination of the modeling steps and describes various assumptions used by various components of the forecasting process.

A.2.1 Treatment of Time

Chart A-2 shows a plot of two-way vehicle volumes recorded during 2000 at the Eisenhower-Johnson Memorial Tunnels. Note that the curve shows a complex pattern of a few larger seasonal peaks, with smaller spikes repeating at regular weekly intervals. This plot reflects some of the temporal patterns of travel in the Corridor.

Seasonal Patterns

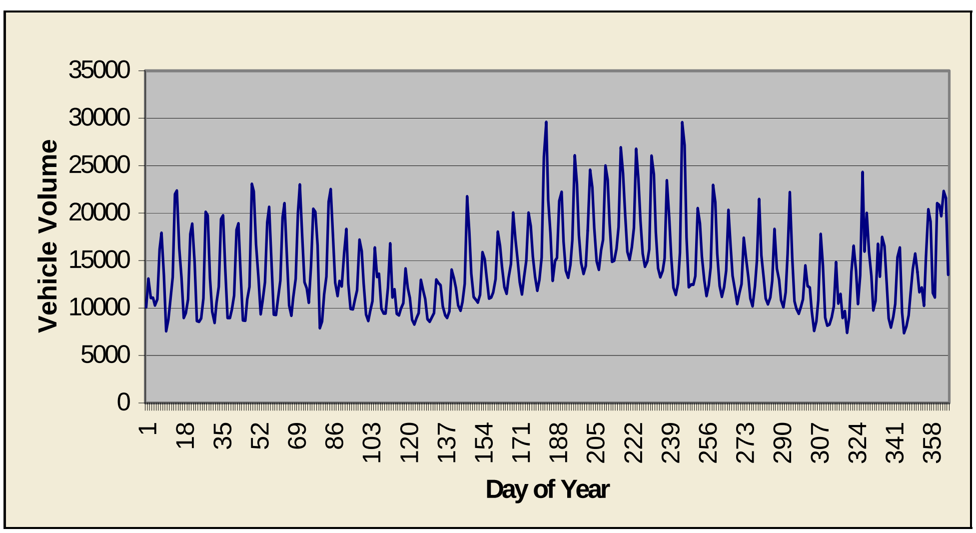
The model uses different trips for winter and summer. Trips in the winter focus on winter recreation between Thanksgiving and mid-April (when the US Forest Service requires that most resorts close their lifts). The two highest peaks in **Chart A-2** are at the limits of the peak summer season, July 4 (around day 181) and Labor Day weekend (around day 241).

Summer outdoor recreation cannot take place until snow melts from the camping areas and hiking trails, which does not usually occur until mid to late June. The off-season between the end of the winter peak recreation season and the beginning of the summer peak recreation season is often referred to as the "mud" season. Because fewer people are willing to travel to the mountains during the mud season, mountain communities usually do not sponsor festivals and sporting events until July.

With children returning to school in late August, the number of outdoor trips and sightseeing trips in the last two weeks of August is diminished. As shown in **Chart A-2**, these trends are reflected in the traffic counted at Eisenhower-Johnson Memorial Tunnels. Fall color viewing creates a substantial volume for the last two weekends in September. However, there is another general reduction in volumes between the end of the summer peak recreation season (in late August) and the beginning of the peak winter recreation season (usually late November, when most ski resorts have opened). This off-season during autumn months is commonly called the "hunting" season. For travel model purposes, the mud and hunting seasons are captured by a single set of model days.

Seasonal characteristics are related to weather and recreational market preferences, not traffic congestion. The study does not expect increased use of the mountains in early June or October for the purpose of avoiding traffic congestion in July or August. Note that the number of weekends in the summer then is considerably less than in the winter: about 20 weekends in the winter and 10 weekends in the summer. Another 10 weekends in the summer in late May, June, early September (after Labor Day but before the aspens turn gold), and early October are considerably lower than the highest summer weekends, but higher than other low-demand weekends in late April, October, and most of November before the ski season starts at Thanksgiving.

Chart A-2. Westbound Traffic Volume by Day of Year at Eisenhower-Johnson Memorial Tunnels for 2000



Source: CDOT.

The low values (weekdays) in **Chart A-2** are noteworthy. Winter volumes on the weekdays are about the same as in the spring and fall, meaning there are few extra vacationing vehicles driving in the Corridor in the winter. In the summer, however, extra vehicles are sightseeing or otherwise traveling on the weekdays. The average difference in vehicles between weekdays and weekends is about 10,000 for the entire year. During the winter season and non-holiday weeks in the summer, the difference is about 11,000, whereas for the off-season periods the average difference is about 8,000. These relationships have been used in future projections for annual traffic in 2025.

Weekly Patterns

Within each week, during all parts of the year, the (extended) weekend days always have the highest volumes. A weekly pattern of travel is not surprising considering the patterns by which people organize their lives. Many full-time employees have a Monday through Friday work schedule. Weekends are often reserved for activities, such as recreation, socializing, running errands, and attending religious services.

To capture these weekly patterns, the I-70 travel demand model can consider several different days of the week as listed below:

- A Thursday represents a typical workday.
- Friday is the transition between the workweek and the weekend; some residents may begin weekend travel Friday night to allow more time for activities later.
- Saturday travelers may be day recreation seekers or people beginning a two-day trip. A fraction of employees, particularly in the service industry, may work on weekends.
- Sunday travel includes work and recreation trips, and Front Range residents returning home to begin the new workweek.

Many model parameters may be varied by the day of the week or the forecast year. For example, trip generation rates reflect the different propensities to travel for certain trips on certain days. Time-of-day factors capture relationships, such as departing for a weekend trip on Friday night or Saturday morning and returning Sunday evening. Transit operators may vary headways on weekdays and weekends to respond to different trip patterns. Certain other human behaviors do not change, such as maximizing the amount of daylight time available for recreation. More trucks travel on weekdays, which affects highway capacities.

In calculating the number of trips for recreation purposes, the travel demand model uses the Saturday of each season as a base day. The other days, Thursday, Friday, and Sunday, are factored from this base day. These relationships between days are some of the trip generation factors shown in **Table A-63**. For example, winter Thursday Front Range Day Recreation trips are 13 percent of the winter Saturday Front Range Day Recreation trips

Daily Patterns

Just as people construct weekly rhythms to their lives, daily schedules affect travel patterns. Certain employees have fixed work shifts. Many people prefer to conduct their activities between sunrise and sunset. The night may be too cold or too dark to participate in specific outdoor activities. Longer daylight hours during summer give people a wider choice of time for activities.

Four Periods Within the Day

To accurately model traffic phenomena, such as queue formation, estimates of daily trips must first be converted into hourly OD tables, which are then used for traffic simulation. The travel demand model achieves this with two modules: First, daily trips are converted to four period trip tables: morning (AM), noon (NN), afternoon (PM), and night (NT). Later, period trip tables are converted to hourly trip tables.

The four periods are defined as follows:

- The AM peak period is from 6:00 AM to 9:59 AM
- The Midday or Noon period is from 10:00 AM to 2:59 PM
- The PM peak period is from 3:00 PM to 6:59 PM
- The Night period is from 7:00 PM to 5:59 AM the next day

Sometimes (as when developing transit operating plans or schedules) the Night period is further divided into an Evening period from 7:00 PM to 12:59 AM, and an *Owl* period from 1:00 AM to 5:59 AM.

Up to this point the travel demand model uses daily production-attraction (PA) tables. This type of table lists trips from their original to activity location without respect to direction. For example, a trip from home to work and then back to home (two trips) is listed in the table as two trips from home to work. Similarly, an out-of-state visitor making a trip from hotel to lifts and returning to the hotel in the evening is recorded as two Corridor Day Recreation trips from hotel to lifts. This convention is useful for estimating trip generation rates; productions are only a function of household or other characteristics, while attractions may be functions of other socioeconomic variables related to activities taking place there. However, trips must be converted to a directional origin-destination (OD) basis before examining the effects of congestion.

This time-of-day module also allows automobile occupancy factors (to convert from the person trips of trip generation to the vehicle volumes needed for traffic modeling) to be applied.

The time-of-day module requires a table of percentages of daily trips that depart (that is, travel in the production-to-attraction direction) and return (attraction-to-production) during each period. This table can also account for day-of-week flow patterns. For example, more traffic is expected to go west on Thursday, Friday, and Saturday as Front Range residents go to the mountains for weekend recreation, and that more traffic goes east on Sunday. **Table A-2** shows these percentages, the amount of travel starting in each of the four periods.

The period trip tables are actually created from two sets of daily trip tables, one based on peak period travel times and another based on free-flow travel times. The OD distribution of trips is expected to be different in peak and off-peak periods because congestion levels and travel times are different during these periods. That is, during peak periods, more shorter distance trips are expected because travelers are unlikely to spend any more time for a particular trip during the peak period than off-peak. **Section A.2.6** discusses trip distribution.

Figure A-2 shows how a model day set of period trip tables is created. In winter, the AM peak and PM peak period tables are created from a daily trip table that used peak period travel times in trip distribution. The Midday and Night period trip tables are created from the table distributed according to free-flow times. However, during the summer, peak volume periods last for a larger fraction of the day. Accordingly, the AM peak, midday, and PM peak period trip tables for a summer model day are derived from the daily table distributed using peak period travel times. The Night period trip table derives from the daily trip table distributed with free-flow times.

Traffic assignment is also conducted for each time period. Note that because the traffic simulation models in VISSIM uses a finer representation of time and vehicles than TransCAD, it must consider a smaller-scale network to meet memory and processing time requirements.

Periods to Hours

The I-70 travel demand model uses a technique known as *speed balancing* or *feedback* to ensure that the travel times assumed for trip distribution are consistent with those predicted by the automobile path choice and traffic performance modules. If the assumed speed is not sufficiently close to the predicted speed, a feedback loop is performed, using the new speeds as the inputs to trip distribution and successive forecasting steps.

A model module spreads the volume in highest hour to other hours in the period based on congestion levels, transit use, and the presence of truck traffic. The peak spreading model calculates the volume at the highest hour as a fraction of period volume for each of the AM peak, midday, and PM peak periods. For the Night period, the distribution among hours is assumed to remain the same. This means that if 7:00 to 8:00 PM has 22.5 percent of the evening period volume for 2000, it has 22.5 percent of the period volume in 2025 regardless of alternative or congestion level.

Hourly ramp counts for several days in each peak season were obtained at most interchanges in the Corridor. The hourly distribution of traffic on each ramp is generally assumed to remain the same for 2025. Trips from each "parking lot" (where traffic is fed into and out of the VISSIM network) are factored by direction using these ramp count values. However, for a few locations where the volume of travel or the mixture of trip purposes changes substantially (for example, the Hidden Valley interchange after the opening of the Central City Parkway), different hourly ramp fractions are specified for 2025 than 2000. Adjustments to the ramp profiles for 2025 were also made so that the resulting 2025 Baseline hourly distribution of trips plots as a smooth curve, without noticeable jumps between the four periods. These same factors were then applied to the 2025 alternatives.

When the traffic levels reach the roadway capacity, that is, the level of service (LOS) reaches F, stop-and-go traffic and queuing is expected. Queues build up as the incoming volume from areas with higher capacity flows into the congested area. VISSIM models these traffic disturbances and reflects them in the travel times.

For example, on the summer Sunday model day, eastbound peak hour achieved flows from Eisenhower-Johnson Memorial Tunnels reach a maximum of about 2,700 vehicles per hour (vph), which is the capacity. When demand levels exceed this level, a queue starts to build there. There is a net increase of traffic (hourly on–ramp traffic is greater than off–ramp traffic) at the Loveland Pass and Georgetown interchanges. When these flows combine with about 800 to 1,000 vph coming from Berthoud Pass, the 3,700-vph capacity of this highway section is exceeded. Traffic backs up, with queues extending west of Silver Plume on some days of the year. For a queue to start to dissipate, incoming demand must be less than the capacity at a bottleneck. That is, traffic near the bottleneck has to exit the front of the queue, and fewer vehicles enter the queue to replace them.

Although VISSIM is capable of modeling transit and highway vehicles together, for this study, only the flow of vehicles on highway networks is modeled. It is critical to model highway and transit systems together when there is interaction between the two systems, such as with the light rail system and streets in Downtown Denver. In this study, the only alternatives where transit and highway vehicles interact are Minimal Action and portions of the Bus in Guideway alternatives where the buses continue in mixed traffic. In these instances, the transit vehicles represent a very small percentage of the overall traffic stream, and it is sufficiently accurate to group them with the other heavy vehicles for highway capacity purposes. To assess the impact of transit systems on traffic operations, the travel demand model accounts for the impact of the transit systems by taking highway trips out of the demand matrices before they are run in VISSIM.

Congestion on transit vehicles is not projected to be an issue in the I-70 Corridor. For example, because a policy decision is made to provide each passenger a seat, there are no standees to interfere with the movements of boarding and alighting passengers at stations. Dwell times at stations are unlikely to be affected by the number of passengers boarding or alighting because the doors are likely remain open sufficiently long for passengers to collect luggage and for the transit vehicles to maintain schedule reliability.

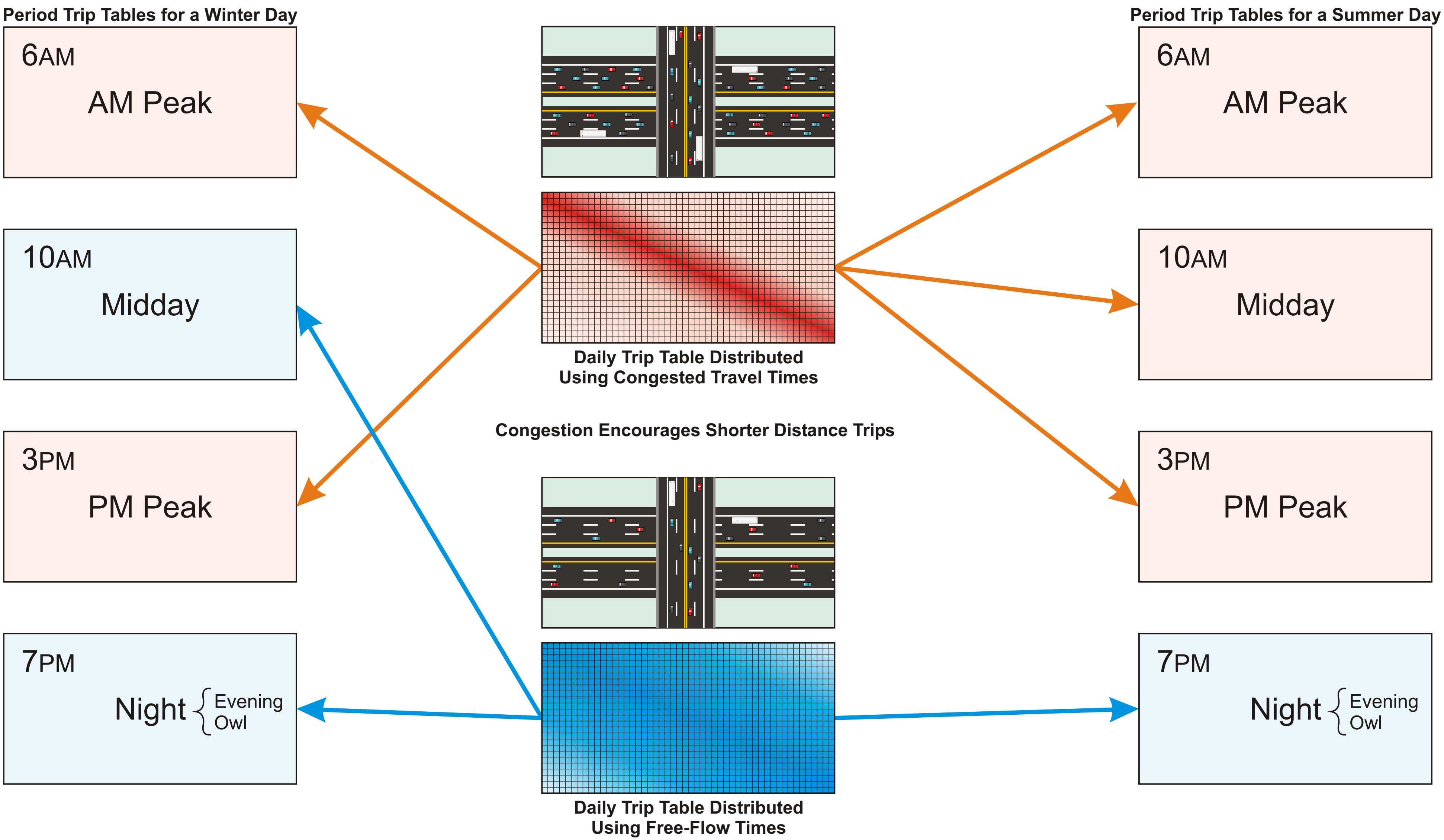


Figure A-2. Development of Period Trip Tables from Speeds and Daily Travel

Table A-2. Time of Day Percentages by Trip Purpose

		Work		Home-Based Other		Non-Home Based		Gaming		Front Range Day Recreation; Stay at Hotel, Resort, or Forest; Resort to Resort; Out-of-State Air; and RV		Stay Visiting Friends and Family; and Stay at Second Home		Out-of-State Automobile		Truck	
Season-Day	Period Name	From Home	From Work	From Home	From Store	From Activity	To Activity	From Home	From Gaming	From Home	From Rec.	From Home	From Rec.	From Home	From Activity	To Delivery or from Depot	From Delivery or to Depot
Summer Thursday	AM Peak	16.7	9.8	10.7	9.5	7.1	7.1	1.4	1.8	8.7	1.0	6.2	4.4	11.9	6.9	2.5	2.5
	Midday	14.7	14.7	26.7	14.9	18.4	18.4	16.7	5.3	30.7	17.3	26.5	7.1	22.9	21.8	12.4	12.4
	PM Peak	11.8	14.7	16.0	12.6	18.4	18.4	20.4	10.4	16.3	15.4	31.0	7.1	15.8	14.8	10.7	10.7
	Night	7.8	9.8	4.3	5.3	6.1	6.1	14.3	29.7	1.9	8.7	13.3	4.4	1.0	4.9	24.4	24.4
Summer Friday	AM Peak	16.4	9.6	10.8	9.6	7.1	7.1	1.3	1.7	12.9	1.1	2.1	2.4	11.9	6.9	2.5	2.5
	Midday	14.4	14.4	21.6	16.1	18.4	18.4	15.8	5.0	34.2	19.3	12.8	13.7	22.9	21.8	12.4	12.4
	PM Peak	11.5	16.4	16.1	16.1	18.4	18.4	21.0	9.8	8.6	16.1	41.1	2.1	15.8	14.8	10.7	10.7
	Night	7.7	9.6	4.3	5.4	6.1	6.1	13.5	31.9	2.1	5.7	22.8	3.0	1.0	4.9	24.4	24.4
Summer Saturday	AM Peak	6.2	6.2	13.0	12.0	11.4	11.4	6.8	1.0	21.2	4.2	19.4	4.7	10.0	10.0	5.2	5.2
	Midday	24.7	6.2	17.0	13.0	13.1	13.1	13.1	10.0	28.0	15.3	27.8	10.9	15.0	15.0	18.8	18.8
	PM Peak	7.4	12.3	15.0	15.0	15.3	15.3	14.3	14.0	4.2	14.4	17.8	7.0	15.0	15.0	10.4	10.4
	Night	18.5	18.5	7.0	8.0	10.2	10.2	15.7	25.1	4.2	8.5	6.2	6.2	10.0	10.0	15.6	15.6
Summer Sunday	AM Peak	2.7	6.8	11.1	5.6	8.8	8.8	**3.0**	**1.0**	7.6	3.8	1.8	3.5	8.9	7.9	9.9	9.9
	Midday	21.6	5.4	17.8	6.7	11.9	11.9	**12.0**	**5.0**	16.1	19.0	7.6	39.5	15.8	10.9	14.6	14.6
	PM Peak	9.5	27.0	11.1	18.8	16.8	16.8	**12.0**	**14.0**	6.6	28.4	7.6	25.3	9.9	15.0	11.6	11.6

		Work		Home-Based Other		Non-Home Based		Gaming		Front Range Day Recreation; Stay at Hotel, Resort, or Forest; Resort to Resort; Out-of-State Air; and RV		Stay Visiting Friends and Family; and Stay at Second Home		Out-of-State Automobile		Truck	
Season-Day	Period Name	From Home	From Work	From Home	From Store	From Activity	To Activity	From Home	From Gaming	From Home	From Rec.	From Home	From Rec.	From Home	From Activity	To Delivery or from Depot	From Delivery or to Depot
	Night	10.8	16.2	12.2	16.7	12.5	12.5	**23.0**	**30.0**	4.3	14.2	2.5	12.2	15.8	15.8	14.6	14.6
Winter Saturday	AM Peak	20.9	5.2	19.4	11.7	12.0	12.0	6.9	2.0	40.0	3.2	43.2	4.0	19.1	9.5	5.0	5.0
	Midday	8.3	16.7	16.9	13.0	13.7	13.7	19.6	5.9	11.2	10.4	14.4	4.6	14.3	14.3	20.0	20.0
	PM Peak	12.5	13.5	13.0	15.6	13.6	13.6	14.7	14.7	6.4	20.8	10.3	13.8	9.5	14.3	10.0	10.0
	Night	10.4	12.5	3.9	6.5	10.9	10.9	9.8	26.4	2.4	5.6	5.7	4.0	9.5	9.5	15.0	15.0

Note: The percentages for the four periods and two directions of each purpose and model day sum to 100 percent. For example, for summer Sunday gaming trips (shown in **bold***), 3 + 12 + 12 + 23 + 1 + 5 + 14 + 30 = 100 percent. See Section A.2.5 and the Trip Matrix Transformation section forr further discussion.*

A.2.2 Highway System

General Representation

Travel Demand Model

The TransCAD highway line layer represents the highway system. The line layer is a composite of the existing 2000 network, additional committed roadways, and all of the alternatives for the I-70 PEIS and the Gaming Area Access EIS. From this composite network, particular roads are selected that make up each specific alternative. The 2000 network was built from two previous networks developed for the Denver Region and the Roaring Fork Valley; the two networks were joined using a Census Bureau 1995 Topologically Integrated Geographic Encoding and Referencing system (TIGER) file. The line layer is associated with a database that lists all highway segments in the travel demand model with the attributes of each segment, including endpoints, direction of flow, speed by period, capacity, and various highway assignment results.

All of the alternatives in the PEIS are evaluated with a common highway network that includes existing projects (as of January 1, 2004) plus committed projects. The committed projects that are not yet built include the following:

- Silver Dollar Metro District (SDMD) Tunnel (also known as the Black Hawk Tunnel or BHT), which has four lanes. This project includes an eastbound auxiliary lane on I-70 extending beyond the top of Floyd Hill.
- SH 119 from SDMD Tunnel to Black Hawk, four lanes
- Central City Parkway (CCP, formerly Southern Access Road or SAR) connecting to I-70 at the Hidden Valley interchange, four lanes (opening scheduled for fall 2004)
- Eagle County Airport interchange (preferred alternative in Environmental Assessment currently being prepared)
- Enlarged Hogback Parking Lot (FHWA has approved a Finding of No Significant Environmental Impact)
- SH 9 from Frisco to Breckenridge, four lanes
- US 285 from Conifer to Bailey, four lanes

These projects are included in each analysis for 2025. The SDMD Tunnel and SH 119 widening were added because they represent the highest potential demand on I-70. The Central City Parkway was added because Central City secured financing for this project during summer 2003 and the project is scheduled for opening during fall 2004. The Eagle County Airport interchange is being evaluated in an Environmental Assessment. The Environmental Assessment for the Hogback Parking Lot was completed in 2002, and the project is scheduled to be built when construction funding becomes available.

The highway line layer is composed of a set of highway segments that are defined by the location of each segment’s endpoints, speed, and capacity. The endpoints are located by longitude (which measures the distance in degrees from a base in Greenwich, England) and latitude (which measures the distance in degrees above the equator). The use of longitude and latitude allows the travel demand model to project maps of the study area, taking the earth’s curvature into consideration. This allows for more accurate calculation of travel distance from one endpoint to another.

Traffic Simulation Model

Roadways in VISSIM are also represented by links. Each link has the following physical dimensions and characteristics that need to be specified:

- Link length
- Number of lanes

- Lane width, which does not influence vehicle speed, but does determine passing characteristics in a simulation
- Gradient, which changes acceleration and deceleration capabilities of all vehicles
- Lane closure, which allows closure of one or more links to any vehicle class

In addition, links with different driving behaviors may be specified allowing different driving characteristics depending on calibration requirements.

The remainder of this section is organized as follows: First, different classification schemes are discussed. Then physical attributes of a roadway are listed. Next, characteristics of drivers and their vehicles are described. The following sections involve speeds and capacities, which result through the interaction of physical, driver, and vehicle characteristics. Then discusses special aspects of highway operations, such as reversible lane facilities and tolled facilities. The final section, describes costs related to automobile operations.

Classification of Highway Links

Travel Demand Model

Data Sources

By representing highway links in a GIS database, various numeric and text attributes may be associated with each link. This discussion describes some of these attributes and how they affect travel and the modeling process.

The Corridor highway link database (which also includes any guideway or facility used by transit) comes from the following sources:

- Denver Regional Council of Governments transportation planning network (links in Adams, Arapahoe, Boulder, Denver, Douglas, and Jefferson counties; Broomfield became a county in 2002, after this DRCOG network was created)
- Roaring Fork Valley (RFV) transportation planning network (links in portions of Eagle, Garfield, and Pitkin counties)
- TIGER highway line file
- Railroad line file derived from the TIGER files

Because they come from planning networks, the DRCOG and RFV links generally included all the data needed. However, certain attributes had to be estimated for links derived from the TIGER files. TransCAD automatically calculates lengths. If speeds are known (for example, from CDOT strip maps of I-70) or can be reasonably assumed, travel times can be calculated. Similarly, link capacity assumptions must be made based on what is known about the TIGER links, such as number of lanes and a description of facility type. This facility type is similar to the functional classes used by the DRCOG and RFV links. Therefore, only a facility type needs to be assigned to use lookup tables to estimate link capacities, free-flow speeds, and so on. (**Table A-15** and **Table A-17** are such lookup tables.)

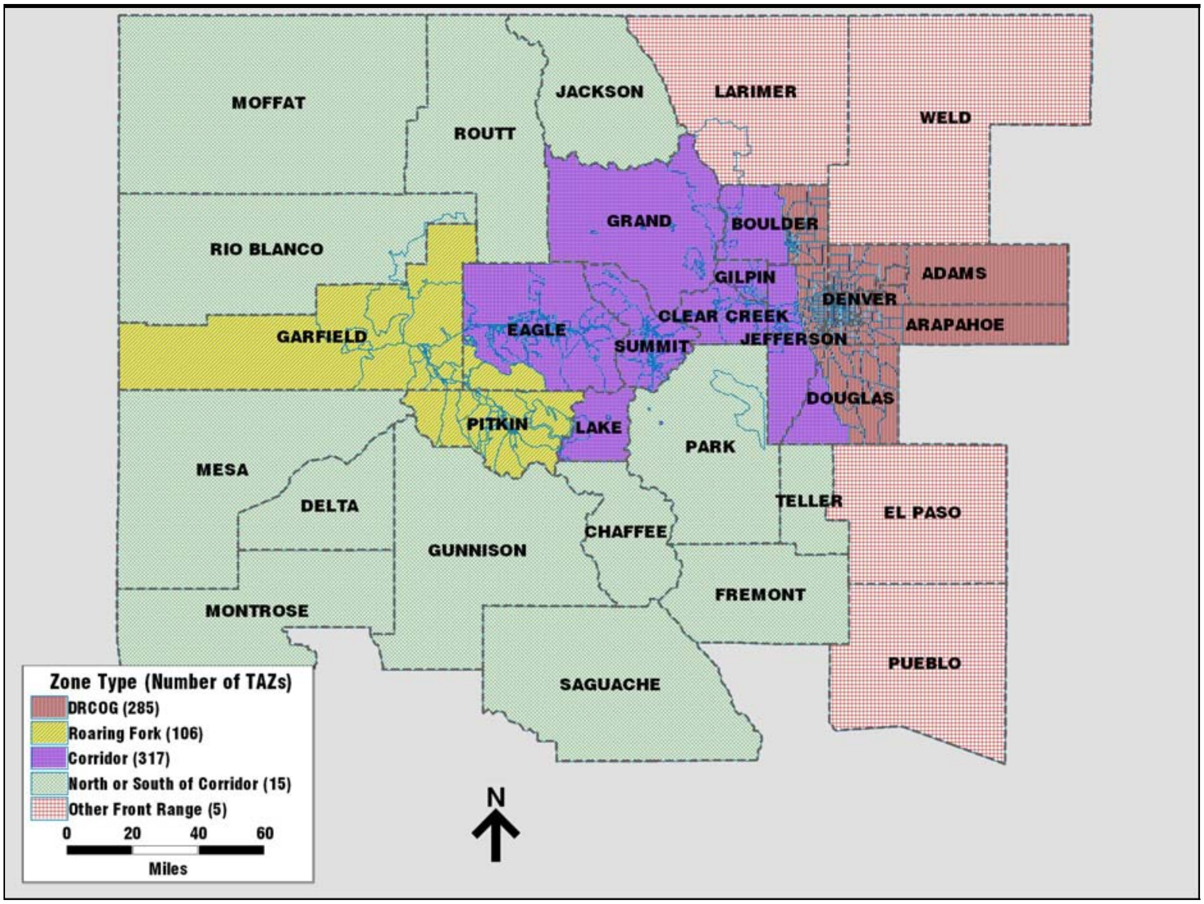
The highway links and TAZ areas contain a zone type variable indicating the source and location of the entity. Zone type codes are shown in **Table A-3**, and which TAZs correspond to each zone type is shown in **Figure A-3**. The zone type field is also used during trip generation to distinguish different production and attraction rates.

Table A-3. Zone Type Coding Convention

Code	Description
1	DRCOG Region
2	Roaring Fork Valley (RFV) Region
3	Corridor
4	North or South of Corridor
5	Remainder of Front Range

Source: J.F. Sato and Associates

Figure A-3. Zone Types in Travel Demand Model Area



Source: J.F. Sato and Associates

Functional Class

Table A-4 shows the combined DRCOG and RFV functional class coding system. Functional class is used as a proxy for estimating capacity, free-flow speed, expected congested speed, and certain traffic flow parameters. A map of the travel demand model area showing roadway functional class is presented in **Figure A-4**. Insets for Clear Creek, Grand, and Jefferson counties (**Figure A-5**); Summit and Eagle counties (**Figure A-6**); and Garfield and Pitkin counties (**Figure A-7**) are also provided.

Centroid connectors are a special type of link that connects the TAZ centroid, where trips are assumed to originate and terminate, to the physical highway network. Therefore, centroid connectors represent the system of local streets within a zone and are generally coded with a high capacity and low speed.

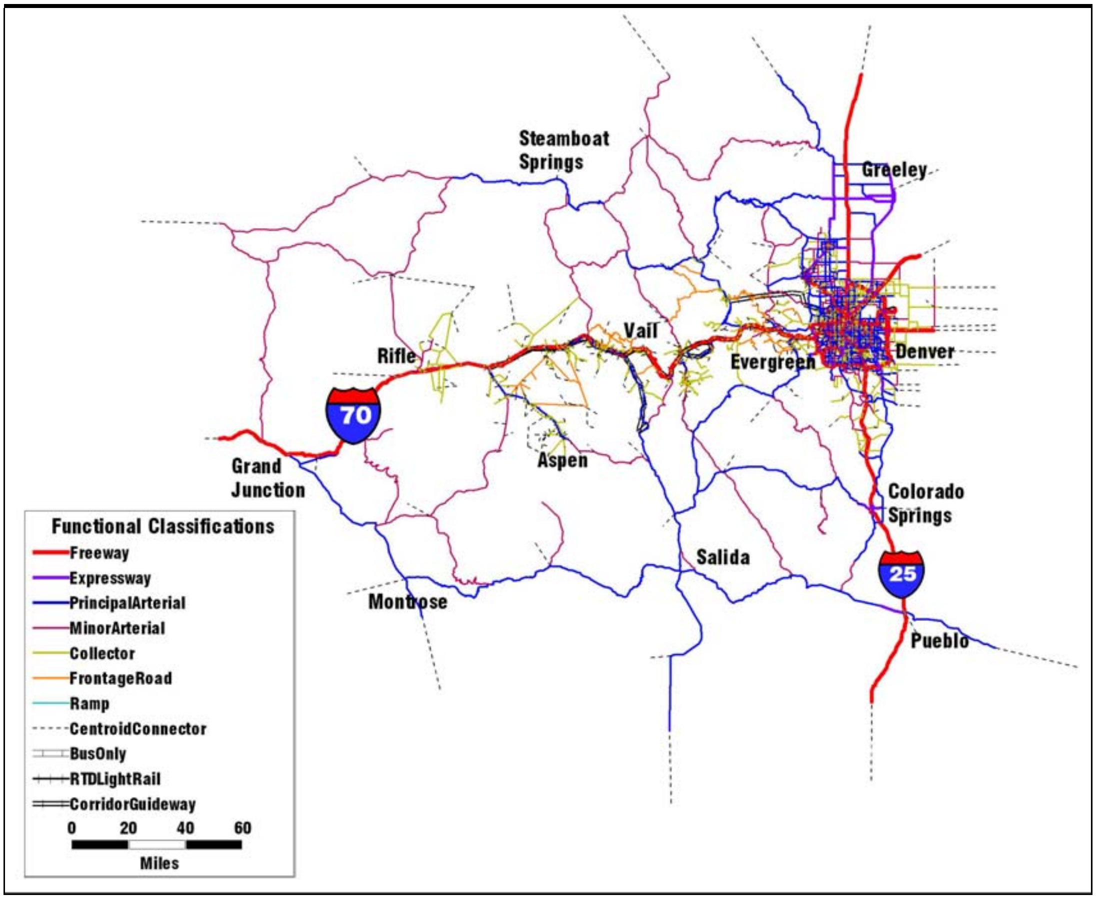
Table A-4. Functional Class Coding Convention

Code	Description
1	Freeway
2	Expressway
3	Principal arterial
4	Minor arterial
5	Collector
6	Frontage road
7	Ramp
8	Centroid connector
10	Transit-only links: RFTA and RTD 16th St Mall
11	Transit-only links: RTD Light Rail
12	Transit-only links: Corridor transit system

Note: Functional class code 9 is used by RFV as a transit access link. These links are not used in the I-70 PEIS travel demand model.

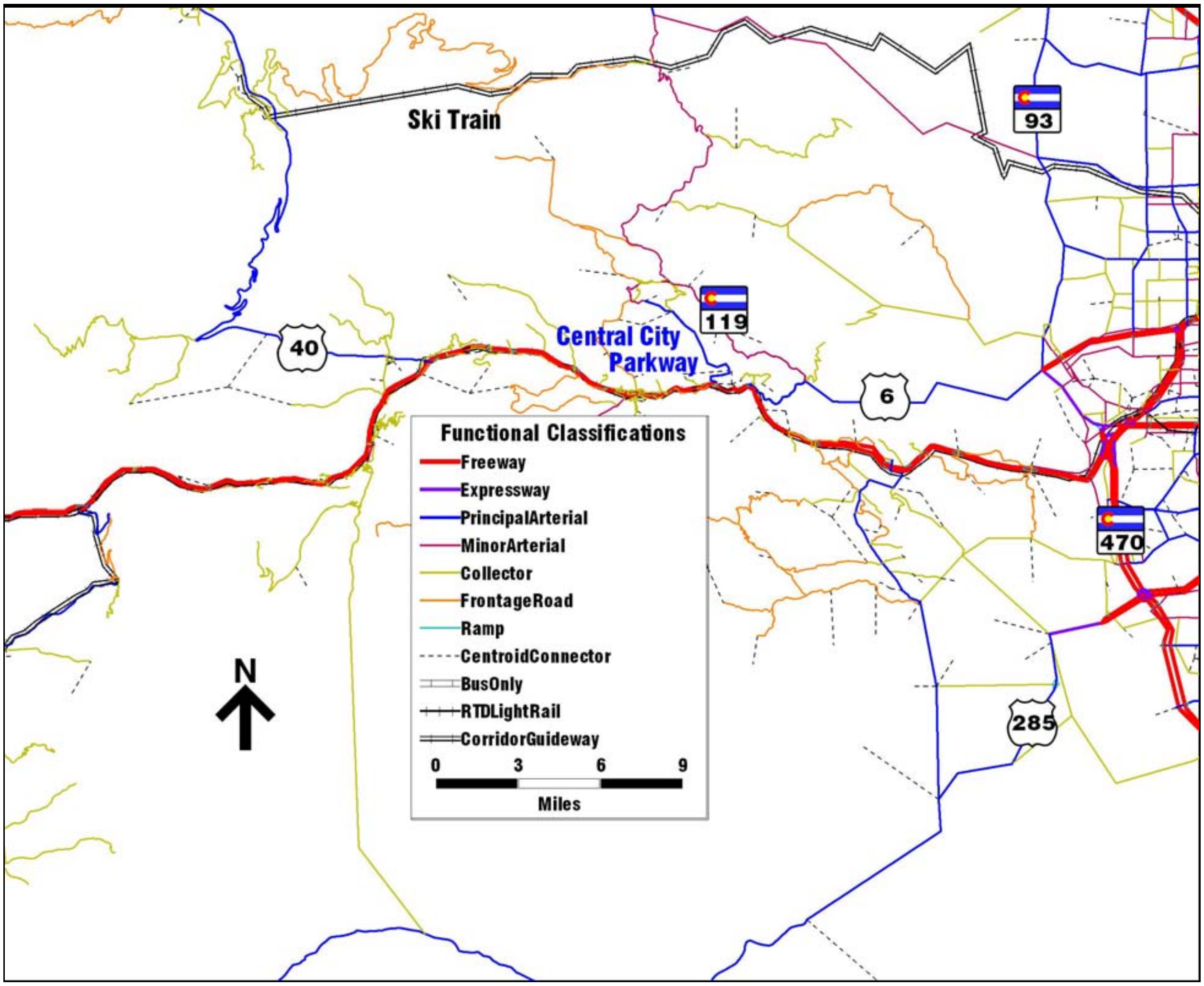
Source: DRCOG, RFV, J.F. Sato and Associates

Figure A-4. Travel Demand Model Area Roadways by Functional Class



Source: DRCOG, RFV, US Census Bureau, J.F. Sato and Associates

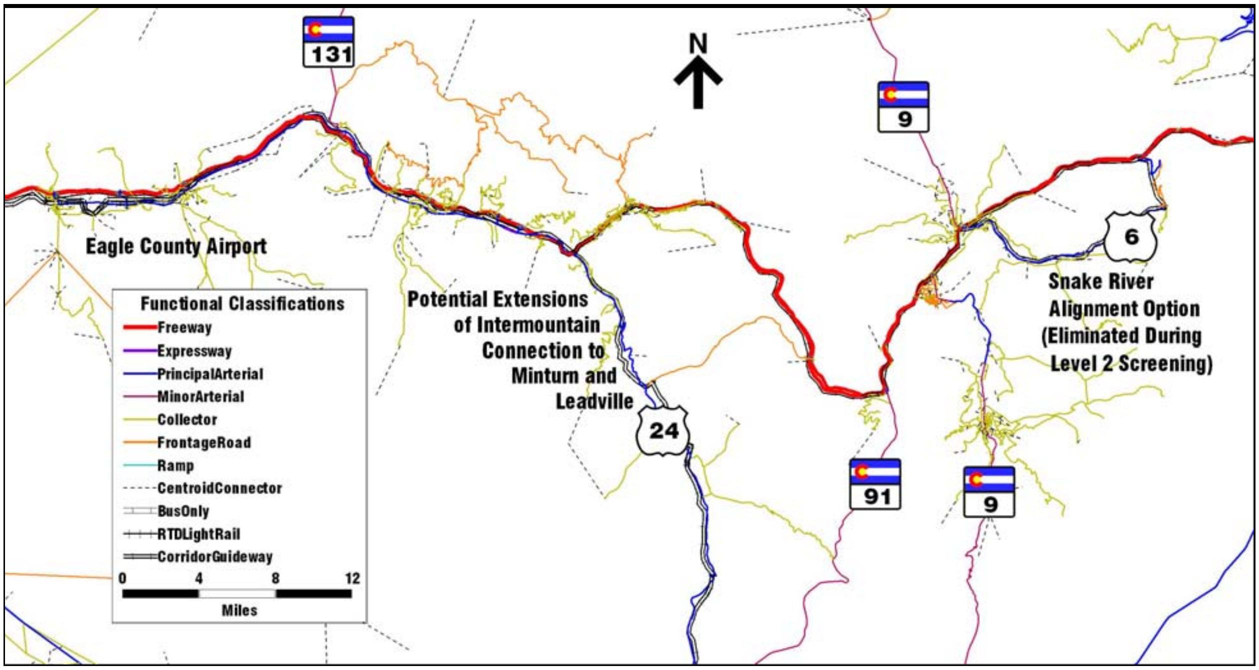
Figure A-5. Clear Creek, Grand, and Jefferson County Roadways by Functional Class



Source: DRCOG, RFV, US Census Bureau, J.F. Sato and Associates

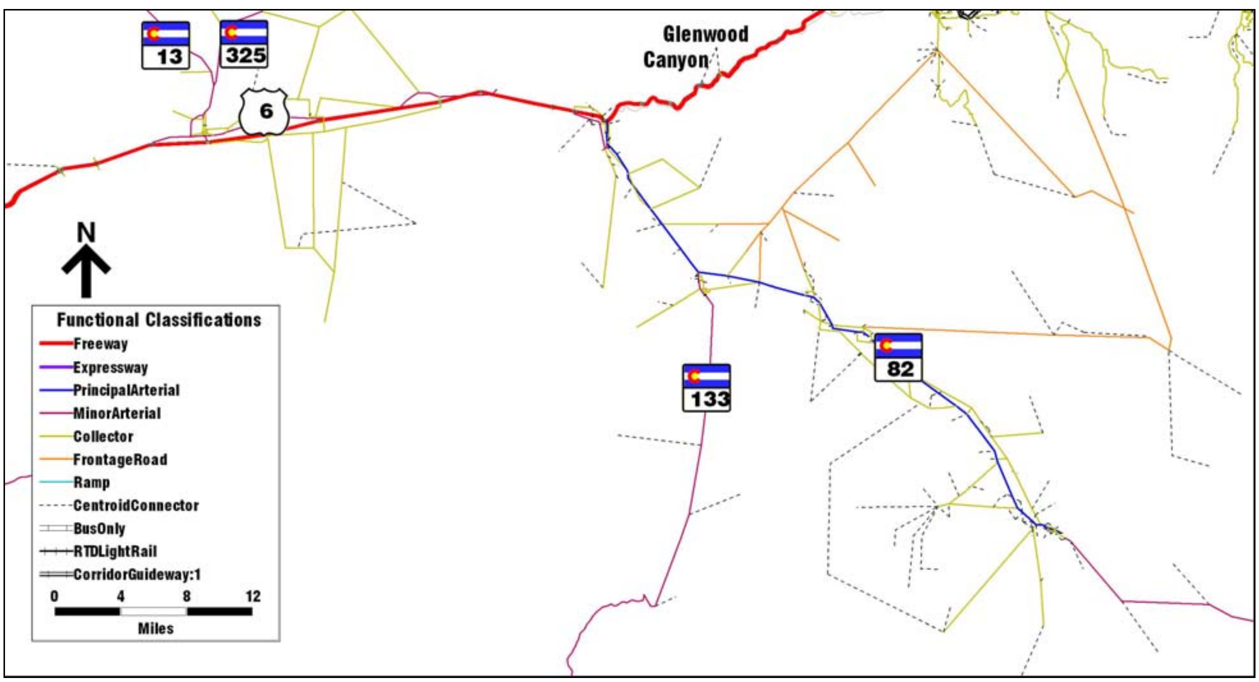
Other special links are indicated with other variables. For example, links representing I-70 within the Corridor are coded with an EB or WB label, representing travel direction, eastbound and westbound respectively. Transit-only links have a code representing the pair of stations at either end of the link. Another field indicates the year a link is constructed, so that future year networks may contain more roadways than the base year (2000) network.

Figure A-6. Eagle and Summit County Roadway Functional Class



Source: DRCOG, RFV, US Census Bureau, J.F. Sato and Associates

Figure A-7. Garfield and Pitkin County Roadways by Functional Class



Source: DRCOG, RFV, US Census Bureau, J.F. Sato and Associates

Surrounding Development Patterns or Area Type

Denver Regional Council of Governments and RFV also use an area type field to classify links. The area type describes the surrounding development patterns, and by implication, different access and facility treatment policies, which, in turn, affect speed and capacity. Different speed and capacity values are assumed for each combination of functional class and area type. Area type is also used with the TAZ layer to specify which set of trip generation rates applies for the TAZ. The coding scheme for area types is shown in **Table A-5**. A series of maps document which area type was assumed for each TAZ. **Figure A-8** shows the area types in the DRCOG region, as designated by that MPO. Similarly, **Figure A-9** shows the designations of area types in the Roaring Fork Valley region. Within and adjacent to the Corridor, **Figure A-10** shows the area types in Eagle County; **Figure A-11**, those in Summit County, **Figure A-12**, those in Clear Creek and Grand counties; and **Figure A-13**, those in Lake and Park counties.

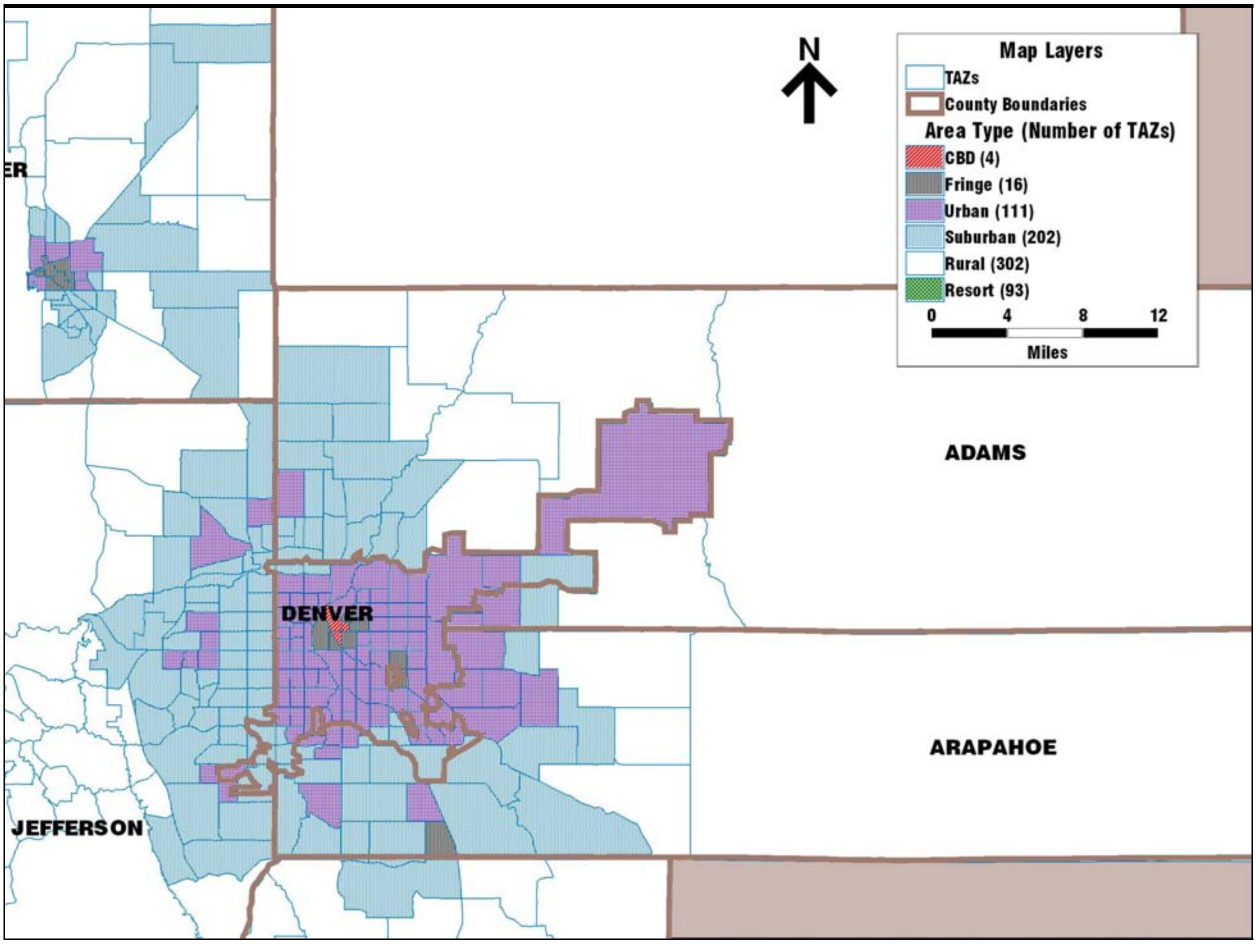
Table A-5. Area Type Coding Conventions

Code	Name	Description
1	CBD[a]	Downtown Denver
2	CBD Fringe	Denver CBD fringe and CBDs of outlying cities (for example, Boulder, Denver Tech Center, Glendale)
3	Urban	Urban neighborhood (for example, Capitol Hill, Congress Park)
4	Suburban	Suburban neighborhood (for example, Broomfield, Highlands Ranch)
5	Rural	Rural area
9[b]	Resort	Corridor resort community

Legend:
[a] = Central Business District
[b] = Area type code 9 is used only for the TAZ layer during trip generation.

Source: DRCOG, J.F. Sato and Associates

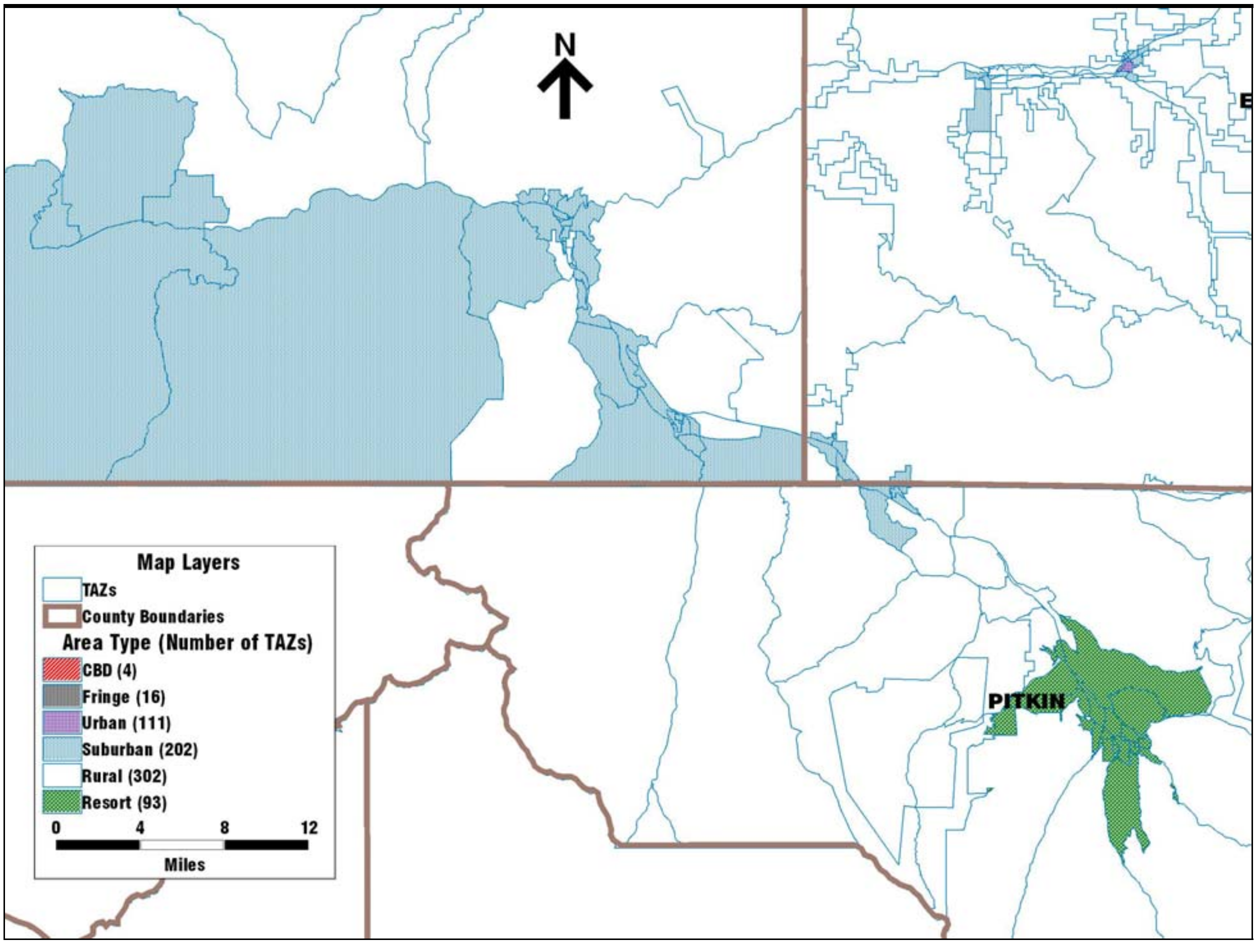
Figure A-8. Area Types in Denver Regional Council of Governments Region



Note: Broomfield, which became a county in 2002, is not shown on the above map. Total numbers of TAZs shown are for the whole I-70 PEIS modeling area. Areas shown in light brown at the northeast and southeast corners are not part of the DRCOG region or part of the I-70 PEIS modeling area.

Source: DRCOG

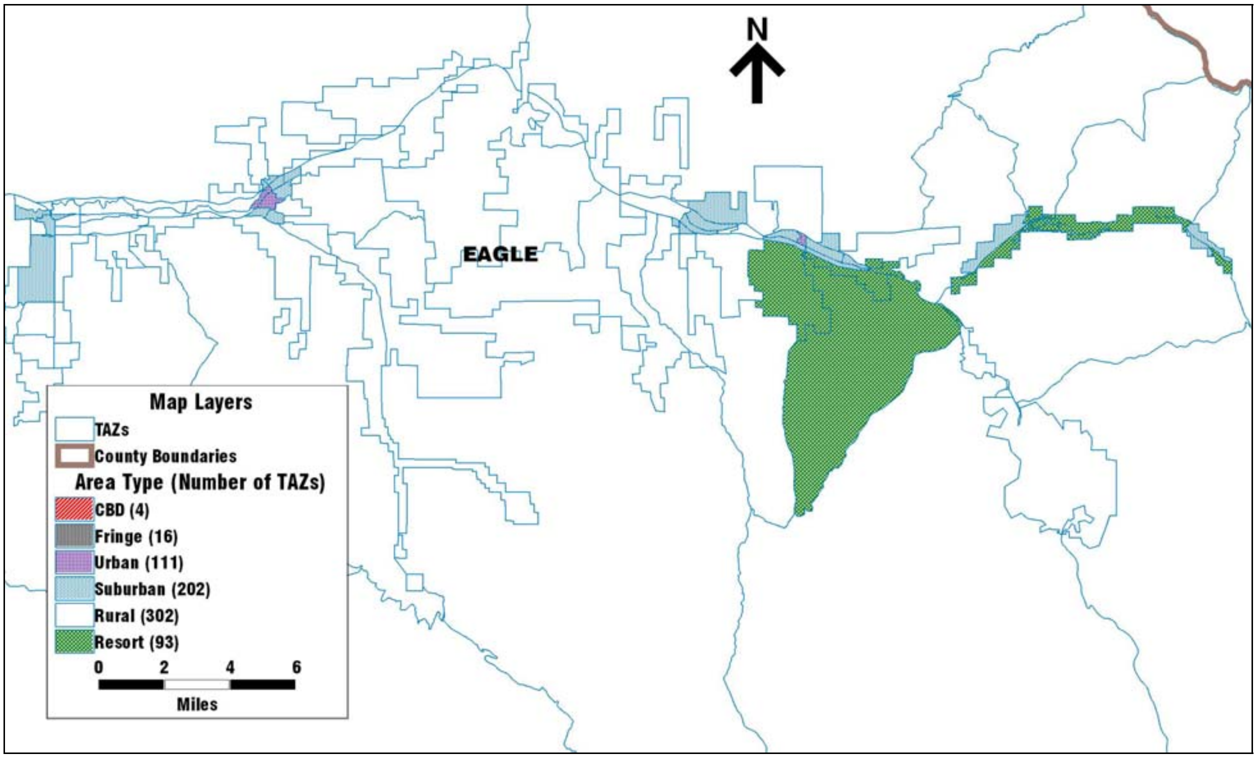
Figure A-9. Area Types in Roaring Fork Valley Region



Note: Total number of TAZs shown is for the whole I-70 PEIS modeling area.

Source: RFV, US Census Bureau, J.F. Sato and Associates

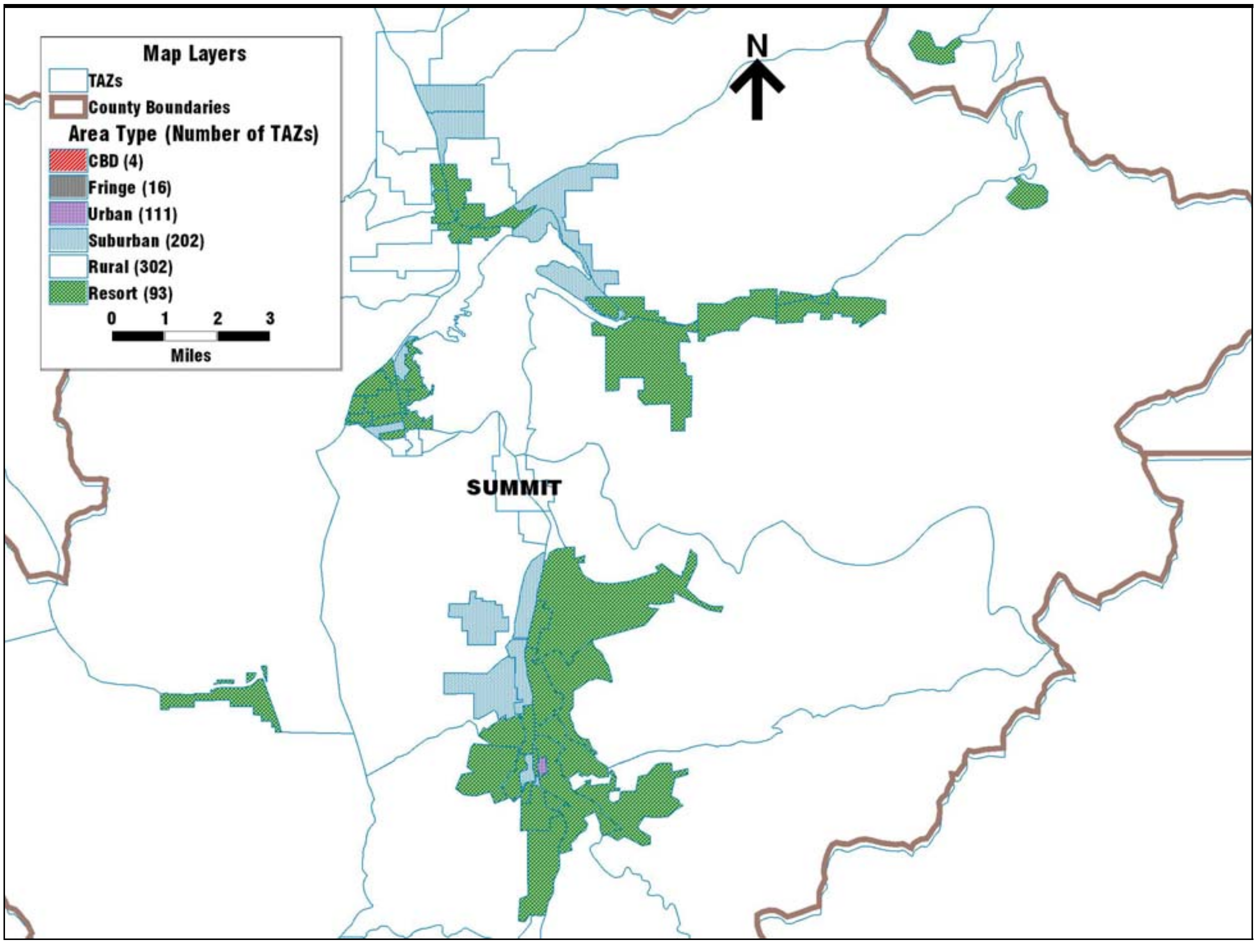
Figure A-10. Eagle County Area Types



Note: The Total number of TAZs shown is for the whole I-70 PEIS modeling area.

Source: RFV, US Census Bureau, J.F. Sato and Associates

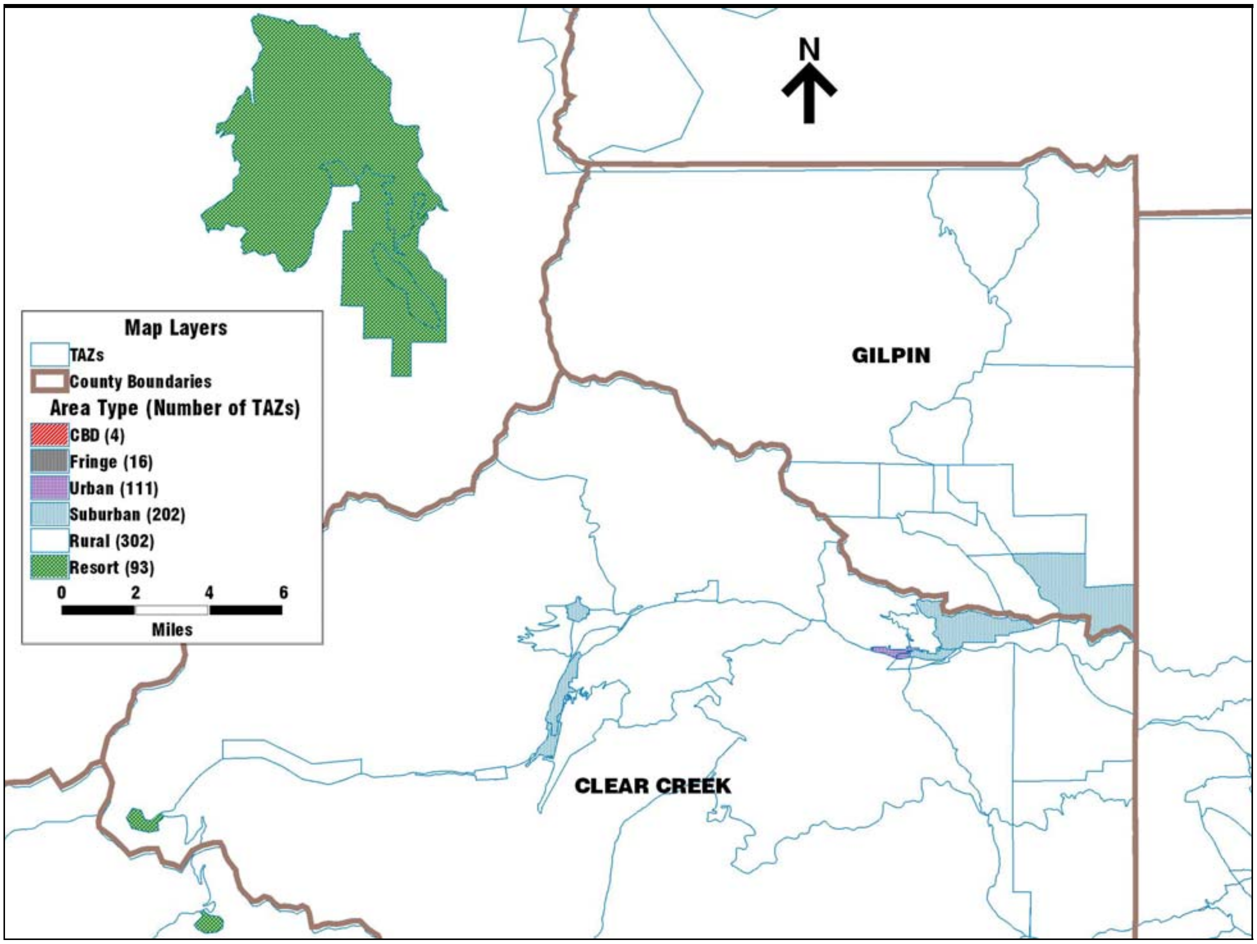
Figure A-11. Summit County Area Types



Note: The total number of TAZs shown is for the whole I-70 PEIS modeling area.

Source: US Census Bureau, J.F. Sato and Associates

Figure A-12. Clear Creek, Gilpin, and Grand County Area Types



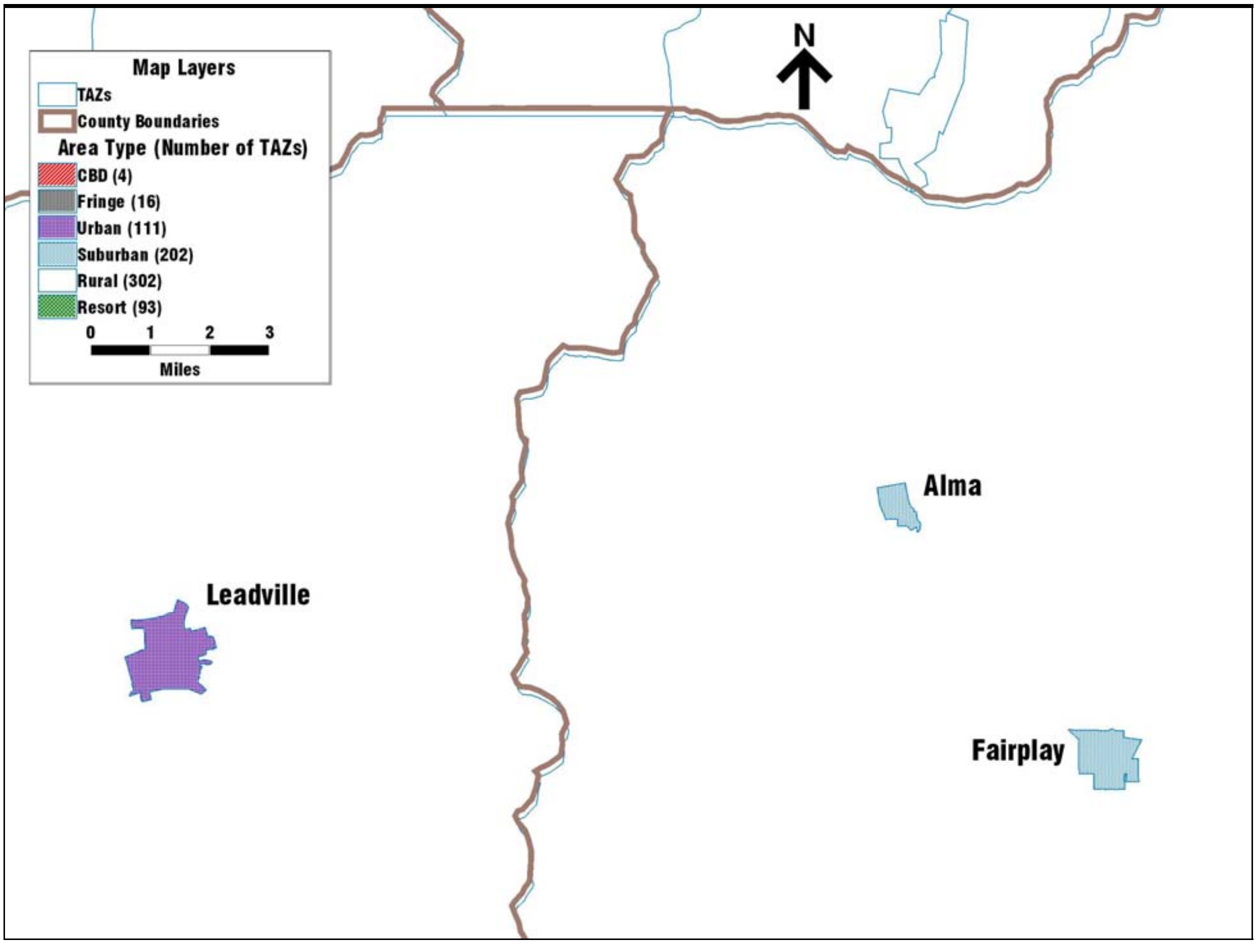
Note: The total number of TAZs shown is for the whole I-70 PEIS modeling area.

Source: DRCOG, US Census Bureau, J.F. Sato and Associates

Traffic Simulation Model

Two types of links are used in the I-70 PEIS VISSIM models, Urban and Freeway, which have considerably different rules governing traffic flow on them. All mainline I-70 links are Freeway links, while most on- and off-ramps and connecting streets are Urban. A link type defines a link's color and the driving behavior of the vehicles that travel across it. Within the type, different vehicle classes can have different driving behaviors. These can be selected from the driving behaviors list.

Figure A-13. Lake and Park County Area Types



Note: The total number of TAZs shown is for the whole I-70 PEIS modeling area.

Source: US Census Bureau, J.F. Sato and Associates

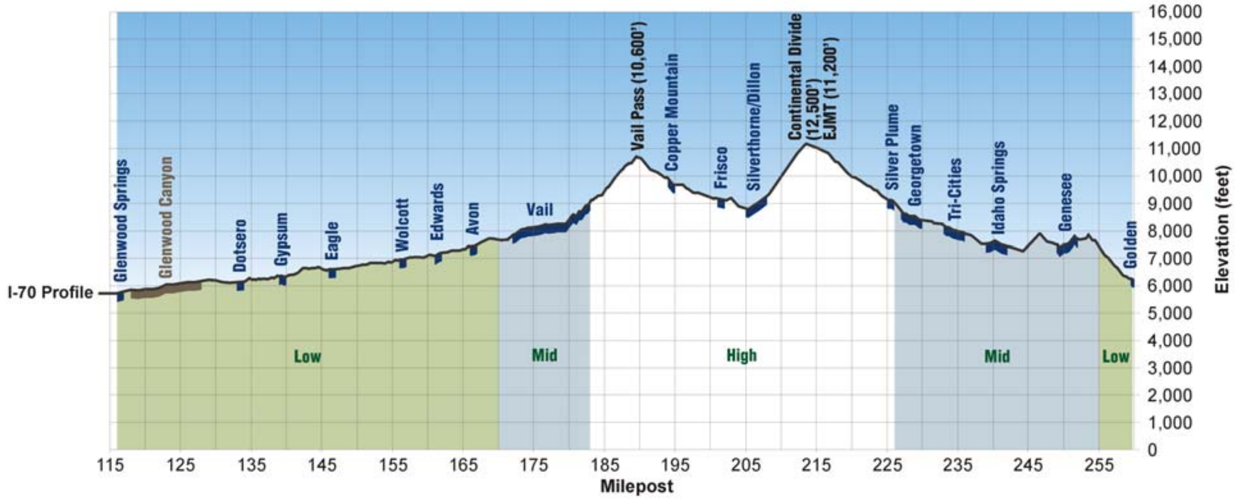
Physical Attributes

General

Grades

Grades were generally obtained from 3-D AutoCAD files, augmented by as-built plans. Grades in Glenwood Canyon were obtained from elevations at mileposts. **Chart A-3** shows the elevation profile of the Corridor.

Chart A-3. I-70 Elevation Profile from Glenwood Springs to C-470



Source: J.F. Sato and Associates

Grade is defined as the familiar rise over run, and is generally expressed as a percentage. More formally,

$$Grade(A \text{ to } B) = 100\% \left[\frac{Elevation_B - Elevation_A}{Distance(A \text{ to } B)} \right].$$

Unlike most urban applications, grades are an important consideration for the Corridor because they have a substantial impact on the speeds of buses, trucks, and other heavy vehicles. These slower vehicles have a proportionally greater impact on roadway capacity than passenger vehicles. Passenger-car-equivalents (PCEs) allow the impact of buses, trucks, and recreational vehicles (RVs) on highway capacity to be assessed. These values are based on the severity and duration (distance) of grade and the percentage of a given type of heavy vehicle within the traffic stream.

Number of Lanes

Different highway alternatives involve different numbers of lanes at different sections of I-70. An integer variable specifies the number of lanes in one direction for TransCAD. Additional integers are used to store the lanes associated with various scenarios listed below:

- Lanes in the calibration year (2000)
- Existing and committed lanes in the forecast year (2025)
- The general Six-Lane Highway Alternative, which is also used for the Combination Highway/Transit Alternatives
- The Reversible/HOV/HOT Lanes Alternative, which includes general widening in Dowd Canyon

Additionally, the link layer and macro allow for testing of some alternatives that have been previously screened out:

- General six-lane widening in Clear Creek County between Empire Junction and Floyd Hill only
- AM and PM peak configurations representing a movable median between Empire Junction and Floyd Hill

When a TransCAD forecast begins, the lanes from the appropriate scenario are copied to the generic lane variable that is used in all travel demand modules.

In VISSIM, different highway networks are used to represent the various highway widening scenarios. Additional networks represent different combinations of auxiliary lanes from the Minimal Action Alternative. (Auxiliary lanes are not modeled in TransCAD because they are unlikely to cause a substantial change in trip-making behavior.)

Travel Lane and Shoulder Widths

Colorado Department of Transportation maintains a database of the widths of travel lanes, shoulders, and medians. These widths vary based on the surrounding topography, local concerns, design treatments, and highway standards in effect when a roadway was constructed. Roadway segment capacity calculations consider the width of travel lanes and shoulders in determining the segment's effective capacity, because narrower roadways cause drivers to slow or be more cautious.

Travel Demand Model

Some of the variables in the TransCAD link layer represent physical quantities, such as elevation, grade, direction of travel, and number of lanes. Other physical descriptions of I-70, such as lane widths and shoulder widths, are stored in other files.

Length

As described earlier, link lengths may be calculated by a GIS platform based on the location of endpoints and internal *shape points*. Link lengths may also be calculated from CDOT geometric description databases.

Direction of Travel

Entities in the TransCAD link layer may represent roadways where one-way or two-way travel is allowed. The TransCAD software uses a direction code (Dir) to specify the legal directions of traffic flow:

- 0 indicates two-way flow is allowed
- 1 indicates one-way flow in the direction the link was originally digitized
- -1 indicates one-way flow in the reverse direction from which the link was digitized

Both the digitization direction and flow direction can be easily viewed on screen.

As a general convention, each roadway of I-70 is coded as a separate one-way link. A text field indicates whether these links correspond to the eastbound or westbound roadway. Most other links in the TransCAD link layer are two-way, with the following exceptions:

- One-way roads, such as those within urbanized areas
- Selected facilities where lane restrictions are under consideration

Traffic Simulation Model

An intensive review has been conducted to verify that the model contains the correct physical characteristics for I-70. The data has been obtained from 3-D AutoCAD files where possible, augmented by as-built plans and field measurements. The key characteristics that were verified were:

- The vertical grade through the Corridor
- The configuration of each interchange
- The length of acceleration and deceleration lanes and tapers at each interchange
- The configuration of lane drops and lane additions
- Signalized intersection characteristics (stop bar locations, turn bay lengths, signal timing)
- Stop signs yield signs and priority rules
- Regulatory signs (speed decisions), warning signs (reduced speed area)

Direction of Travel

In VISSIM, all links are one-way; two-way facilities are represented by two one-way links side by side. The Reversible/HOV/HOT Lanes Alternative is modeled as two separate networks in VISSIM: one for the eastbound direction and one for westbound. Separate eastbound and westbound trip tables are also required.

A pair of "parking lots" represents entry to and exit from the reversible/HOV/HOT lanes. For each vehicle exiting the general-purpose lanes, a vehicle is created at the parking lot entering the reversible/HOV/HOT lanes. A similar process occurs for a vehicle exiting the reversible lanes. Note that for the AM peak (westbound) network, the gap between parking lots for the reversible/HOV/HOT lanes and general-purpose lanes is modeled just east of the Herman Gulch exit. This network coding allows identification of any queues that may form when the reversible lanes merge with the general traffic.

Flow within the reversible/HOV/HOT lanes is controlled primarily through the OD trip table. Therefore, care must be taken not to specify an OD table with flows in the opposite direction from what the reversible lanes are operating. After the simulation, a manual check must be performed to ensure that all traffic cleared after the lanes closed in one direction before any traffic appears in the reversible lane OD pairs for the opposite direction.

Interchange Configuration

VISSIM is very sensitive to the characteristics of on- and off-ramps. During the PEIS, two special studies were done to test the sensitivity of these locations to make sure that they were properly modeled. The first study examined merge and diverge configurations throughout the Corridor. A second study focused on the Base of Floyd Hill (milepost 244, in the vicinity of the interchange with US 6 and the future Black Hawk Tunnel) under the Six-Lane Highway alternatives.

Through observation of the speed, queue length and flow data in the first file, it can be concluded that parallel acceleration and deceleration lanes work better than tapers. Additionally, increasing the parallel lane length improves the performance characteristics near the ramp-freeway junction. These results are generally consistent with both field observations and the *Highway Capacity Manual*.

The second file provides the results of different off-ramp configurations at the critical, high volume ramp that feeds from I-70 to the SDMD tunnel. It provides guidance on the appropriate values for the "distance-back" parameter, which controls how far before the off-ramp exiting VISSIM vehicles start attempting to get into the proper lane. Using the most reasonable parameters, the taper configuration only processed 86 percent of the input vehicles for the critical demand case, whereas the parallel configuration processed all of the input vehicles. The most reasonable value for the "distance-back" parameter was determined to be 1,000 feet, meaning that cars get into the parallel off-ramp near its starting point.

Table A-6 shows the existing ramp characteristics in the Corridor. Acceleration lengths are for on-ramps, and deceleration lengths are for off-ramps.

Table A-6. Characteristics of I-70 Corridor Ramps

Approximate Milepost	Location	Data Source	Direction	Off-Ramp Type	Deceleration Length (ft)	On-Ramp Type	Acceleration Length (ft)
133	Dotsero	As-Builts	EB	taper	660	parallel	400
			WB	taper	280	parallel	1,700
140	Gypsum	As-Builts	EB	parallel	1,075	parallel	1,200
			WB	parallel	910	parallel	1,200
147	Eagle	As-Builts	EB	taper	475	taper	650
			WB	taper	500	taper	1,200
157	Wolcott (SH 131)	As-Builts	EB	taper	400	taper	620
			WB	taper	250	taper	250
163	Edwards	As-Builts	EB	taper	360	parallel	550
			WB	taper	170	parallel	370
167	Avon	As-Builts	EB	taper	360	parallel	210
			WB	taper	900	taper	850
171	Minturn (US 6/US 24)	As-Builts	EB	parallel	360	parallel	260
			WB	parallel	250	parallel	250
173	Vail West Entrance	As-Builts	EB	taper	250	parallel	750
			WB	taper	250	parallel	750
176	Vail (Main Entrance)	As-Builts	EB	taper	250	parallel	750
			WB	taper	250	parallel	750
180	Vail East Entrance	As-Builts	EB	parallel	100	parallel	725
			WB	parallel	350	parallel	1,010
190	Vail Pass	As-Builts	EB	N/A	N/A	N/A	N/A
			WB	parallel	300	parallel	700
195	Copper Mountain	As-Builts	EB	taper	175	parallel	700
			WB	taper	100	taper	almost none
198	Officers Gulch	AutoCAD Drawing	EB	parallel	232	parallel	428
			WB	taper	629	taper	810
201	Frisco Main Street	AutoCAD Drawing	EB	parallel	445	parallel	858
			WB	parallel	846	parallel	418
203	Frisco SH 9	AutoCAD Drawing	EB	parallel	301	parallel	819
			WB	parallel	1,259	parallel	948
205	Silverthorne (US 6)	AutoCAD Drawing	EB	parallel	831	parallel	1,282
			WB	parallel	665	taper	915
216	Loveland Pass (US 6)	AutoCAD Drawing	EB	taper	826	parallel	1,943
			WB	taper	217	parallel	436
218	Herman Gulch	AutoCAD Drawing	EB	parallel	376	parallel	334
			WB	taper	744	parallel	481

Table A-6. Characteristics of I-70 Corridor Ramps

Approximate Milepost	Location	Data Source	Direction	Off-Ramp Type	Deceleration Length (ft)	On-Ramp Type	Acceleration Length (ft)
221	Bakerville	AutoCAD Drawing	EB	parallel	360	taper	965
			WB	taper	949	parallel	306
226	Silver Plume	AutoCAD Drawing	EB	parallel	262	parallel	533
			WB	parallel	187	taper	491
228	Georgetown	AutoCAD Drawing	EB	taper	385	parallel	302
			WB	parallel	400	parallel	1,280
232	Empire Jct. (US 40)	AutoCAD Drawing	EB	parallel	633	parallel	559
			WB	parallel	239	taper	722
233	Lawson	AutoCAD Drawing	EB	parallel	289	no ramp	no ramp
234	Downieville	AutoCAD Drawing	EB	parallel	612	parallel	718
			WB	N/A	N/A	N/A	N/A
235	Dumont	AutoCAD Drawing	EB	no ramp	no ramp	taper	398
			WB	taper	373	no ramp	no ramp
238	Fall River Road	AutoCAD Drawing	EB	parallel	412	parallel	455
			WB	parallel	383	parallel	492
239	West Idaho Springs	AutoCAD Drawing	EB	taper	337	no ramp	no ramp
			WB	taper	230	parallel	643
240	Mt. Evans (SH 103)	AutoCAD Drawing	EB	parallel	471	parallel	372
			WB	parallel	461	parallel	438
241	East Idaho Springs	AutoCAD Drawing	EB	parallel	737	parallel	483
			WB	parallel	1,912	parallel	963
	(tight cloverleaf)		WB	parallel	almost none	no ramp	no ramp
243	Hidden Valley	AutoCAD Drawing	EB	taper	928	parallel	291
			WB	parallel	348	parallel	328
244	US 6/Gaming Area	AutoCAD Drawing	EB	parallel	745	no ramp	no ramp
			WB	parallel	224	parallel	804
247	Hyland Hills	AutoCAD Drawing	EB	taper	959	no ramp	no ramp
			WB	no ramp	no ramp	parallel	439
248	Beaver Brook	As-Builts	EB	no ramp	no ramp	taper	490
			WB	taper	260	no ramp	no ramp

Table A-6. Characteristics of I-70 Corridor Ramps

Approximate Milepost	Location	Data Source	Direction	Off-Ramp Type	Deceleration Length (ft)	On-Ramp Type	Acceleration Length (ft)
251	El Rancho	As-Builts	EB	parallel	400	no ramp	no ramp
			WB	no ramp	no ramp	parallel	925
252	Evergreen (SH 74)	As-Builts	EB	no ramp	no ramp	parallel	500
			WB	parallel	500	no ramp	no ramp
253	Chief Hosa	As-Builts	EB	parallel	2,500	taper	750
			WB	taper	720	parallel	1,750
254	Genesee	As-Builts	EB	taper	625	parallel	530
			WB	parallel	400	parallel	275
256	Lookout Mountain	As-Builts	EB	parallel	550	parallel	200
			WB	parallel	900	parallel	1,300
259	Morrison (Hogback)	As-Builts	EB	parallel	580	parallel	550
			WB	taper	200	parallel	550

Notes: N/A = Not available. The notation "no ramp" indicates that no roadway is provided for this movement.

Driver and Vehicle Characteristics

In addition to highway characteristics, traffic flows are influenced by the actions of drivers and the performance of their vehicles. Driver characteristics considered, include trip purpose, desired speed, vehicle following and lane-changing behavior, and vehicle occupancy (willingness to travel with other people). Important vehicle characteristics include the type of vehicle (passenger automobile, single-unit truck, combination-unit or semi-truck, RV, or bus), acceleration characteristics, power-to-weight ratio, and size (sometimes expressed in passenger-car equivalents or PCEs).

Travel Demand Model

Trip Purpose

People travel for many different reasons. Each purpose has certain characteristics that make it similar to some trips and different from others. Some of these characteristics include the income of the travelers, the type and location of the origin and destination, and the type of vehicle used. Trip purpose influences value of time, willingness to consider other modes, and willingness to carpool.

The I-70 travel demand model considers the following types of trip purposes:

- Home-Based Work trips by four income groups
- Home-Based Other trips (that is, non-work)
- Non-Home Based local trips
- Day Gaming trips
- Front Range Day Recreation trips (for example, skiing, hiking)
- Corridor Day Recreation trips (by residents, second home owners, and visitors)
- Resort to Resort trips
- Stay Overnight at Hotel, Resort, or Forest trips
- Stay Overnight at Second Home trips
- Stay Overnight Visiting Friends or Family trips
- Corridor to Airport or Front Range trips

- Out-of-State Air Passenger trips
- Out-of-State Automobile trips
- RV trips
- Single-Unit Truck (for example, delivery van) trips
- Combination-Unit Truck (for example, semitrailer) trips
- Single-Unit Truck Internal-External and Through trips
- Combination-Unit Truck Internal-External and Through trips

These trip purposes may be grouped in different ways for modeling and reporting. For example, the mode choice model uses 10 different sets of parameters for 15 trip purposes that are eligible to use transit. Time-of-day factors are applied to the 21 purposes based on 8 patterns, which are shown in **Table A-2**.

Vehicle Occupancy

Average vehicle occupancies are determined for four groups of trip purposes. Work trips (for four income groups) are assumed to average 1.1 persons per vehicle. Local Non-Work trips—Home-Based Other and Non-Home Based—have an average occupancy of 1.7 persons. None of the Out-of-State Automobile trips, RV trips, and truck trips (four types) are eligible to use transit and are assumed to be occupied by a single driver. The remaining nine recreation purposes have an average occupancy of 2.6 persons per vehicle.

Traffic Simulation Model

Traffic Composition

Traffic composition involves specifying the types of vehicles and their percentage of the overall traffic flow. The traffic composition has a substantial effect on overall traffic operation results. Vehicles have been categorized into five types based on the weight, power, and length of the vehicle. The five vehicle types are as follows:

1. Car
2. Semi: Combination Semitractor Trailers
3. Single-Unit Truck: Includes smaller delivery trucks, rental moving trucks, and buses.
4. Low Performance RV: Self-contained motor homes and large motor homes pulled by another vehicle
5. High Performance RV: Vehicles pulling trailers (with snowmobiles, boats, and so forth)

Volumes of Semis and Single-Unit Trucks were obtained from the truck volume data shown in the *Overall Definition of Truck Volumes in the I-70 Mountain Corridor Report.* Various data sources were used to prepare that report, including information from CDOT, the Colorado Department of Revenue, and field studies. By combining these truck volumes with the overall demand values determined by the travel demand model, the percentage of Semi and Single-Unit Trucks was obtained for each time period. The percent of RVs was obtained from field observations. **Table A-7** shows dates and locations of these field observations.

Table A-7. Date and Location of Traffic Composition Field Observations

Date	Location
February 23, 2002	Vail Pass
March 4, 10, and 17, 2001	Bakerville
July 20 and 21, 2001	Georgetown

Vehicle Performance Characteristics

Distinctions between different vehicle types are important in several components of the travel demand model. For example, trucks are assumed to be carrying freight, which is not effectively carried on a transit vehicle. The highway capacity calculations consider the fractions of certain vehicle types, which have different PCEs related to their size and ability to travel on grades. For traffic simulation, each class of vehicles has a particular distribution of engine power and acceleration capabilities.

Different vehicle types are defined in VISSIM using the following parameters:

- Length, width, occupancy, acceleration and deceleration curves (define the acceleration and deceleration characteristics of the vehicle)
- Weight and power distributions (for heavy vehicles such as semi's, single-unit trucks, and RVs)
- Vehicle types can be combined into one vehicle class if they incorporated similar general driving behavior.
- The vehicle types used in the PEIS analysis consisted of automobiles, semis, single-unit trucks, low-performance RVs, and high-performance RVs.

Table A-8 provides the lengths and range of desired and maximum acceleration and deceleration for the five vehicle types considered.

Acceleration Characteristics

In VISSIM, the primary vehicle characteristics that control performance on grades are acceleration and deceleration capabilities, not the weight and horsepower. **Table A-8** shows the values for each vehicle type.

Table A-8. Characteristics Associated with the Five Vehicle Types

	Vehicle Parameters				
		Acceleration (ft/s^2)		Deceleration (ft/s^2)	
Vehicle Type	**Length (ft)**	**Maximum**	**Desired**	**Maximum**	**Desired**
Car	17	(12,99.4)	(11.5,99.4)	(-24.6, -19.7)	(-9, -9)
Single-Unit Trucks	40	(9.9,99.4)	(2.8,99.4)	(-19.7, -6.0)	(-4.1, -4.1)
Semi's	80	(9.5,99.4)	(2.8,99.4)	(-19.7, -6.0)	(-4.1, -4.1)
Low Performance RVs	60	(9.6,99.4)	(2.8,99.4)	(-19.7, -6.0)	(-4.1, -4.1)
High Performance RVs	40	(11.2,99.4)	(2.8,99.4)	(-19.7, -6.0)	(-4.1, -4.1)

Note: Ranges are presented as two values in parentheses, separated by commas. Values for a particular vehicle are drawn from a uniform distribution.

Speed Characteristics

VISSIM uses a model of vehicle-following to simulate traffic dynamics. Each automobile and driver is assumed to have a preferred travel speed and certain acceleration capabilities. As more vehicles are on the roadway, a driver is less likely to be able to travel at her or his desired speed, and instead needs to slow down to avoid crashing with a vehicle downstream. **Table A-9** shows parameters related to vehicle-following behavior.

Table A-9. Vehicle-Following Parameters by Functional Class

Parameter	Freeway	Urban Streets
Model	***Weidmann 99***	***Weidmann 74***
Observed Vehicles	2	2
Minimum Look Ahead Distance (ft)	820.21	820.21
Lateral Behavior	Middle of Lane	Middle of Lane

Table A-10 shows the 10 parameters involved in freeway behavior in the *Weidmann 99* model for various model days. The parameter CC1 varies because of different compositions of drivers (a greater proportion of unfamiliar drivers) on weekends compared to weekdays.

Table A-10. *Weidmann 99* Freeway Vehicle-Following Parameters

Parameters	Definition	Default value
CC0	Distance between the stop cars	4.92 ft
CC1	Headway time	0.95 sec
CC2	Longitudinal oscillation, how much more distance above the safety distance allowed	13.48 ft
CC3	Start of the deceleration	-12.00
CC4	Reaction of driver to acceleration	-0.25
CC5	Reaction of driver to deceleration	0.35
CC6	Influence of distance on speed oscillation while following the car	6.00
CC7	Actual acceleration during the oscillation process	0.25
CC8	Desired acceleration when starting from standstill	6.56 ft/s^2
CC9	Desired acceleration	4.92 ft/s^2

CC0 and CC1 parameters influence overall highway capacity the most substantially. The value of CC0 has been left at the default value. Different values for CC1 have been used for the various model days, with the value sometimes differing between the eastern and western networks for the same model day. This parameter helps to account for capacity factors that do not vary between different locations within the model, such as the peak hour and population familiarity factors. Table A-11 provides the values that were used:

Table A-11. CC1 Parameter, Headway Time

Model Segment	Season	Model Day	CC1 Value (seconds)
Eastern	Summer	Weekdays	1.05
		Weekend	1.15
	Winter	Weekdays	1.05
		Weekend	1.15
Western	Summer	Weekdays	1.25
		Weekend	1.25
	Winter	Weekdays	1.15
		Weekend	1.25

The *Weidmann 74* model describes vehicle-following behavior on urban streets. Parameters of the model, which are shown in Table A-12, relate to components of desired spacing between vehicles.

Table A-12. *Weidmann 74* Urban Street Vehicle-Following Parameters

Parameter	Value
Average Standstill Distance (ft)	6.56
Additive Desired Safety Distance (ft)	2.00
Multiplicative Desired Safety Distance	3.00

Lane-Changing Behavior

Within VISSIM, lane-changing behavior is characterized by the following parameters:

- Whether overtaking is allowed on right or left sides, and in any lane or only the fast lane
- The minimum headway, which defines the minimum distance to the vehicle in front that must be available for a lane change at a standstill condition; VISSIM modifies the minimum headway to account for differences in speeds between vehicles
- A parameter defining the minimum time headway toward the next vehicle on the slow lane, so that a vehicle on the fast lane changes to the slower lane to avoid a collision

These lane-changing parameters vary depending on whether a link is part of a freeway and are shown in Table A-13.

Table A-13. Lane-Changing Parameters by Functional Class

Parameter	Functional Class	
	Freeway	Urban Streets
Model	*Weidmann 99*	*Weidmann 74*
Overtaking Behavior	Right Side Rule	Right Side Rule
Waiting Time (s)	45	45
Minimum Headway (s)	1.64	1.64
To slower lane if collision time above (s)	11	11

Free-Flow Speeds

Free-flow speed is an important parameter of traffic flow theory. Free-flow speed represents the maximum speed a reasonable driver is able to obtain on a roadway when the volume of vehicles is sufficiently low that no vehicles interfere with each other.

Travel Demand Model

In some applications, a policy decision is made to assume that free-flow speeds do not exceed posted speed limits. However, in other applications, particularly metropolitan and regional modeling before the advent of GIS, acquiring the posted speed of every roadway being modeled may be cumbersome and, therefore, a table of speeds by roadway classification may be used. This table may be derived from a speed study or professional judgment.

The PEIS takes a hybrid approach to estimating free-flow speeds in TransCAD. Free-flow speeds of links representing I-70 in the Corridor are based on posted speeds, as shown in **Table A-14**. All other links use free-flow speeds from **Table A-15**, which is derived from the DRCOG and RFV models.

Table A-14. I-70 Posted (Free-Flow) Speeds

I-70 Eastbound			I-70 Westbound		
From	To	Speed Limit (mph)	From	To	Speed Limit (mph)
Glenwood Springs	Milepost 131.5	50	C-470	East of Hyland Hills	65
Milepost 131.5	East of Avon	75	East of Hyland Hills	West of Twin Tunnels	55
East of Avon	Milepost 170	65	West of Twin Tunnels	West of West Idaho Springs	60
Milepost 170	West of Vail West Entrance	60	West of West Idaho Springs	West of US 6/Loveland Pass	65
West of Vail West Entrance	East of Silverthorne	65	West of US 6/Loveland Pass	West of EJMT West Portal	50
East of Silverthorne	West of EJMT West Portal	60	West of EJMT West Portal	East of Silverthorne	60
West of EJMT West Portal	West of US 6/Loveland Pass	50	East of Silverthorne	West of Vail West Entrance	65
West of US 6/Loveland Pass	West of West Idaho Springs	65	West of Vail West Entrance	East of Dowd Junction	60
West of West Idaho Springs	West of Twin Tunnels	60	East of Dowd Junction	West of Dowd Junction	55
West of Twin Tunnels	East of US 6/Gaming	55	West of Dowd Junction	West of Avon	65
East of US 6/Gaming	Genesee	65	West of Avon	Milepost 131.5	75
Genesee	C-470	55	Milepost 131.5	Milepost 131.0	65
			Milepost 131.0	Glenwood Springs	50

Source: CDOT.

Table A-15. Highway Free-Flow Speeds for Links Other Than I-70 by Functional Class and Area Type

Area Type and Functional Classification	CBD	Fringe	Urban	Suburb	Rural
Freeway	55	55	58	58	63
Expressway	40	40	45	45	49
Principal arterial	27	35	37	45	48
Minor arterial	25	30	35	40	44
Collector	20	25	30	30	35
Frontage road	15	15	15	15	15
Ramp	30	30	32	35	37
Centroid connector	15	20	25	30	35

Source: J. F. Sato and Associates, modified from DRCOG and RFV.

Traffic Simulation Model

Free-flow speeds in VISSIM are an outcome of an interaction of the physical alignment of the roadway (curves, grades, and so on) with the characteristics of the drivers (that is, the vehicle-following model) and the physical limitations of the vehicles (including acceleration and deceleration curves, and weight to power ratio). The free-flow speeds should represent real-world conditions, which were checked as part of the calibration process and which included adjusting the aforementioned parameters. The free-flow travel times that are included in Appendix B were determined based on posted speed limits, with assumptions that vehicles typically drive faster than those limits to varying degrees depending on what the limit is.

Speed is controlled in VISSIM by a variety of means, as follows:

Desired Speed Distribution. Desired speed distributions have a substantial effect on the speed and capacity on straight sections of the highway. Each vehicle class has its own desired speed distribution, which has been based on field data from I-70. The base speed range for cars is 60 to 90 mph on the straight part of highway and Truck and RVs is 50 to 80 mph. The desired speed distribution was adjusted to match the field data and is shown in Table A-16.

Table A-16: Percentage of Vehicles in Different Speed Ranges

Vehicle Type	Percentage of Vehicle in Each Speed Range							
	50 to 54 mph	54 to 60 mph	60 to 65 mph	65 to 70 mph	70 to 75 mph	75 to 80 mph	80 to 85 mph	85 to 90 mph
Car	0%	0%	6%	9%	38%	38%	6%	3%
Truck and RV	5%	16%	60%	6%	6%	7%	0%	0%

Speed Decisions. The desired speed distributions are matched to the speeds in the Corridor sections with the highest speeds limits (75 mph), such as the area east of the Eagle interchange. For all areas with lesser speed limits, a speed decision is put in to reduce speeds. These speed decisions define a speed distribution for each vehicle class. They can also be used to limit speeds in areas with narrow shoulders.

Steep Grades. The grades along the Corridor are defined in the input file. The speed of vehicles on these grades varies, depending on their performance characteristics.

Reduced Speed Zones. Simply having a curve on a link has no effect on the speed of any of the vehicles. Reduced speed zones are put in to reduce speeds in these areas. They are also used to slow down vehicles on off-ramps.

Congested Speeds

Travel Demand Model

Table A-17 shows the assumed speed for each highway segment initially in the travel demand model. Each segment was assigned to one of five roadway categories based on how it serves abutting property, from freeways with no access to collectors with the most access. As shown in the table, speed declines as access increases. For each highway category, the type of area the highway passes through also affects segment speed. The Corridor passes mainly through rural areas, but within its small towns one might expect reduced speed due to the decreased spacing of the interchanges on I-70 and the signalized intersections on arterial and collector streets. The initial speeds were adapted from those developed by DRCOG.

Speeds are used in the travel demand model to distribute trips between one TAZ and another. They are also important in showing the minimum time path used in highway assignment. Traffic is loaded onto segments on this time path. After the model completes an iteration of the four-step process and has forecasted period highway volumes for each highway segment, the speed of each segment is adjusted to better reflect the likely speed given the newly forecasted traffic volume.

Speed also varies by day of the week and season. This variation in speeds tries to mimic the actual speeds that occur during the day and season. Free-flow and congested speeds cause vehicle slowing as more vehicles affect a driver's ability to maneuver and achieve speeds as high as possible within the constraints of the segment speed limit and geometry.

Special speeds are used for I-70 between C-470 and the west Eagle County boundary located on the east side of Glenwood Canyon. These speeds are calculated from the Traffic Simulation Model (VISSIM) and account for the number and power levels of trucks, grades, length of grades and drivers' propensity to switch lanes, change speeds, and follow the vehicle ahead at a specific distance. Average speeds for a period are calculated and incorporated into the TransCAD model. These speeds are calculated after the first iteration of the travel demand model and vary by alternative.

Table A-17. Initial Highway Speeds

Winter Weekday	CBD	Fringe	Urban	Suburb	Rural
Freeway	27	48.4	51.1	55.5	62.8
Expressway	16	34.8	41.7	43.6	48.9
Principal arterial	26.3	32.9	34.8	42.8	47.5
Minor arterial	24.1	28.6	33.1	38.7	43.9
Collector	19.9	24.9	24.9	29.9	34.9
Frontage road	12	12	12	15	15
Ramp	35	35	35	38	39
Centroid connector	13	16	18	20.5	23
Winter Saturday	**CBD**	**Fringe**	**Urban**	**Suburb**	**Rural**
Freeway	27	52.3	54.9	56.7	62.8
Expressway	16	36.1	43.6	44.5	48.9
Principal arterial	26.9	34.1	36.3	44	47.7
Minor arterial	24.5	29.5	34.2	39.5	43.9
Collector	19.9	25	25	30	35
Frontage road	12	12	12	15	15
Ramp	35	35	35	38	39
Centroid connector	13	16	18	20.5	23
Winter Sunday	**CBD**	**Fringe**	**Urban**	**Suburb**	**Rural**
Freeway	27	54.7	57.7	57.9	63
Expressway	16	38.9	44.9	45	48.9
Principal arterial	27	35	37	44.9	47.9
Minor arterial	25	30	35	39.9	44
Collector	20	25	25	30	35
Frontage road	12	12	12	15	15
Ramp	35	35	35	38	39
Centroid connector	13	16	18	20.5	23

Table A-17. Initial Highway Speeds

Summer Weekday	CBD	Fringe	Urban	Suburb	Rural
Freeway	27	54.2	57.1	57.7	63
Expressway	16	38.6	44.7	44.9	48.9
Principal arterial	27	35	36.9	44.7	47.8
Minor arterial	25	29.8	35	39.8	44
Collector	19.9	25	25	30	35
Frontage road	12	12	12	15	15
Ramp	35	35	35	38	39
Centroid connector	13	16	18	20.5	23
Summer Saturday	**CBD**	**Fringe**	**Urban**	**Suburb**	**Rural**
Freeway	27	54.9	57.9	58.4	62.9
Expressway	16	37.8	45	45	49
Principal arterial	27	35	37	44.7	47.3
Minor arterial	25	29.9	35	39.8	43.5
Collector	20	25	25	30	34.9
Frontage road	12	12	12	15	15
Ramp	35	35	35	38	39
Centroid connector	13	16	18	20.5	23
Summer Sunday	**CBD**	**Fringe**	**Urban**	**Suburb**	**Rural**
Freeway	27	53.8	55.8	57.4	62.1
Expressway	16	36.9	44	44.8	49
Principal arterial	27	34.6	36.5	43.9	47.8
Minor arterial	24.9	29.9	34.8	39.1	43.4
Collector	19.9	25	24.8	29.5	34.6
Frontage road	12	12	12	15	15
Ramp	35	35	35	38	39
Centroid connector	13	16	18	20.5	23

Source: J.F. Sato and Associates.

Traffic Simulation Model

One of the primary purposes of these models is to determine congested speeds for various alternatives and model days. These speeds are used for two purposes:

- Display the speeds/travel times in the PEIS report as a means of comparing alternatives
- Provide feedback to the travel demand model so that the congested speeds can be properly accounted for

These speeds and travel times are determined during the model runs. They are dependent on all of the previously mentioned model characteristics. Travel time segments are inserted into the models. At the end of each run, a travel time summary file is produced. Travel times for the entire traffic stream are most commonly used, but travel time for any given vehicle. With these travel times, and known segment distances, speeds can be calculated.

Capacities

Table A-21 through **Table A-26** show the capacities in the six days for peak and off-peak periods. Capacities were calculated using a method based on the *Highway Capacity Manual* methodology (HCM) (Transportation Research Board, National Research Council), with certain adjustments to reflect conditions specific to the study corridor.

Capacities vary with assumed weather conditions, driver familiarity with the segment, and the percentage of trucks, RVs, and buses. For this study, the term capacity is defined as the value between LOS E and F; the greatest number of vehicles consistently able to use a roadway segment in 1 hour. Traffic volumes greater than this value should be expected to be unstable; stop-and-go conditions can occur at any time, and accident rates may be higher than at lower volumes due to the increased complexity of the driving environment.

Capacities are listed as the lowest calculated value within each highway stretch, by direction. Brief descriptions of each of the columns in the capacity charts are as follows:

- **Highway Stretch.** The section of highway in question. Capacities can vary within these sections in each of the models, but this list of sections was chosen to represent the corridor in the summaries.
- **Milepost.** The approximate location of the controlling capacity section within each highway stretch:
- **LOS E Capacity per Lane, Vehicles per Hour per Lane (vphpl).** This is simply the total capacity divided by the number of lanes.
- **Number of lanes (N).** This is the number of through lanes. It does not include short auxiliary lanes that do not continue for the length of the stretch.
- **LOS E Capacity, Vehicles per Hour (vph).** This is the total capacity after all reduction factors, such as the peak-hour factor (PHF) and the population factor (f_p), have been applied. The form of the equation used comes from HCM 1997. *See additional explanation below*.
- **Posted Speed.** The posted regulatory speed (black letters on white sign panel) in the section.
- **Maximum Service Flow (MSF), Vehicles per Hour per Lane (vphpl).** The maximum flow for the given posted speed, under ideal conditions. This assumes that all cars are passenger cars and that none of the capacity reduction factors, such as the peak-hour factor (PHF) and the population factor (f_p), are applied. These values come from the 2000 HCM.
- **Minimum Shoulder Width (feet).** This helps in defining the width factor (f_w).
- **1 or 2 sides?** This helps in defining the width factor (f_w). It specifies whether the minimum shoulder width occurs on both sides of the highway or on only one. The value is typically 1, such as when the inside shoulder is 4 feet wide and the outside shoulder width is 10 feet wide. The value of 2 usually indicates that I-70 is in a tunnel, such as at the Twin Tunnels, where the shoulder is 2 feet on each side.
- **Lane Width (feet).** This helps in defining the width factor (f_w). It is always 12 feet in the Corridor.
- **Grade.** Is the critical section of the highway stretch flat, uphill (up) or downhill (down)?
- **Percent Grade.** What is the percent grade on the controlling (lowest capacity) section of the highway stretch? This helps to define the heavy-vehicle factor (f_{HV}).
- **Grade Length (mi).** What is the length of that grade? This helps to define the heavy-vehicle factor (f_{HV}).

- **Peak-Hour Factor (PHF).** An indicator of flow variability throughout the hour. It equals the peak-hour volume divided by four times the peak-15-minute volume
- **Weather Factor ($f_{weather}$).** Accounts for the greater chance of snow and ice in winter found at higher elevations. It is a factor that was created for this study. *See additional explanation below.*
- **Width Factor (f_w).** Accounts for variability in shoulder and lane width. This factor was explicitly included in HCM 1997 as a factor in the capacity calculation. In HCM 2000, it comes in when calculating the Free-Flow Speed (FFS), which leads to speed (s), density (d), and LOS.
- **Population Factor (f_p).** Accounts for the prior knowledge of drivers as they drive each segment. During the weekdays, more drivers are assumed to be familiar with each highway segment, and thus driving faster and at a closer headway to the vehicle in front of them. On the weekends, however, more drivers are from out of state and are assumed to drive with a longer headway, thus reducing the capacity of each affected segment.
- **Heavy-Vehicle Factor (f_{HV}).** Accounts for the impact of slow-moving trucks, buses, and RVs on the traffic stream. *See additional explanation below.*

LOS E Capacity Equation

The capacity equation in HCM 1997 is as follows:

$$MSF_i = \frac{V_i}{\left(PHF \cdot N \cdot f_w \cdot f_{HV} \cdot f_p\right)}.$$

The *i* subscript represents the different LOS values, A to E. To calculate capacity directly, the equation can be manipulated to the following format (shown with the addition of the weather factor):

$$Capacity_{\text{LOS E}} = V_{\text{LOS E}} = MSF_{\text{LOS E}}\left(PHF \cdot N \cdot f_w \cdot f_{HV} \cdot f_p \cdot f_{weather}\right)$$

It was decided that the 1997 equation form is being used because the 2000 equation no longer provides an explicit calculation of capacity. The MSF values from HCM 2000 were used because those were considered to be a positive improvement in the understanding of high capacity.

To determine capacities throughout the Corridor, locations and times where capacity is directly measured were investigated. This allowed us to help determine values for the equation factors. The capacity values at these locations are provided in Table A-18 and Table A-19.

Table A-18. Basis for Westbound Capacity Values

<table>
<tr><th rowspan="2">Location</th><th rowspan="2">Model Day</th><th colspan="2">PEIS Capacity</th><th rowspan="2" colspan="5">Basis for Value</th></tr>
<tr><th>Total</th><th>Per Lane</th></tr>
<tr><td>Hyland Hills – US 6 Gaming</td><td>Winter Weekend</td><td>3,648</td><td>1,824</td><td colspan="5">2-23-02: Observed congested flow for a period of about 4 hours, w/ no noted incidents</td></tr>
<tr><td>Twin Tunnels</td><td>Winter Weekend</td><td>3,501</td><td>1,751</td><td colspan="5">Data from Twin Tunnels (TT) ATR for 2-23-02 (Saturday)</td></tr>
<tr><td rowspan="2">Hyland Hills – US 6 Gaming</td><td rowspan="2">Summer Weekend</td><td rowspan="2">3,575</td><td rowspan="2">1,788</td><td>6-7 AM</td><td>7-8 AM</td><td>8-9 AM</td><td>9-10 AM</td><td>10-11 AM</td></tr>
<tr><td>3,426</td><td>3,533</td><td>3,001</td><td>3,050</td><td>2,823</td></tr>
<tr><td>Twin Tunnels</td><td>Summer Weekend</td><td>3,431</td><td>1,716</td><td colspan="5">2000 Data from TT ATR:
High = 3,971; 2nd High = 3,922; 30th High = 3,458</td></tr>
</table>

		PEIS Capacity		
Location	Model Day	Total	Per Lane	Basis for Value
Georgetown Hill	Summer Weekend	2,627	1,314	Research Project in Summer 2001 (field data from 7-20 & 7-21-01) Value is greater than HCM 1997, but less than HCM 2000

Note: Winter values are before applying weather factor (that is, $f_{weather} = 1.0$)

Table A-19. Basis for Eastbound Capacity Values

		PEIS Capacity		
Location	Model Day	Total	per Lane	Basis for Value
Eisenhower-Johnson Memorial Tunnels (EJMT)	Summer Weekend	2,853	1,427	ATR indicates capacity (as evidenced by frequent queues), as the two-lane section just east of merge controls capacity. 2000 Data from EJMT ATR: High = 2,869; 2nd High = 2,825; 30th High = 2,488
East of Empire Junction	Summer Weekend	3,734	1,867	9-03-01: Observed congested flow for a period of at least 4 hours, w/ no noted incidents. (This was Labor Day, Monday)
Twin Tunnels	Summer Weekend	3,431	1,716	ATR indicates capacity (as evidenced by frequent queues). 2000 Data from Twin Tunnels ATR: High = 3,730; 2nd High = 3,529; 30th High = 3,331

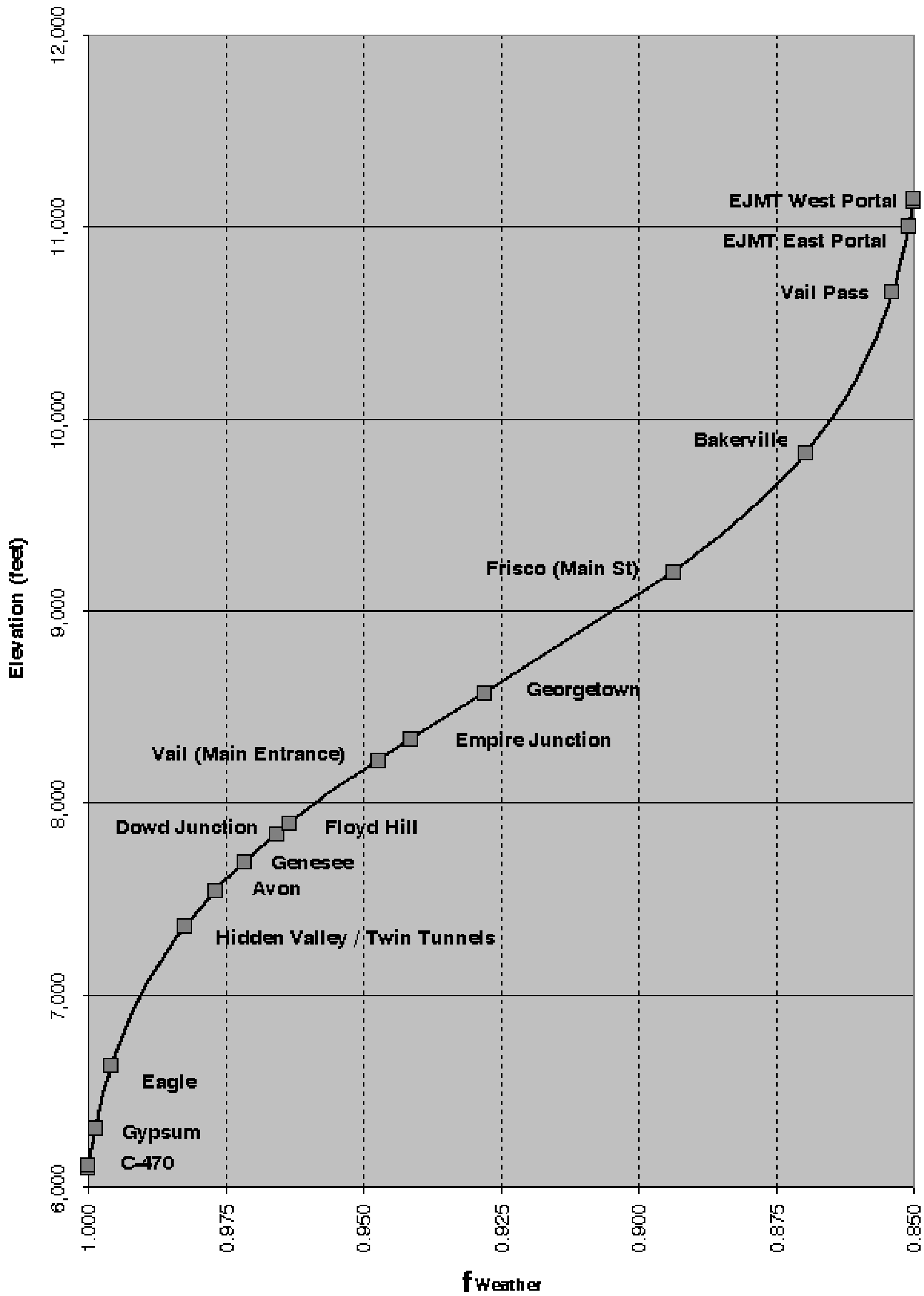
Weather Factor

The weather factor ($f_{weather}$) accounts for the likelihood of snow and ice on the road during the winter. It represents an average value covering the entire winter season. The factor suggests that with snow and ice on the highway, drivers reduce their vehicle speed and increase their headway, thus reducing the capacity of the affected highway segment. The factor is a function of elevation with the expectation that snow and ice are encountered more frequently at higher elevations within the corridor. The factor was developed to use a logistic curve fitted to earlier professional judgments of a reasonable weather factor. This curve is shown in Chart A-4. The weather factor takes a value of 1.0 at the lowest elevations (such as near C-470), and a value of 0.85 at the Eisenhower-Johnson Memorial Tunnels west portal, the highest point on I-70 in the Corridor. The weather factor is calculated as:

$$f_{weather} = 1.004 - \frac{0.158}{1 + \exp(12.538 - 0.00145 * elevation)}$$

where elevation is in feet above sea level.

Chart A-4. Relationship Between Elevation and Weather



Factor

Source: J.F. Sato and Associates

Heavy-Vehicle Factor

The heavy-vehicle factor (f_{HV}) accounts for the impact of heavy vehicles on highway capacity. The equation in the HCM (1997 or 2000) is as follows:

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$$

where E is the passenger-car equivalent and P is the percentage of the overall traffic composition. The T subscripts are for trucks and the R subscripts are for recreational vehicles.

It was decided that new E values needed to be specifically determined for the I-70 PEIS for the following reasons:

- The E values changed substantially from HCM 1997 to HCM 2000, as shown in **Table A-20**.
- There was no field verification of these changes.
- Only two types of heavy vehicles are referenced, trucks and RVs. In reality, there are considerable differences in performance between the two truck classes and between the two RV classes previously described.
- The HCM E values for downgrades show very little impact from heavy-vehicles. Field observation indicates that these impacts are under-estimated.

HCM 2000 indicates that the impact of trucks on highway capacity is substantially less than HCM 1997 indicated. **Table A-20** shows the values for the passenger-car equivalent value for trucks, E_T, and the difference in capacity between HCM 1997 and HCM 2000.

Table A-20. Passenger-Car Equivalent Between HCM 1997 and HCM 2000

Manual	Grade	Length of Grade	E_T Value	LOS E Capacity
HCM 1997	6% Up Hill	> 1 Miles	15	2,384 veh/hour
HCM 2000	6% Up Hill	> 1 Miles	7	3,014 veh/hour

Note: Capacity calculations based on 2 percent trucks and 4 percent RVs.

A report titled "Assessment of the passenger-car equivalents for trucks contained in the 2000 Highway Capacity Manual (HCM)" describes the assessment of appropriate E values for westbound traffic near Georgetown, which is available upon request. As part of that study, traffic in the Georgetown Flats and Georgetown Hill areas was counted, observed and videotaped during the following periods:

- Friday, July 20 from 3:30 PM to 5:00 PM
- Saturday, July 21 from 9:00 AM – 1:00 PM

The 1997 HCM capacity value agreed fairly well with the maximum observed volumes at the Georgetown Hill location. The 2000 value indicates that it is possible to move over 600 vehicles per hour more if sufficient demand volume approaching the hill were there. Based on visual observation of the traffic flow of more than 2,200 vph on Georgetown Hill, it was deemed unreasonable that a capacity of 3,000 vph can be achieved. This judgment was primarily based on observation of the distribution of traffic between the two lanes, along with the speeds and densities in each lane. A capacity of 2,500 or 2,600 vph seems more appropriate.

Using this as the capacity for the given traffic composition, new E_i (passenger-car equivalent for i^{th} heavy-vehicle type) values for I-70 are determined. These values are somewhere between HCM 1997 and

HCM 2000. From this starting point, a new set of E_i values was determined for use in the capacity calculations. For downgrades, the E_T values for semi-trucks from HCM 2000 (and HCM 1997) for section lengths greater than 4 miles were used for this study. These values were used for shorter steep grades, however, because field observation indicated that this is appropriate for the unique travel conditions on I-70. The E_i on downgrades for the remaining vehicle types (including single-unit trucks) are the same as for flat sections.

The methodology for determining the E_i values for upgrade sections is as follows:

- Calibrate VISSIM model for specific locations with desired physical and traffic flow characteristics (such as grades, curves, and merge/diverge areas) along I-70 Corridor.
- Obtain vehicle counts (simulated ATR counts) from several VISSIM runs at these specific locations.
- Vary traffic compositions between different VISSIM runs, to obtain an array of counts for different heavy-vehicle percentages and grades
- Calculate f_{HV} (heavy-vehicle adjustment factor) as the ratio of vehicle counts under two specific conditions: 100 percent cars and any specified percentage of heavy vehicle (where only one kind of heavy vehicle is used in any specific run, that is, there are only two vehicles types).
- Calculate E_i values, from f_{HV} obtained above, based on the HCM formula
- $f_{HV} = \dfrac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1) + \ldots + P_i(E_i - 1)}$
- Where,
- E_T, E_R, E_i = passenger car equivalents for trucks/buses, recreational vehicles (RV) and i^{th} vehicle type, respectively
- P_T, P_R, P_i = proportion of trucks/buses, RV and i^{th} vehicle type in the traffic stream, respectively.
- Calculate a set of E_i values for each of the following: Semi, Single-unit trucks, Low-performance RV and High-performance RV.
- Interpolate, if necessary, between the results obtained above to get E_i values for different grades or percent heavy vehicles.

Table A-21. Existing (2000) Capacity: Winter Weekend, Eastbound

Highway Stretch	Milepost	LOS E Capacity per Lane (vphpl)	Number of Lanes	Total LOS E Capacity (vph)	Posted Speed (mph)	Max Service Flow (vphpl)	Minimum Shoulder (ft)	1 or 2 sides?	Lane Width (ft)	Grade	Pct. Grade	Grade Length (mi)	PHF	$f_{weather}$	f_w	f_P	f_{HV}
Glenwood Canyon	130	1,480	2	2,950	50	2,200	2	1	12	flat			0.85	1.00	0.97	0.85	0.92
Dotsero-Gypsum	135	1,480	2	2,960	75	2,400	4	1	12	up	3.0	0.50	0.85	1.00	0.99	0.85	0.83
Gypsum-Eagle	145	1,310	2	2,630	75	2,400	4	1	12	up	5.0	1.25	0.85	1.00	0.99	0.85	0.74
Eagle-Wolcott (SH 131)	152	1,530	2	3,060	75	2,400	4	1	12	up	2.0	1.00	0.85	0.99	0.99	0.85	0.87
Wolcott (SH 131)-Edwards	160	1,450	2	2,910	75	2,400	4	1	12	up	3.0	0.25	0.85	0.98	0.99	0.85	0.83
Edwards-Avon	165	1,450	2	2,890	75	2,400	4	1	12	up	3.0	0.25	0.85	0.98	0.99	0.85	0.83
Avon-Minturn	169	1,200	2	2,400	60	2,300	4	1	12	up	5.0	1.25	0.85	0.95	0.99	0.85	0.74
Minturn-W Vail	172	1,350	2	2,700	60	2,300	4	1	12	up	3.0	0.75	0.85	0.95	0.99	0.85	0.83
W Vail-Vail	175	1,370	2	2,750	65	2,350	4	1	12	up	3.0	1.00	0.85	0.95	0.99	0.85	0.83
Vail-E Vail	178	1,580	2	3,160	65	2,350	4	1	12	up	2.0	1.00	0.95	0.93	0.99	0.85	0.87
E Vail-Vail Pass	185	1,090	2	2,170	65	2,350	4	1	12	up	7.0	4.00	0.95	0.85	0.99	0.85	0.65
Vail Pass-Copper Mountain	193	1,560	2	3,120	65	2,350	4	1	12	down	-5.0	5.50	0.95	0.85	0.99	0.90	0.88
Copper Mountain-Tenmile	196	1,490	2	2,990	65	2,350	4	1	12	up	3.0	0.25	0.95	0.87	0.99	0.90	0.83
Tenmile-Officers Gulch	197	1,660	2	3,320	65	2,350	4	1	12	down	-5.0	1.25	0.95	0.87	0.99	0.90	0.92
Officers Gulch-Frisco Main	199	1,660	2	3,320	65	2,350	4	1	12	down	-5.0	1.25	0.95	0.87	0.99	0.90	0.92
Frisco Main-9	202	1,700	2	3,400	65	2,350	4	1	12	flat			0.95	0.89	0.99	0.90	0.92
Frisco 9-Dillon Overlook	203	1,530	2	3,050	65	2,350	4	1	12	up	3.0	0.75	0.95	0.89	0.99	0.90	0.83
Dillon Overlook-Silverthorne	204	1,700	2	3,390	65	2,350	4	1	12	down	-5.0	1.00	0.95	0.89	0.99	0.90	0.92
Silverthorne-Lane Drop	208	1,210	3	3,620	60	2,300	4	1	12	up	7.0	3.00	0.95	0.85	0.99	0.90	0.70
Lane Drop-EJMT	213	1,200	2	2,400	50	2,200	2	2	12	up	6.0	1.00	0.95	0.85	0.99	0.95	0.69
Johnson Tunnel	214	1,460	2	2,910	50	2,200	2	2	12	down	-2.0	0.25	0.95	0.85	0.95	0.90	0.92
Loveland Pass-Herman Gulch	217	1,410	2	2,820	65	2,350	2	2	11	down	-6.0	1.25	0.95	0.85	0.90	0.90	0.88
Herman Gulch-Bakerville	220	1,560	2	3,130	65	2,350	4	1	12	down	-4.0	0.75	0.95	0.86	0.99	0.90	0.88
Bakerville-Silver Plume	223	1,590	2	3,170	65	2,350	4	1	12	down	-4.0	1.25	0.95	0.87	0.99	0.90	0.88

Highway Stretch	Milepost	LOS E Capacity per Lane (vphpl)	Number of Lanes	Total LOS E Capacity (vph)	Posted Speed (mph)	Max Service Flow (vphpl)	Minimum Shoulder (ft)	1 or 2 sides?	Lane Width (ft)	Grade	Pct. Grade	Grade Length (mi)	PHF	$f_{weather}$	f_w	f_P	f_{HV}
Silver Plume-Georgetown	227	1,630	2	3,270	65	2,350	4	1	12	down	-6.0	1.50	0.95	0.89	0.99	0.90	0.88
Georgetown-Empire	230	1,770	2	3,540	65	2,350	4	1	12	down	-3.0	0.50	0.95	0.93	0.99	0.90	0.92
Empire-Downieville	233	1,790	2	3,590	65	2,350	4	1	12	down	-3.0	0.75	0.95	0.94	0.99	0.90	0.92
Downieville-Dumont	234	1,820	2	3,650	65	2,350	4	1	12	down	-3.0	0.75	0.95	0.96	0.99	0.90	0.92
Dumont-Fall River Rd	236	1,830	2	3,650	65	2,350	4	1	12	down	-3.0	0.25	0.95	0.96	0.99	0.90	0.92
Fall River Rd-Idaho Springs	238	1,840	2	3,690	65	2,350	4	1	12	flat			0.95	0.97	0.99	0.90	0.92
Idaho Springs West-103	239	1,820	2	3,630	60	2,300	4	1	12	flat			0.95	0.97	0.99	0.90	0.92
Idaho Springs 103-Water Wheel	239	1,620	2	3,240	60	2,300	3	1	12	up	3.0	0.25	0.95	0.97	0.98	0.90	0.83
Idaho Springs Water Wheel-East	240	1,800	2	3,600	60	2,300	3	1	12	down	-3.0	0.50	0.95	0.97	0.98	0.90	0.92
Twin Tunnels	242	1,710	2	3,420	55	2,250	2	2	12	flat			0.95	0.98	0.95	0.90	0.92
Hidden Valley-US 6 Gaming	244	1,790	2	3,580	55	2,250	4	1	12	flat			0.95	0.98	0.99	0.90	0.92
US 6 Gaming-Hyland Hills	245	1,560	3	4,680	65	2,350	4	1	12	up	6.0	1.75	0.95	0.96	0.99	0.95	0.74
Hyland Hills-Beaver Brook	248	1,940	3	5,810	65	2,350	4	1	12	down	-6.0	1.00	0.95	0.96	0.99	0.95	0.92
Beaver Brook-Evergreen	250	1,580	3	4,730	65	2,350	4	1	12	up	6.0	0.75	0.95	0.98	0.99	0.95	0.74
Evergreen-Chief Hosa	252	1,970	3	5,920	65	2,350	8	1	12	down	-5.0	0.75	0.95	0.97	1.00	0.95	0.92
Chief Hosa-Genesee	253	1,630	3	4,900	65	2,350	4	1	12	up	5.0	0.35	0.95	0.97	0.99	0.95	0.77
Genesee-Lookout Mountain	255	1,790	3	5,380	55	2,250	4	1	12	down	-6.0	1.50	0.95	0.97	0.99	0.95	0.88
Lookout Mountain-Morrison	257	1,830	3	5,480	55	2,250	4	1	12	down	-6.0	2.25	0.95	0.99	0.99	0.95	0.88
Morrison-C-470	259	1,840	3	5,520	55	2,250	4	1	12	down	-4.0	1.25	0.95	1.00	0.99	0.95	0.88
C-470-Denver	261	2,010	3	6,030	65	2,350	4	1	12	flat			0.95	1.00	0.99	0.95	0.92

Notes: Capacity values in the table are rounded after computations. Corridor-wide heavy vehicle fractions are 1.8 percent combination-unit trucks, 1.2 percent single-unit trucks, and 4 percent recreational vehicles. Buses are included as single-unit trucks.

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Table A-22. Existing (2000) Capacity: Summer Weekend, Eastbound

Highway Stretch	Milepost	LOS E Capacity per Lane (pcphpl)	Number of Lanes	Total LOS E Capacity (pcph)	Posted Speed (mph)	Max Service Flow (pcphpl)	Minimum Shoulder (ft)	1 or 2 sides?	Lane Width (ft)	Grade	Pct. Grade	Grade Length (mi)	PHF	$f_{weather}$	f_w	f_P	f_{HV}
Glenwood Canyon	130	1,490	2	2,970	50	2,200	2	1	12	flat			0.85	1.00	0.97	0.85	0.93
Dotsero-Gypsum	135	1,490	2	2,970	75	2,400	4	1	12	up	3.0	0.50	0.85	1.00	0.99	0.85	0.83
Gypsum-Eagle	145	1,330	2	2,660	75	2,400	4	1	12	up	5.0	1.25	0.85	1.00	0.99	0.85	0.74
Eagle-Wolcott (SH 131)	152	1,550	2	3,110	75	2,400	4	1	12	up	2.0	1.00	0.85	1.00	0.99	0.85	0.87
Wolcott (SH 131)-Edwards	160	1,490	2	2,970	75	2,400	4	1	12	up	3.0	0.25	0.85	1.00	0.99	0.85	0.83
Edwards-Avon	165	1,490	2	2,970	75	2,400	4	1	12	up	3.0	0.25	0.85	1.00	0.99	0.85	0.83
Avon-Minturn	169	1,270	2	2,550	60	2,300	4	1	12	up	5.0	1.25	0.85	1.00	0.99	0.85	0.74
Minturn-W Vail	172	1,430	2	2,850	60	2,300	4	1	12	up	3.0	0.75	0.85	1.00	0.99	0.85	0.83
W Vail-Vail	175	1,460	2	2,910	65	2,350	4	1	12	up	3.0	1.00	0.85	1.00	0.99	0.85	0.83
Vail-E Vail	178	1,700	2	3,400	65	2,350	4	1	12	up	2.0	1.00	0.95	1.00	0.99	0.85	0.87
E Vail-Vail Pass	185	1,280	2	2,560	65	2,350	4	1	12	up	7.0	4.00	0.95	1.00	0.99	0.85	0.65
Vail Pass-Copper Mountain	193	1,850	2	3,700	65	2,350	4	1	12	down	-5.0	5.50	0.95	1.00	0.99	0.90	0.89
Copper Mountain-Tenmile	196	1,720	2	3,450	65	2,350	4	1	12	up	3.0	0.25	0.95	1.00	0.99	0.90	0.83
Tenmile-Officers Gulch	197	1,920	2	3,830	65	2,350	4	1	12	down	-5.0	1.25	0.95	1.00	0.99	0.90	0.93
Officers Gulch-Frisco Main	199	1,920	2	3,830	65	2,350	4	1	12	down	-5.0	1.25	0.95	1.00	0.99	0.90	0.93
Frisco Main-9	202	1,920	2	3,830	65	2,350	4	1	12	flat			0.95	1.00	0.99	0.90	0.93
Frisco 9-Dillon Overlook	203	1,720	2	3,450	65	2,350	4	1	12	up	3.0	0.75	0.95	1.00	0.99	0.90	0.83
Dillon Overlook-Silverthorne	204	1,920	2	3,830	65	2,350	4	1	12	down	-5.0	1.00	0.95	1.00	0.99	0.90	0.93
Silverthorne-Lane Drop	208	1,430	3	4,280	60	2,300	4	1	12	up	7.0	3.00	0.95	1.00	0.99	0.90	0.70
Lane Drop-EJMT	213	1,430	2	2,850	50	2,200	4	1	12	up	6.0	1.00	0.95	1.00	0.99	0.95	0.70
Johnson Tunnel	214	1,680	2	3,360	50	2,200	2	2	12	down	-2.0	0.25	0.95	1.00	0.95	0.90	0.90
Loveland Pass-Herman Gulch	217	1,620	2	3,240	65	2,350	2	2	11	down	-6.0	1.25	0.95	1.00	0.90	0.90	0.86
Herman Gulch-Bakerville	220	1,780	2	3,560	65	2,350	4	1	12	down	-4.0	0.75	0.95	1.00	0.99	0.90	0.86
Bakerville-Silver Plume	223	1,780	2	3,560	65	2,350	4	1	12	down	-4.0	1.25	0.95	1.00	0.99	0.90	0.86

Highway Stretch	Milepost	LOS E Capacity per Lane (pcphpl)	Number of Lanes	Total LOS E Capacity (pcph)	Posted Speed (mph)	Max Service Flow (pcphpl)	Minimum Shoulder (ft)	1 or 2 sides?	Lane Width (ft)	Grade	Pct. Grade	Grade Length (mi)	PHF	$f_{weather}$	f_w	f_p	f_{HV}
Silver Plume-Georgetown	227	1,780	2	3,560	65	2,350	4	1	12	down	-6.0	1.50	0.95	1.00	0.99	0.90	0.86
Georgetown-Empire	230	1,870	2	3,730	65	2,350	4	1	12	down	-3.0	0.50	0.95	1.00	0.99	0.90	0.90
Empire-Downieville	233	1,870	2	3,730	65	2,350	4	1	12	down	-3.0	0.75	0.95	1.00	0.99	0.90	0.90
Downieville-Dumont	234	1,870	2	3,730	65	2,350	4	1	12	down	-3.0	0.75	0.95	1.00	0.99	0.90	0.90
Dumont-Fall River Rd	236	1,870	2	3,730	65	2,350	4	1	12	down	-3.0	0.25	0.95	1.00	0.99	0.90	0.90
Fall River Rd-Idaho Springs	238	1,870	2	3,730	65	2,350	4	1	12	flat			0.95	1.00	0.99	0.90	0.90
Idaho Springs West-103	239	1,830	2	3,660	60	2,300	4	1	12	flat			0.95	1.00	0.99	0.90	0.90
Idaho Springs 103-Water Wheel	239	1,580	2	3,160	60	2,300	3	1	12	up	3.0	0.25	0.95	1.00	0.98	0.90	0.79
Idaho Springs Water Wheel-East	240	1,810	2	3,620	60	2,300	3	1	12	down	-3.0	0.50	0.95	1.00	0.98	0.90	0.90
Twin Tunnels	242	1,720	2	3,430	55	2,250	2	2	12	flat			0.95	1.00	0.95	0.90	0.90
Hidden Valley-US 6 Gaming	244	1,790	2	3,580	55	2,250	4	1	12	flat			0.95	1.00	0.99	0.90	0.90
US 6 Gaming-Hyland Hills	245	1,500	3	4,480	65	2,350	4	1	12	up	6.0	1.75	0.95	1.00	0.99	0.95	0.68
Hyland Hills-Beaver Brook	248	1,970	3	5,910	65	2,350	4	1	12	down	-6.0	1.00	0.95	1.00	0.99	0.95	0.90
Beaver Brook-Evergreen	250	1,500	3	4,480	65	2,350	4	1	12	up	6.0	0.75	0.95	1.00	0.99	0.95	0.68
Evergreen-Chief Hosa	252	1,990	3	5,970	65	2,350	8	1	12	down	-5.0	0.75	0.95	1.00	1.00	0.95	0.90
Chief Hosa-Genesee	253	1,560	3	4,690	65	2,350	4	1	12	up	5.0	0.35	0.95	1.00	0.99	0.95	0.72
Genesee-Lookout Mountain	255	1,800	3	5,400	55	2,250	4	1	12	down	-6.0	1.50	0.95	1.00	0.99	0.95	0.86
Lookout Mountain-Morrison	257	1,800	3	5,400	55	2,250	4	1	12	down	-6.0	2.25	0.95	1.00	0.99	0.95	0.86
Morrison-C-470	259	1,800	3	5,400	55	2,250	4	1	12	down	-4.0	1.25	0.95	1.00	0.99	0.95	0.86
C-470-Denver	261	1,970	3	5,910	65	2,350	4	1	12	flat			0.95	1.00	0.99	0.95	0.90

Notes: Capacity values in the table are rounded after computations. Heavy vehicle fractions in the western network (Glenwood Springs to EJMT) are 1.5 percent combination-unit trucks, 2 percent single-unit trucks and 3 percent recreational vehicles. In the eastern network, they are 2 percent, 2 percent, and 5 percent, respectively. Buses are included as single-unit trucks.

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Table A-23. Existing (2000) Capacity: Summer Weekday, Eastbound

Highway Stretch	Milepost	LOS E Capacity per Lane (pcphpl)	Number of Lanes	Total LOS E Capacity (pcph)	Posted Speed (mph)	Max Service Flow (pcphpl)	Minimum Shoulder (ft)	1 or 2 sides?	Lane Width (ft)	Grade	Pct. Grade	Grade Length (mi)	PHF	$f_{weather}$	f_w	f_P	f_{HV}
Glenwood Canyon	130	1,650	2	3,290	50	2,200	2	1	12	flat			0.85	1.00	0.97	0.95	0.92
Dotsero-Gypsum	135	1,610	2	3,220	75	2,400	4	1	12	up	3.0	0.50	0.85	1.00	0.99	0.95	0.81
Gypsum-Eagle	145	1,420	2	2,830	75	2,400	4	1	12	up	5.0	1.25	0.85	1.00	0.99	0.95	0.71
Eagle-Wolcott (SH 131)	152	1,700	2	3,400	75	2,400	4	1	12	up	2.0	1.00	0.85	1.00	0.99	0.95	0.85
Wolcott (SH 131)-Edwards	160	1,610	2	3,220	75	2,400	4	1	12	up	3.0	0.25	0.85	1.00	0.99	0.95	0.81
Edwards-Avon	165	1,610	2	3,220	75	2,400	4	1	12	up	3.0	0.25	0.85	1.00	0.99	0.95	0.81
Avon-Minturn	169	1,360	2	2,710	60	2,300	4	1	12	up	5.0	1.25	0.85	1.00	0.99	0.95	0.71
Minturn-W Vail	172	1,540	2	3,090	60	2,300	4	1	12	up	3.0	0.75	0.85	1.00	0.99	0.95	0.81
W Vail-Vail	175	1,580	2	3,150	65	2,350	4	1	12	up	3.0	1.00	0.85	1.00	0.99	0.95	0.81
Vail-E Vail	178	1,860	2	3,720	65	2,350	4	1	12	up	2.0	1.00	0.95	1.00	0.99	0.95	0.85
E Vail-Vail Pass	185	1,330	2	2,670	65	2,350	4	1	12	up	7.0	4.00	0.95	1.00	0.99	0.95	0.61
Vail Pass-Copper Mountain	193	1,910	2	3,830	65	2,350	4	1	12	down	-5.0	5.50	0.95	1.00	0.99	0.95	0.88
Copper Mountain-Tenmile	196	1,760	2	3,530	65	2,350	4	1	12	up	3.0	0.25	0.95	1.00	0.99	0.95	0.81
Tenmile-Officers Gulch	197	2,010	2	4,010	65	2,350	4	1	12	down	-5.0	1.25	0.95	1.00	0.99	0.95	0.92
Officers Gulch-Frisco Main	199	2,010	2	4,010	65	2,350	4	1	12	down	-5.0	1.25	0.95	1.00	0.99	0.95	0.92
Frisco Main-9	202	2,010	2	4,010	65	2,350	4	1	12	flat			0.95	1.00	0.99	0.95	0.92
Frisco 9-Dillon Overlook	203	1,760	2	3,530	65	2,350	4	1	12	up	3.0	0.75	0.95	1.00	0.99	0.95	0.81
Dillon Overlook-Silverthorne	204	2,010	2	4,010	65	2,350	4	1	12	down	-5.0	1.00	0.95	1.00	0.99	0.95	0.92
Silverthorne-Lane Drop	208	1,410	3	4,240	60	2,300	4	1	12	up	7.0	3.00	0.95	1.00	0.99	0.95	0.66
Lane Drop-EJMT	213	1,350	2	2,700	50	2,200	4	1	12	up	6.0	1.00	0.95	1.00	0.99	0.95	0.66
Johnson Tunnel	214	1,740	2	3,490	50	2,200	2	2	12	down	-2.0	0.25	0.95	1.00	0.95	0.95	0.89
Loveland Pass-Herman Gulch	217	1,610	2	3,230	65	2,350	2	2	11	down	-6.0	1.25	0.95	1.00	0.90	0.95	0.81
Herman Gulch-Bakerville	220	1,770	2	3,550	65	2,350	4	1	12	down	-4.0	0.75	0.95	1.00	0.99	0.95	0.81
Bakerville-Silver Plume	223	1,770	2	3,550	65	2,350	4	1	12	down	-4.0	1.25	0.95	1.00	0.99	0.95	0.81
Silver Plume-Georgetown	227	1,770	2	3,550	65	2,350	4	1	12	down	-6.0	1.50	0.95	1.00	0.99	0.95	0.81

Highway Stretch	Milepost	LOS E Capacity per Lane (pcphpl)	Number of Lanes	Total LOS E Capacity (pcph)	Posted Speed (mph)	Max Service Flow (pcphpl)	Minimum Shoulder (ft)	1 or 2 sides?	Lane Width (ft)	Grade	Pct. Grade	Grade Length (mi)	PHF	$f_{weather}$	f_w	f_P	f_{HV}
Georgetown-Empire	230	1,940	2	3,880	65	2,350	4	1	12	down	-3.0	0.50	0.95	1.00	0.99	0.95	0.89
Empire-Downieville	233	1,940	2	3,880	65	2,350	4	1	12	down	-3.0	0.75	0.95	1.00	0.99	0.95	0.89
Downieville-Dumont	234	1,940	2	3,880	65	2,350	4	1	12	down	-3.0	0.75	0.95	1.00	0.99	0.95	0.89
Dumont-Fall River Rd	236	1,940	2	3,880	65	2,350	4	1	12	down	-3.0	0.25	0.95	1.00	0.99	0.95	0.89
Fall River Rd-Idaho Springs	238	1,940	2	3,880	65	2,350	4	1	12	flat			0.95	1.00	0.99	0.95	0.89
Idaho Springs West-103	239	1,900	2	3,800	60	2,300	4	1	12	flat			0.95	1.00	0.99	0.95	0.89
Idaho Springs 103-Water Wheel	239	1,560	2	3,110	60	2,300	3	1	12	up	3.0	0.25	0.95	1.00	0.98	0.95	0.74
Idaho Springs Water Wheel-East	240	1,880	2	3,760	60	2,300	3	1	12	down	-3.0	0.50	0.95	1.00	0.98	0.95	0.89
Twin Tunnels	242	1,780	2	3,570	55	2,250	2	2	12	flat			0.95	1.00	0.95	0.95	0.89
Hidden Valley-US 6 Gaming	244	1,860	2	3,720	55	2,250	4	1	12	flat			0.95	1.00	0.99	0.95	0.89
US 6 Gaming-Hyland Hills	245	1,400	3	4,200	65	2,350	4	1	12	up	6.0	1.75	0.95	1.00	0.99	1.00	0.61
Hyland Hills-Beaver Brook	248	2,040	3	6,130	65	2,350	4	1	12	down	-6.0	1.00	0.95	1.00	0.99	1.00	0.89
Beaver Brook-Evergreen	250	1,400	3	4,200	65	2,350	4	1	12	up	6.0	0.75	0.95	1.00	0.99	1.00	0.61
Evergreen-Chief Hosa	252	2,060	3	6,190	65	2,350	8	1	12	down	-5.0	0.75	0.95	1.00	1.00	1.00	0.89
Chief Hosa-Genesee	253	1,480	3	4,450	65	2,350	4	1	12	up	5.0	0.35	0.95	1.00	0.99	1.00	0.65
Genesee-Lookout Mountain	255	1,790	3	5,360	55	2,250	4	1	12	down	-6.0	1.50	0.95	1.00	0.99	1.00	0.81
Lookout Mountain-Morrison	257	1,790	3	5,360	55	2,250	4	1	12	down	-6.0	2.25	0.95	1.00	0.99	1.00	0.81
Morrison-C-470	259	1,790	3	5,360	55	2,250	4	1	12	down	-4.0	1.25	0.95	1.00	0.99	1.00	0.81
C-470-Denver	261	2,040	3	6,130	65	2,350	4	1	12	flat			0.95	1.00	0.99	1.00	0.89

Notes: Capacity values in the table are rounded after computations. Heavy-vehicle fractions in the western network (Glenwood Springs to EJMT) are 2 percent combination-unit trucks, 2 percent single-unit trucks, and 3 percent recreational vehicles. In the eastern network, they are 4 percent, 2 percent, and 3 percent, respectively. Buses are included as single-unit trucks.

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Table A-24. Existing (2000) Capacity: Winter Weekend, Westbound

Highway Stretch	Milepost	LOS E Capacity per Lane (pcphpl)	Number of Lanes	Total LOS E Capacity (pcph)	Posted Speed (mph)	Max Service Flow (pcphpl)	Minimum Shoulder (ft)	1 or 2 sides?	Lane Width (ft)	Grade	Pct. Grade	Grade Length (mi)	PHF	$f_{weather}$	f_w	f_P	f_{HV}
Denver-C-470	261	2,010	3	6,030	65	2,350	4	1	12	flat			0.95	1.00	0.99	0.95	0.92
C-470-Morrison	259	1,750	3	5,260	65	2,350	4	1	12	up	4.0	1.25	0.95	1.00	0.99	0.95	0.80
Morrison-Lookout Mountain	257	1,600	3	4,810	65	2,350	4	1	12	up	6.0	2.25	0.95	0.99	0.99	0.95	0.74
Lookout Mountain-Genesee	255	1,570	3	4,720	65	2,350	4	1	12	up	6.0	1.50	0.95	0.97	0.99	0.95	0.74
Genesee-Chief Hosa	253	1,950	3	5,860	65	2,350	4	1	12	down	-5.0	0.35	0.95	0.97	0.99	0.95	0.92
Chief Hosa-Evergreen	252	1,650	3	4,950	65	2,350	8	1	12	up	5.0	0.75	0.95	0.97	1.00	0.95	0.77
Evergreen-Beaver Brook	250	1,640	3	4,910	65	2,350	4	1	12	up	5.0	0.60	0.95	0.98	0.99	0.95	0.77
Beaver Brook-Hyland Hills	248	1,490	3	4,480	55	2,250	4	1	12	up	6.0	1.00	0.95	0.96	0.99	0.95	0.74
Hyland Hills-US 6 Gaming	245	1,760	2	3,510	55	2,250	4	1	12	down	-6.0	1.75	0.95	0.96	0.99	0.90	0.92
US 6 Gaming-Hidden Valley	244	1,790	2	3,580	55	2,250	4	1	12	flat			0.95	0.98	0.99	0.90	0.92
Twin Tunnels	242	1,710	2	3,420	55	2,250	2	2	12	flat			0.95	0.98	0.95	0.90	0.92
Idaho Springs East-Water Wheel	240	1,620	2	3,240	60	2,300	3	1	12	up	3.0	0.50	0.95	0.97	0.98	0.90	0.83
Idaho Springs Water Wheel-103	239	1,800	2	3,600	60	2,300	3	1	12	down	-3.0	0.25	0.95	0.97	0.98	0.90	0.92
Idaho Springs 103-West	239	1,820	2	3,630	60	2,300	4	1	12	flat			0.95	0.97	0.99	0.90	0.92
Idaho Springs West-Fall River Rd	238	1,840	2	3,690	65	2,350	4	1	12	flat			0.95	0.97	0.99	0.90	0.92
Fall River Rd-Dumont	236	1,640	2	3,290	65	2,350	4	1	12	up	3.0	0.25	0.95	0.96	0.99	0.90	0.83
Dumont-Downieville	234	1,640	2	3,280	65	2,350	4	1	12	up	3.0	0.75	0.95	0.96	0.99	0.90	0.83
Downieville-Empire	233	1,610	2	3,230	65	2,350	4	1	12	up	3.0	0.75	0.95	0.94	0.99	0.90	0.83
Empire-Georgetown	230	1,590	2	3,180	65	2,350	4	1	12	up	3.0	0.50	0.95	0.93	0.99	0.90	0.83
Georgetown-Silver Plume	227	1,280	2	2,560	65	2,350	4	1	12	up	6.0	1.50	0.95	0.89	0.99	0.90	0.69
Silver Plume-Bakerville	223	1,430	2	2,860	65	2,350	4	1	12	up	4.0	1.25	0.95	0.87	0.99	0.90	0.79
Bakerville-Herman Gulch	220	1,410	2	2,820	65	2,350	4	1	12	up	4.0	0.75	0.95	0.86	0.99	0.90	0.79

Highway Stretch	Milepost	LOS E Capacity per Lane (pcphpl)	Number of Lanes	Total LOS E Capacity (pcph)	Posted Speed (mph)	Max Service Flow (pcphpl)	Minimum Shoulder (ft)	1 or 2 sides?	Lane Width (ft)	Grade	Pct. Grade	Grade Length (mi)	PHF	$f_{weather}$	f_w	f_P	f_{HV}
Herman Gulch-Loveland Pass	217	1,400	2	2,800	65	2,350	4	1	12	up	4.0	2.00	0.95	0.85	0.99	0.90	0.79
Loveland Pass-EJMT	216	1,220	2	2,430	65	2,350	4	1	12	up	6.0	0.75	0.95	0.85	0.99	0.90	0.69
Eisenhower Tunnel	214	1,370	2	2,740	50	2,200	2	2	12	up	2.0	0.25	0.95	0.85	0.95	0.90	0.87
Eisenhower Tunnel-Silverthorne	208	1,500	3	4,510	65	2,350	4	1	12	down	-7.0	3.00	0.95	0.85	0.99	0.90	0.86
Silverthorne-Dillon Overlook	204	1,420	3	4,250	65	2,350	4	1	12	up	5.0	1.00	0.95	0.89	0.99	0.90	0.77
Dillon Overlook-Frisco 9	203	1,700	3	5,090	65	2,350	4	1	12	down	-3.0	0.75	0.95	0.89	0.99	0.90	0.92
Frisco 9-Main	202	1,520	2	3,050	65	2,350	4	1	12	flat			0.85	0.89	0.99	0.90	0.92
Frisco Main-Officers Gulch	199	1,190	2	2,390	65	2,350	4	1	12	up	5.0	1.25	0.85	0.87	0.99	0.90	0.74
Officers Gulch-Tenmile	197	1,190	2	2,380	65	2,350	4	1	12	up	5.0	1.25	0.85	0.87	0.99	0.90	0.74
Tenmile-Copper Mountain	196	1,480	2	2,970	65	2,350	4	1	12	down	-3.0	0.25	0.85	0.87	0.99	0.90	0.92
Copper Mountain-Vail Pass	193	1,170	2	2,340	65	2,350	4	1	12	up	5.0	5.50	0.85	0.85	0.99	0.90	0.74
Vail Pass-Vail East	185	1,280	2	2,550	65	2,350	4	1	12	down	-7.0	4.00	0.85	0.85	0.99	0.85	0.86
Vail East-Vail Main	178	1,510	2	3,010	65	2,350	4	1	12	down	-2.0	1.00	0.85	0.93	0.99	0.85	0.92
Vail Main-Vail West	175	1,530	2	3,050	65	2,350	4	1	12	down	-3.0	1.00	0.85	0.95	0.99	0.85	0.92
Vail West-Minturn	172	1,460	2	2,930	55	2,250	4	1	12	flat		0.75	0.85	0.95	0.99	0.85	0.92
Minturn-Avon	169	1,460	2	2,930	55	2,250	4	1	12	down	-5.0	1.25	0.85	0.95	0.99	0.85	0.92
Avon-Edwards	165	1,570	2	3,150	65	2,350	4	1	12	down	-3.0	0.25	0.85	0.98	0.99	0.85	0.92
Edwards-Wolcott (SH 131)	160	1,620	2	3,230	75	2,400	4	1	12	down	-3.0	0.25	0.85	0.98	0.99	0.85	0.92
Wolcott (SH 131)-Eagle	152	1,630	2	3,250	75	2,400	4	1	12	down	-2.0	0.25	0.85	0.99	0.99	0.85	0.92
Eagle-Gypsum	145	1,470	2	2,950	75	2,400	4	1	12	up	3.0	1.25	0.85	1.00	0.99	0.85	0.83
Gypsum-Dotsero	135	1,640	2	3,280	75	2,400	4	1	12	down	-3.0	0.50	0.85	1.00	0.99	0.85	0.92
Glenwood Canyon	130	1,480	2	2,950	50	2,200	2	1	12	flat			0.85	1.00	0.97	0.85	0.92

Notes: Capacity values in the table are rounded after computations. Corridor-wide, heavy-vehicle fractions are 1.8 percent combination-unit trucks, 1.2 percent single-unit trucks, and 4 percent recreational vehicles. Buses are included as single-unit trucks.

Table A-25. Existing (2000) Capacity: Summer Weekend, Westbound

Highway Stretch	Milepost	LOS E Capacity per Lane (pcphpl)	Number of Lanes	Total LOS E Capacity (pcph)	Posted Speed (mph)	Max Service Flow (pcphpl)	Minimum Shoulder (ft)	1 or 2 sides?	Lane Width (ft)	Grade	Pct. Grade	Grade Length (mi)	PHF	$f_{weather}$	f_w	f_P	f_{HV}
Denver-C-470	261	1,970	3	5,910	65	2,350	4	1	12	flat			0.95	1.00	0.99	0.95	0.90
C-470-Morrison	259	1,650	3	4,960	65	2,350	4	1	12	up	4.0	1.25	0.95	1.00	0.99	0.95	0.76
Morrison-Lookout Mountain	257	1,500	3	4,490	65	2,350	4	1	12	up	6.0	2.25	0.95	1.00	0.99	0.95	0.68
Lookout Mountain-Genesee	255	1,500	3	4,490	65	2,350	4	1	12	up	6.0	1.50	0.95	1.00	0.99	0.95	0.68
Genesee-Chief Hosa	253	1,970	3	5,910	65	2,350	4	1	12	down	-5.0	0.35	0.95	1.00	0.99	0.95	0.90
Chief Hosa-Evergreen	252	1,580	3	4,740	65	2,350	8	1	12	up	5.0	0.75	0.95	1.00	1.00	0.95	0.72
Evergreen-Beaver Brook	250	1,570	3	4,690	65	2,350	4	1	12	up	5.0	0.60	0.95	1.00	0.99	0.95	0.72
Beaver Brook-Hyland Hills	248	1,430	3	4,300	55	2,250	4	1	12	up	6.0	1.00	0.95	1.00	0.99	0.95	0.68
Hyland Hills-US 6 Gaming	245	1,790	2	3,580	55	2,250	4	1	12	down	-6.0	1.75	0.95	1.00	0.99	0.90	0.90
US 6 Gaming-Hidden Valley	244	1,790	2	3,580	55	2,250	4	1	12	flat			0.95	1.00	0.99	0.90	0.90
Twin Tunnels	242	1,720	2	3,430	55	2,250	2	2	12	flat			0.95	1.00	0.95	0.90	0.90
Idaho Springs East-Water Wheel	240	1,580	2	3,160	60	2,300	3	1	12	up	3.0	0.50	0.95	1.00	0.98	0.90	0.79
Idaho Springs Water Wheel-103	239	1,810	2	3,620	60	2,300	3	1	12	down	-3.0	0.25	0.95	1.00	0.98	0.90	0.90
Idaho Springs 103-West	239	1,830	2	3,660	60	2,300	4	1	12	flat			0.95	1.00	0.99	0.90	0.90
Idaho Springs West-Fall River Rd	238	1,870	2	3,730	65	2,350	4	1	12	flat			0.95	1.00	0.99	0.90	0.90
Fall River Rd-Dumont	236	1,630	2	3,260	65	2,350	4	1	12	up	3.0	0.25	0.95	1.00	0.99	0.90	0.79
Dumont-Downieville	234	1,630	2	3,260	65	2,350	4	1	12	up	3.0	0.75	0.95	1.00	0.99	0.90	0.79
Downieville-Empire	233	1,630	2	3,260	65	2,350	4	1	12	up	3.0	0.75	0.95	1.00	0.99	0.90	0.79
Empire-Georgetown	230	1,630	2	3,260	65	2,350	4	1	12	up	3.0	0.50	0.95	1.00	0.99	0.90	0.79
Georgetown-Silver Plume	227	1,310	2	2,630	65	2,350	4	1	12	up	6.0	1.50	0.95	1.00	0.99	0.90	0.63
Silver Plume-Bakerville	223	1,550	2	3,090	65	2,350	4	1	12	up	4.0	1.25	0.95	1.00	0.99	0.90	0.75
Bakerville-Herman Gulch	220	1,550	2	3,090	65	2,350	4	1	12	up	4.0	0.75	0.95	1.00	0.99	0.90	0.75

Highway Stretch	Milepost	LOS E Capacity per Lane (pcphpl)	Number of Lanes	Total LOS E Capacity (pcph)	Posted Speed (mph)	Max Service Flow (pcphpl)	Minimum Shoulder (ft)	1 or 2 sides?	Lane Width (ft)	Grade	Pct. Grade	Grade Length (mi)	PHF	$f_{weather}$	f_w	f_P	f_{HV}
Herman Gulch-Loveland Pass	217	1,550	2	3,090	65	2,350	4	1	12	up	4.0	2.00	0.95	1.00	0.99	0.90	0.75
Loveland Pass-EJMT	216	1,310	2	2,630	65	2,350	4	1	12	up	6.0	0.75	0.95	1.00	0.99	0.90	0.63
Eisenhower Tunnel	214	1,550	2	3,100	50	2,200	2	2	12	up	2.0	0.25	0.95	1.00	0.95	0.90	0.83
Eisenhower Tunnel-Silverthorne	208	1,720	3	5,170	65	2,350	4	1	12	down	-7.0	3.00	0.95	1.00	0.99	0.90	0.83
Silverthorne-Dillon Overlook	204	1,480	3	4,450	65	2,350	4	1	12	up	5.0	1.00	0.95	1.00	0.99	0.90	0.72
Dillon Overlook-Frisco 9	203	1,870	3	5,600	65	2,350	4	1	12	down	-3.0	0.75	0.95	1.00	0.99	0.90	0.90
Frisco 9-Main	202	1,670	2	3,340	65	2,350	4	1	12	flat			0.85	1.00	0.99	0.90	0.90
Frisco Main-Officers Gulch	199	1,270	2	2,540	65	2,350	4	1	12	up	5.0	1.25	0.85	1.00	0.99	0.90	0.69
Officers Gulch-Tenmile	197	1,270	2	2,540	65	2,350	4	1	12	up	5.0	1.25	0.85	1.00	0.99	0.90	0.69
Tenmile-Copper Mountain	196	1,670	2	3,340	65	2,350	4	1	12	down	-3.0	0.25	0.85	1.00	0.99	0.90	0.90
Copper Mountain-Vail Pass	193	1,270	2	2,540	65	2,350	4	1	12	up	5.0	5.50	0.85	1.00	0.99	0.90	0.69
Vail Pass-Vail East	185	1,460	2	2,910	65	2,350	4	1	12	down	-7.0	4.00	0.85	1.00	0.99	0.85	0.83
Vail East-Vail Main	178	1,580	2	3,160	65	2,350	4	1	12	down	-2.0	1.00	0.85	1.00	0.99	0.85	0.90
Vail Main-Vail West	175	1,580	2	3,160	65	2,350	4	1	12	down	-3.0	1.00	0.85	1.00	0.99	0.85	0.90
Vail West-Minturn	172	1,510	2	3,020	55	2,250	4	1	12	flat		0.75	0.85	1.00	0.99	0.85	0.90
Minturn-Avon	169	1,510	2	3,020	55	2,250	4	1	12	down	-5.0	1.25	0.85	1.00	0.99	0.85	0.90
Avon-Edwards	165	1,580	2	3,160	65	2,350	4	1	12	down	-3.0	0.25	0.85	1.00	0.99	0.85	0.90
Edwards-Wolcott (SH 131)	160	1,610	2	3,220	75	2,400	4	1	12	down	-3.0	0.25	0.85	1.00	0.99	0.85	0.90
Wolcott (SH 131)-Eagle	152	1,610	2	3,220	75	2,400	4	1	12	down	-2.0	0.25	0.85	1.00	0.99	0.85	0.90
Eagle-Gypsum	145	1,410	2	2,810	75	2,400	4	1	12	up	3.0	1.25	0.85	1.00	0.99	0.85	0.79
Gypsum-Dotsero	135	1,610	2	3,220	75	2,400	4	1	12	down	-3.0	0.50	0.85	1.00	0.99	0.85	0.90
Glenwood Canyon	130	1,450	2	2,890	50	2,200	2	1	12	flat			0.85	1.00	0.97	0.85	0.90

Notes: Capacity values in the table are rounded after computations. Corridor-wide, heavy-vehicle fractions are 2 percent combination-unit trucks, 2 percent single-unit trucks, and 5 percent recreational vehicles. Buses are included as single-unit trucks.

Table A-26. Existing (2000) Capacity: Summer Weekday, Westbound

Highway Stretch	Milepost	LOS E Capacity per Lane (pcphpl)	Number of Lanes	Total LOS E Capacity (pcph)	Posted Speed (mph)	Max Service Flow (pcphpl)	Minimum Shoulder (ft)	1 or 2 sides?	Lane Width (ft)	Grade	Pct. Grade	Grade Length (mi)	PHF	$f_{weather}$	f_w	f_P	f_{HV}
Denver-C-470	261	2,040	3	6,130	65	2,350	4	1	12	flat			0.95	1.00	0.99	1.00	0.89
C-470-Morrison	259	1,600	3	4,790	65	2,350	4	1	12	up	4.0	1.25	0.95	1.00	0.99	1.00	0.69
Morrison-Lookout Mountain	257	1,400	3	4,200	65	2,350	4	1	12	up	6.0	2.25	0.95	1.00	0.99	1.00	0.61
Lookout Mountain-Genesee	255	1,400	3	4,200	65	2,350	4	1	12	up	6.0	1.50	0.95	1.00	0.99	1.00	0.61
Genesee-Chief Hosa	253	2,040	3	6,130	65	2,350	4	1	12	down	-5.0	0.35	0.95	1.00	0.99	1.00	0.89
Chief Hosa-Evergreen	252	1,500	3	4,500	65	2,350	8	1	12	up	5.0	0.75	0.95	1.00	1.00	1.00	0.65
Evergreen-Beaver Brook	250	1,480	3	4,450	65	2,350	4	1	12	up	5.0	0.60	0.95	1.00	0.99	1.00	0.65
Beaver Brook-Hyland Hills	248	1,340	3	4,020	55	2,250	4	1	12	up	6.0	1.00	0.95	1.00	0.99	1.00	0.61
Hyland Hills-US 6 Gaming	245	1,860	2	3,720	55	2,250	4	1	12	down	-6.0	1.75	0.95	1.00	0.99	0.95	0.89
US 6 Gaming-Hidden Valley	244	1,860	2	3,720	55	2,250	4	1	12	flat			0.95	1.00	0.99	0.95	0.89
Twin Tunnels	242	1,780	2	3,570	55	2,250	2	2	12	flat			0.95	1.00	0.95	0.95	0.89
Idaho Springs East-Water Wheel	240	1,560	2	3,110	60	2,300	3	1	12	up	3.0	0.50	0.95	1.00	0.98	0.95	0.74
Idaho Springs Water Wheel-103	239	1,880	2	3,760	60	2,300	3	1	12	down	-3.0	0.25	0.95	1.00	0.98	0.95	0.89
Idaho Springs 103-West	239	1,900	2	3,800	60	2,300	4	1	12	flat			0.95	1.00	0.99	0.95	0.89
Idaho Springs West-Fall River Rd	238	1,940	2	3,880	65	2,350	4	1	12	flat			0.95	1.00	0.99	0.95	0.89
Fall River Rd-Dumont	236	1,610	2	3,210	65	2,350	4	1	12	up	3.0	0.25	0.95	1.00	0.99	0.95	0.74
Dumont-Downieville	234	1,610	2	3,210	65	2,350	4	1	12	up	3.0	0.75	0.95	1.00	0.99	0.95	0.74
Downieville-Empire	233	1,610	2	3,210	65	2,350	4	1	12	up	3.0	0.75	0.95	1.00	0.99	0.95	0.74
Empire-Georgetown	230	1,610	2	3,210	65	2,350	4	1	12	up	3.0	0.50	0.95	1.00	0.99	0.95	0.74
Georgetown-Silver Plume	227	1,220	2	2,440	65	2,350	4	1	12	up	6.0	1.50	0.95	1.00	0.99	0.95	0.56
Silver Plume-Bakerville	223	1,490	2	2,990	65	2,350	4	1	12	up	4.0	1.25	0.95	1.00	0.99	0.95	0.68
Bakerville-Herman Gulch	220	1,490	2	2,990	65	2,350	4	1	12	up	4.0	0.75	0.95	1.00	0.99	0.95	0.68
Herman Gulch-Loveland Pass	217	1,490	2	2,990	65	2,350	4	1	12	up	4.0	2.00	0.95	1.00	0.99	0.95	0.68
Loveland Pass-EJMT	216	1,220	2	2,440	65	2,350	4	1	12	up	6.0	0.75	0.95	1.00	0.99	0.95	0.56
Eisenhower Tunnel	214	1,560	2	3,110	50	2,200	2	2	12	up	2.0	0.25	0.95	1.00	0.95	0.95	0.79

Highway Stretch	Milepost	LOS E Capacity per Lane (pcphpl)	Number of Lanes	Total LOS E Capacity (pcph)	Posted Speed (mph)	Max Service Flow (pcphpl)	Minimum Shoulder (ft)	1 or 2 sides?	Lane Width (ft)	Grade	Pct. Grade	Grade Length (mi)	PHF	$f_{weather}$	f_w	f_P	f_{HV}
Eisenhower Tunnel-Silverthorne	208	1,670	3	5,000	65	2,350	4	1	12	down	-7.0	3.00	0.95	1.00	0.99	0.95	0.76
Silverthorne-Dillon Overlook	204	1,410	3	4,230	65	2,350	4	1	12	up	5.0	1.00	0.95	1.00	0.99	0.95	0.65
Dillon Overlook-Frisco 9	203	1,940	3	5,820	65	2,350	4	1	12	down	-3.0	0.75	0.95	1.00	0.99	0.95	0.89
Frisco 9-Main	202	1,740	2	3,470	65	2,350	4	1	12	flat			0.85	1.00	0.99	0.95	0.89
Frisco Main-Officers Gulch	199	1,200	2	2,400	65	2,350	4	1	12	up	5.0	1.25	0.85	1.00	0.99	0.95	0.62
Officers Gulch-Tenmile	197	1,200	2	2,400	65	2,350	4	1	12	up	5.0	1.25	0.85	1.00	0.99	0.95	0.62
Tenmile-Copper Mountain	196	1,740	2	3,470	65	2,350	4	1	12	down	-3.0	0.25	0.85	1.00	0.99	0.95	0.89
Copper Mountain-Vail Pass	193	1,200	2	2,400	65	2,350	4	1	12	up	5.0	5.50	0.85	1.00	0.99	0.95	0.62
Vail Pass-Vail East	185	1,490	2	2,980	65	2,350	4	1	12	down	-7.0	4.00	0.85	1.00	0.99	0.95	0.76
Vail East-Vail Main	178	1,640	2	3,290	65	2,350	4	1	12	down	-2.0	1.00	0.85	1.00	0.99	0.90	0.89
Vail Main-Vail West	175	1,640	2	3,290	65	2,350	4	1	12	down	-3.0	1.00	0.85	1.00	0.99	0.90	0.89
Vail West-Minturn	172	1,580	2	3,150	55	2,250	4	1	12	flat		0.75	0.85	1.00	0.99	0.90	0.89
Minturn-Avon	169	1,580	2	3,150	55	2,250	4	1	12	down	-5.0	1.25	0.85	1.00	0.99	0.90	0.89
Avon-Edwards	165	1,640	2	3,290	65	2,350	4	1	12	down	-3.0	0.25	0.85	1.00	0.99	0.90	0.89
Edwards-Wolcott (SH 131)	160	1,770	2	3,550	75	2,400	4	1	12	down	-3.0	0.25	0.85	1.00	0.99	0.95	0.89
Wolcott (SH 131)-Eagle	152	1,770	2	3,550	75	2,400	4	1	12	down	-2.0	0.25	0.85	1.00	0.99	0.95	0.89
Eagle-Gypsum	145	1,470	2	2,930	75	2,400	4	1	12	up	3.0	1.25	0.85	1.00	0.99	0.95	0.74
Gypsum-Dotsero	135	1,770	2	3,550	75	2,400	4	1	12	down	-3.0	0.50	0.85	1.00	0.99	0.95	0.89
Glenwood Canyon	130	1,590	2	3,180	50	2,200	2	1	12	flat			0.85	1.00	0.97	0.95	0.89

Notes: Capacity values in the table are rounded after computations. Corridor-wide, heavy-vehicle fractions are 4 percent combination-unit trucks, 2 percent single-unit trucks, and 3 percent recreational vehicles. Buses are included as single-unit trucks.

Differences in Capacities Between the Model Days

The following general trends can be observed in the capacity values.

Compare Summer Weekend versus Summer Weekday

- Because there are more trucks on the weekdays, the heavy-vehicle factor is typically lower. This only affects sections with upgrades, however, and to a lesser degree sections with downgrades.
- The population familiarity factor is higher on weekdays because a greater percentage of the drivers are very familiar with the Corridor as compared to on weekends.
- These factors counteract each other, so no general statement can be made that weekday capacities are typically lower than weekend capacities throughout the corridor.

Compare Summer Weekend versus Winter Weekend

- The weather factor reduces capacities in the winter, but the impact is insubstantial or nonexistent at the lower elevation locations within the Corridor.
- The heavy vehicles percentages are somewhat lower in winter. For lower elevation sections, this can result in the winter capacity being higher than the summer capacity.
- A general statement can be made that winter capacities are typically lower than summer capacities, though the winter capacities can be higher at the east and west ends of the Corridor.

Field Data on Capacities

Direct field observations were conducted at several times and locations to assess Corridor capacities. The goal of these observations was to directly obtain capacities for calibration purposes, through observation and counting of traffic flow before and during queuing. Files that contain field data on capacity observations are available upon request. The list of locations, days, and directions is as follows:

- Westbound at Georgetown Hill and Georgetown Flats, Friday, July 20, and Saturday July 21, 2001
- Eastbound East of Empire Junction, August 26, 2001
- Eastbound East of Empire Junction, September 3, 2001
- Westbound in the West Evergreen to Hidden Valley Area, including Floyd Hill, February 23, 2002

Capacities Outside the Corridor (for the Travel Demand Model)

Capacities for facilities other than I-70 are determined from a DRCOG lookup table based on functional class, area type, and number of lanes. The directional capacity per lane of different roadway types is shown in Table A-27.

Table A-27. Hourly Capacity per Lane by Functional Class and Area Type

		Area Type				
Functional Class	Number of Lanes	CBD	CBD Fringe and Outlying CBD	Urban Neighborhood	Suburban Neighborhood	Rural
Freeway	Any	2,000	2,000	2,000	2,000	2,000
Expressway	1 or 2	1,280	1,280	1,280	1,280	1,350
	3 or more	1,160	1,160	1,160	1,160	1,575

		Area Type				
Functional Class	Number of Lanes	CBD	CBD Fringe and Outlying CBD	Urban Neighborhood	Suburban Neighborhood	Rural
Principal arterial	1	800	935	955	1,000	955
	2				960	1,135
	3	750	840	875	875	
	4 or more		800	835	835	
Minor arterial	1	415	580	615	750	940
	2	460				1,135
	3 or more		500	540	700	
Collector or frontage road	1	400	500	550	600	800
	2 or more	415				880
Ramp	1	1,100	1,100	1,100	1,100	1,100
	2	750	750	750	750	750
	3	500	500	500	500	500
	4 or more	375	375	375	375	375
Centroid connector	Any	11,111	11,111	11,111	11,111	11,111

Notes: Centroid connector capacity is intended to be a large number, as the purpose of these links is to load all trips from a zone to the physical network. Transit-only links are not used in highway assignment and, therefore, have a dummy value for capacity.

Source: DRCOG, RFV, J.F. Sato and Associates

Special Operations

Reversible Facility

The Reversible/HOV/HOT Lanes alternative requires special operations. Reversible lanes are proposed between Beaver Brook, milepost 248, and the west side of the Eisenhower-Johnson Memorial Tunnels (milepost 213), with intermediate interchanges at US 6/Base of Floyd Hill and Empire Junction. Travelers who want to use another exit must use the general-purpose lanes. The Reversible/HOV/HOT Lanes alternative allows for variations regarding which vehicles are eligible to use the lanes as listed below:

- All traffic
- All traffic except for combination and single-unit trucks
- High-occupancy vehicles (HOVs)
- Vehicles willing to pay a toll
- HOVs; and vehicles not meeting the occupancy criteria, but willing to pay a premium for the right to travel in the lanes—this concept is called a High Occupancy/Toll (HOT) lane
- Transit vehicles or commercial passenger vehicles.

A decision was made early in the PEIS process to exclude combination and single-unit trucks from the reversible lanes to maximize the added capacity of this new facility and help to attract a sufficient number of vehicles to allow the general-purpose lanes to function properly.

Changing the operating direction of the reversible lanes involves several steps, which are listed below for the change from westbound to eastbound operation. A similar process is used to change from eastbound to westbound operation.

1. The entry gate at Beaver Brook is closed.
2. Westbound traffic is allowed to clear the 33-mile reversible/HOV/HOT lanes. Under prevailing traffic conditions, these first two steps may take about 45 minutes.
3. After westbound traffic is clear, the eastbound entry gates at Empire Junction and the west portal of the Eisenhower-Johnson Memorial Tunnels are opened.

The operating direction of the reversible lanes is chosen to minimize congestion in both directions. That is, entry gates are raised and lowered when traffic levels in one direction have peaked and are receding—but before volumes in the opposite direction reach their peak. More detailed study of these operations will be made during the Tier 2 studies if the Reversible/HOV/HOT Lanes alternative advances as the preferred alternative. Decisions on operating hours for the reversible facility influence how demand is loaded in the Traffic Simulation Model.

Toll Lanes

To test a toll lane option, the reversible lanes are assumed to be tolled and to operate as described above. Toll collection might be accomplished by means of a window automatic vehicle identification (AVI) card purchased from the toll authority, on the Internet, or at retail stores (similar to ski ticket purchases at grocery stores). Alternative pricing will be analyzed in Tier 2 studies if the Reversible/HOV/HOT Lanes alternative is selected as the preferred alternative.

Automotive Costs

Automotive costs are one type of factor used in determining mode choice. Automotive costs include out-of-pocket costs such as for parking, fuel, and other maintenance costs. Because the decision to own an automobile involves a long timeframe, similar to that for residence choice, rather than being made each trip, the costs of owning or leasing and insuring an automobile are not included in the travel demand model.

Operating Expenses

Automobile operating costs are estimated based on the distance traveled. Due to the primary trip purpose along the corridor being recreational, it has been assumed that a decision to own or lease a vehicle has already been made for other trip purposes; therefore, the cost of owning, leasing, or insuring a vehicle is assumed to be a sunk cost and is not included in the model. Automobile operating cost is based on 36.5 cents per mile, consistent with Internal Revenue Service (IRS) policies for deducting business expenses. Automobile costs are projected to be shared among all vehicle occupants.

Parking

A parking fee is included in the travel demand model for all relevant mountain resorts, some of which offer structured parking for day recreation users. In some locations, a discount is offered in summer or the off-season. Where areas offer multiple lots with different fee structures, an average rate is used. Areas included are Winter Park Resort, Keystone Resort, Breckenridge, Vail, Avon (for Beaver Creek), and Aspen. Parking fees also apply in Downtown Denver.

The parking fee is included in the mode choice calculation regarding how many people are choosing an automobile in favor of a transit mode. Parking costs may be assigned on a TAZ, year, and season basis as shown in Table A-28. Parking costs for the Denver metropolitan area were derived from DRCOG's databases.

Tolls

TransCAD has capabilities for modeling tolls as link attributes (which is most representative of a mainline toll plaza), and for building least-generalized-cost paths using toll matrices. A manual adjustment technique also be applied outside TransCAD; for example, removing trips that might use a toll facility as a separate mode or trip purpose. A concurrent study by the Colorado Tolling Enterprise, *CTE Preliminary Traffic and Revenue Study*, is examining the feasibility of using tolls to financing additional transportation infrastructure in ten corridors statewide, including I-70 between the Eisenhower-Johnson Memorial Tunnels and the Denver metropolitan area.

In 2000, E-470 was the only toll facility in the study area, serving commuting and distribution functions within the Denver metropolitan area. Since that time, the Northwest Parkway between I-25 and US 36 has opened. Neither toll facility is expected to have a substantial impact on traffic patterns within the Corridor. While tolls defeat the primary purpose of the reversible lanes in reducing congestion in the general-purpose lanes, a toll module consistent with related Corridor studies (for example, the Northwest Corridor, C-470 Value Lanes, I-25 North Value Lanes, and I-70 Value Lanes in the Denver metropolitan area) was considered to estimate the possible receipts that might be used to offset construction costs.

Vehicle Rental

One important cost that out-of-state air passengers must consider is that of renting a vehicle upon arrival. Most rental vehicle companies charge a certain amount per day and provide unlimited mileage if the vehicle remains within Colorado or certain other states. On average, arriving air passengers are assumed to pay $300 per visit to Colorado. This vehicle rental cost is divided between the trip from the airport to the destination resort and the return trip to the airport.

Table A-28. Parking Costs Assumed for Mode Choice

TAZ #	Location	Parking Cost in 2000			Parking Cost in 2025		
		Winter	Summer	Off-Season	Winter	Summer	Off-Season
135	Coors Field and Northern Five Points	$3.18	$3.18	$3.18	$3.18	$3.18	$3.18
136	Lower Downtown Denver	3.06	3.06	3.06	3.06	3.06	3.06
137	Central Downtown Denver	4.44	4.44	4.44	4.44	4.44	4.44
139	Auraria Campus and Northwest Baker	1.42	1.42	1.42	1.42	1.42	1.42
1279	Breckenridge	2.00	none	none	10.00	2.50	none
1408	Vail Village	3.00	none	none	12.00	3.00	none
1415	Vail Lionshead	3.88	none	none	12.00	3.00	none
1810, 1813, 1818	Central Aspen	3.00	3.00	3.00	12.00	12.00	12.00
1811	Herron Park, Aspen	5.15	5.15	5.15	12.00	12.00	12.00
1812, 1814-1817, 1819-1821	Remainder of Aspen	none	none	none	6.00	6.00	6.00

TAZ #	Location	Parking Cost in 2000			Parking Cost in 2025		
		Winter	Summer	Off-Season	Winter	Summer	Off-Season
2020, 2021	Keystone Resort	2.00	none	none	8.00	2.00	none
2050	Copper Mountain Resort	2.00	none	none	8.00	2.00	none
2080-2083	Aspen Snowmass Ski Area	5.00	5.00	5.00	12.00	12.00	12.00
2210	Routt County (Steamboat Resort)	5.00	5.00	5.00	12.00	12.00	12.00

Note: All charges are for eight hours, in year 2000 dollars

Legend:

TAZ 135 = Bounded by Washington Street, Downing Street, Stout Street, 20th Street, and the South Platte River.
TAZ 136 = Bounded by 20th Street, Lawrence Street, Speer Boulevard, and the South Platte River.
TAZ 137 = Bounded by 20th Street, Broadway, Colfax Avenue, and Speer Boulevard.
TAZ 139 = Bounded by Speer Boulevard, Colfax Avenue, Kalamath Street, 6th Avenue, and the South Platte River.
TAZ 1810 = Bounded by SH 82 (Main Street, Original Street, and Cooper Avenue) to the north, Durant Avenue to the south, and Galena Street to the west, and includes the Ute Trail area.
TAZ 1811 = Bounded by the Roaring Fork River, SH 82 (Cooper Avenue, Original Street, and Main Street), and Spring Street.
TAZ 1813 = Bounded by the Roaring Fork River, Spring Street, SH 82 (Main Street, 7th Street, and Hallam Street), and Castle Creek.
TAZ 1818 = Bounded by the Roaring Fork River, Castle Creek, SH 82, and Maroon Creek.

The Aspen Snowmass ski area includes Snowmass (TAZ 2080), Buttermilk (TAZ 2081), Aspen Highlands (TAZ 2082), and Aspen Mountain, formerly known as Ajax (TAZ 2083).

A.2.3 Transit System

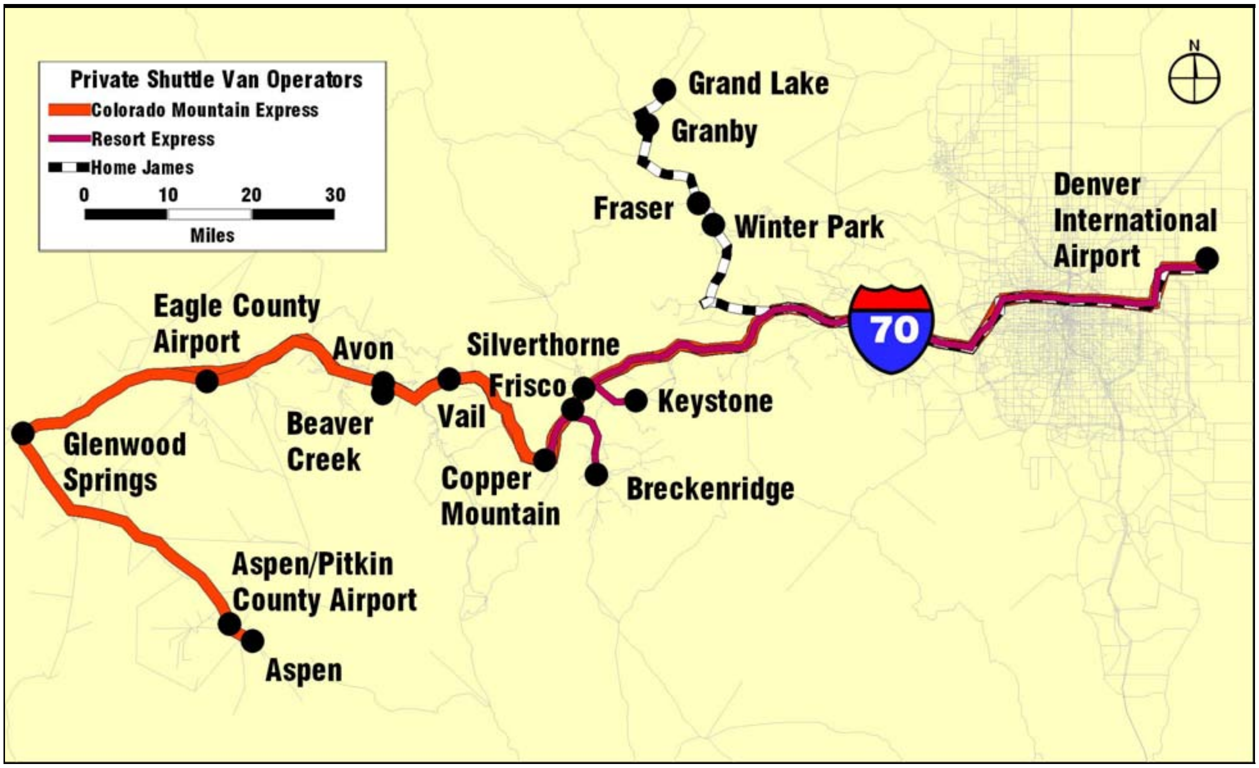
Transit networks are composed of a set of routes and are explicitly defined in the travel demand model by highway or special transit guideway segment. A route is defined as a set of vehicles operating at a specific headway, seated capacity (shown on **Table A-30**), and speed traveling over a specific set of highway or guideway segments. **Figure A-20** shows the extent of the transit routes in the model for years 2000 and 2025.

Transit Operators, Route Attributes and Route Structures

As described in other sections, many different entities provide transit service within the Corridor. These operators include private firms and pseudo-public corporations, including Amtrak, regional agencies, and individual counties. **Figure A-14** through **Figure A-21** show the route structures of various Corridor operators.

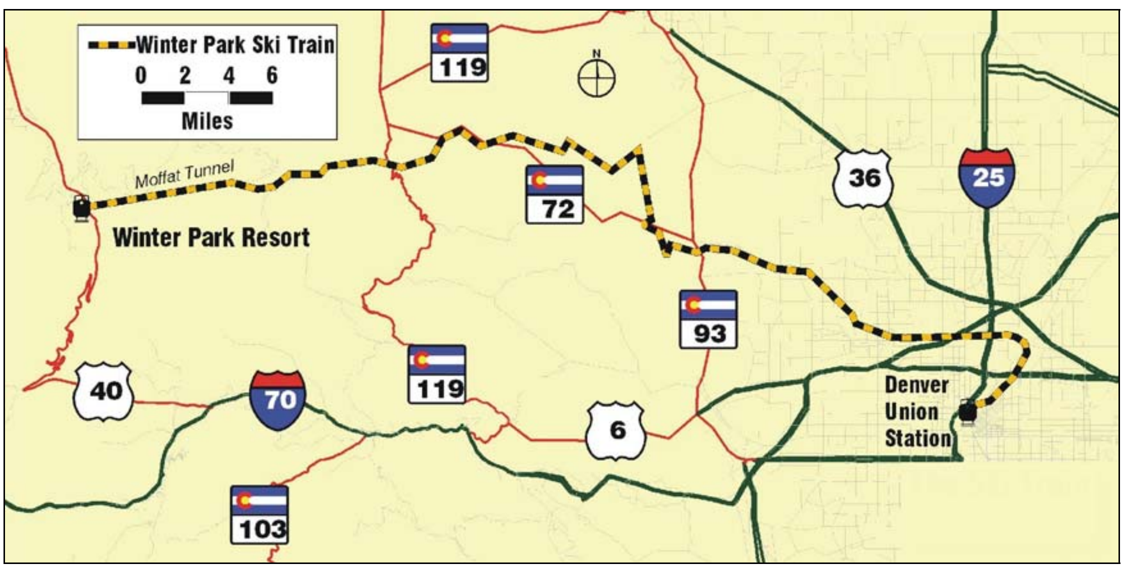
Longer-distance markets are shown in **Figure A-14** and **Figure A-15**, which illustrate privately operated shuttle vans serving resort areas from DIA, and the Ski Train between Winter Park and Denver's Union Station, respectively.

Figure A-14. Route Structure of Private Shuttle Van Operators



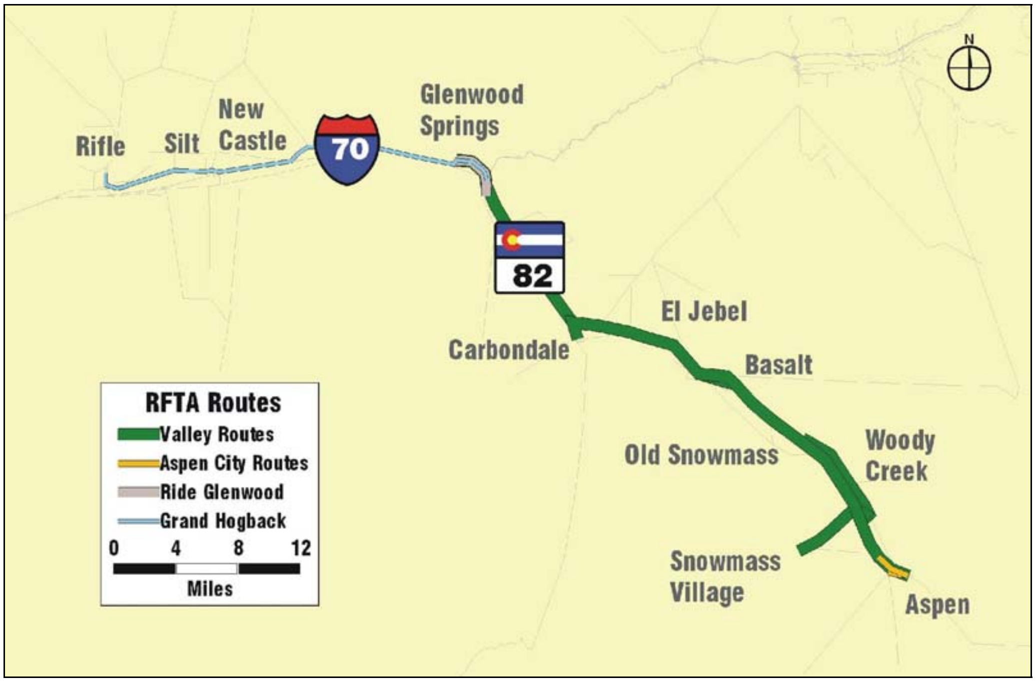
Note: In 2004, East West Partners, a family of related companies operating Colorado Mountain Express and Resort Express shuttles began marketing its Summit County routes under the Colorado Mountain Express brand. The map above is based on Year 2000 services.

Figure A-15. Route of the Ski Train



Routes of the Roaring Fork Transportation Authority (RFTA), one of two multicounty public transit operators authorized by the Colorado Legislature (the other is the Regional Transportation District, or RTD, serving the Denver metropolitan area), are shown in **Figure A-16**. While routes within Aspen are free, the Ride Glenwood route has a fare of $1 each way. The Valley and Grand Hogback services use a zoned-fare structure, with fares ranging from $1 to $9.

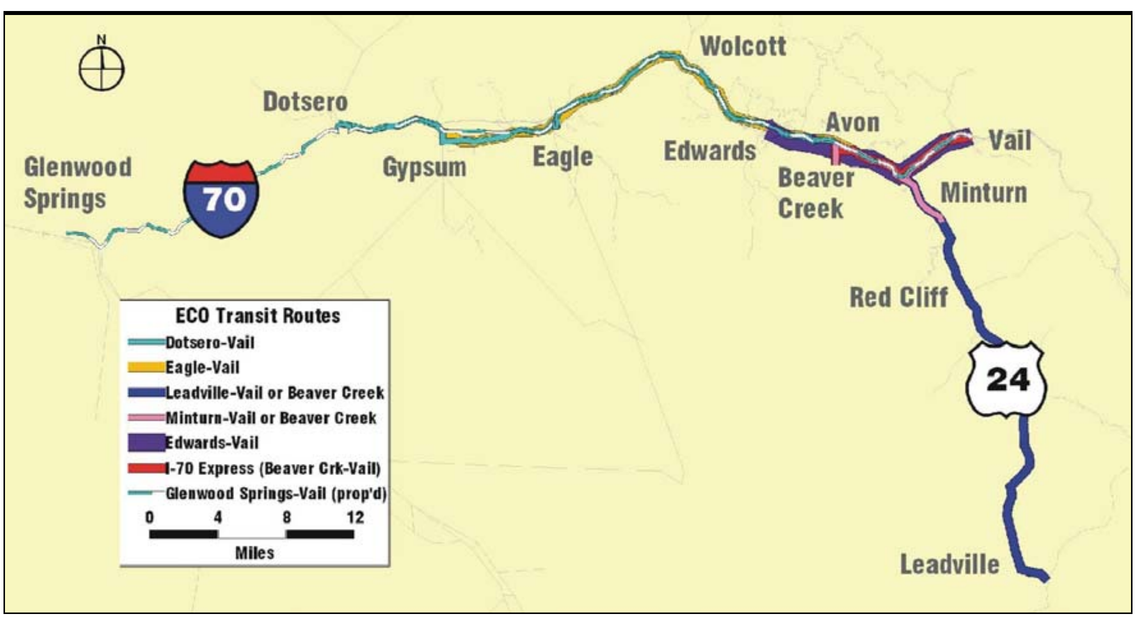
Figure A-16. Roaring Fork Transportation Authority Route Structure



Routes operated by counties and municipalities are shown in **Figure A-17** through **Figure A-19**.

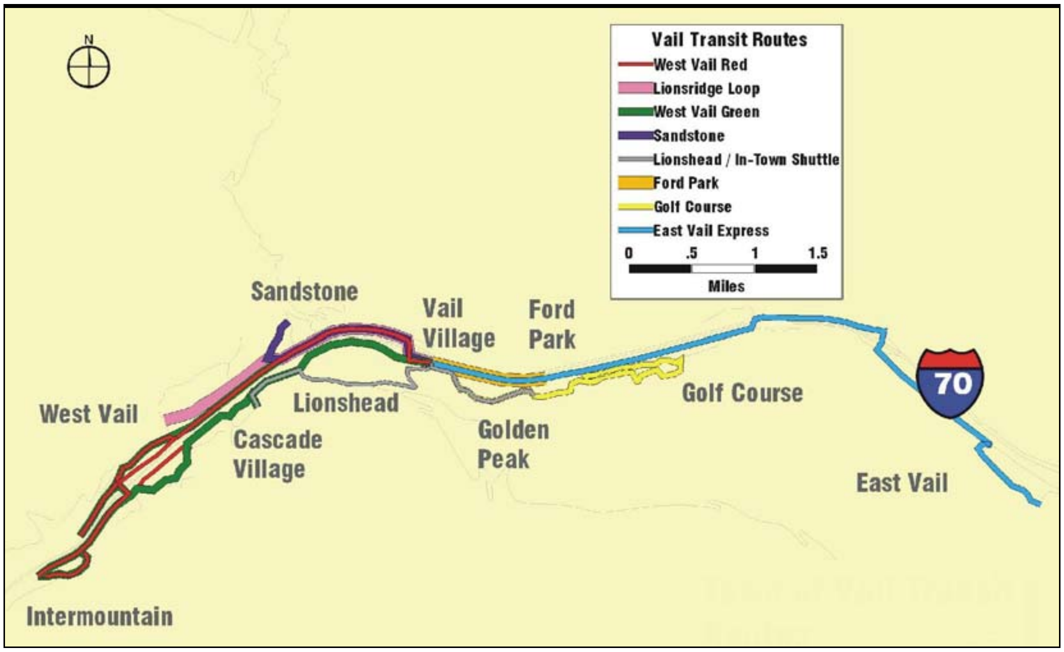
Figure A-17 shows the route structure of the Eagle County Regional Transportation Authority, or ECO Transit. The routes are generally focused on commuting and recreation destinations in Avon and Vail. ECO Transit is subsidized by a county sales tax. Fares are $2 for local routes within Eagle County and $3 on the I-70 Express between Vail and Beaver Creek, as well as on the Leadville route. ECO Transit operates of fleet of 60 buses during the winter, with summer service covered by 30 buses. Local buses or demand-responsive vans replace some routes during the summer.

Figure A-17. Eagle County Regional Transportation Authority Route Structure



Free shuttles operated by the town provide circulation within Vail. Routes operated during the peak winter season are shown in **Figure A-18**. During the summer a few routes are discontinued or replaced with demand-responsive services, while other routes operate at reduced frequencies.

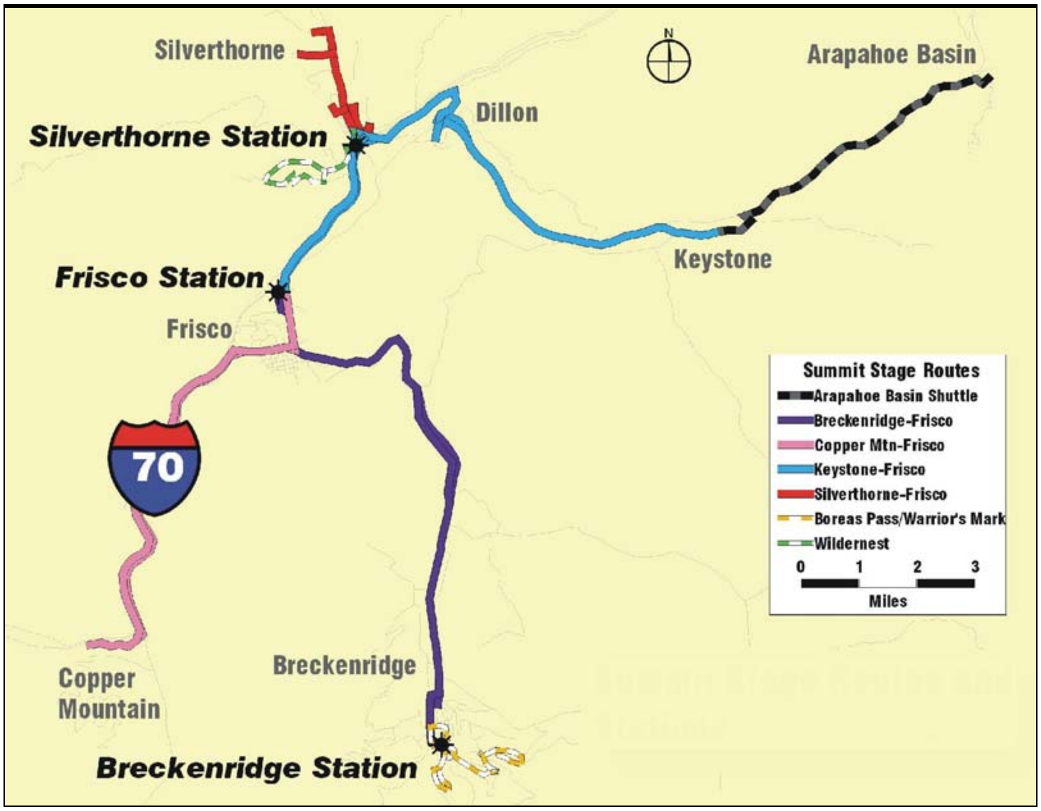
Figure A-18. Town of Vail Transit Route Structure



The Summit Stage Route structure is shown in **Figure A-19**. Town-to-town routes have a hub at Frisco Station and connect the communities of Summit County. Other routes provide local circulation or shuttle service between Keystone Resort and Arapahoe Basin Ski Area. All Summit Stage routes are free, with funding coming from a county sales tax and federal grants.

Some municipal operators are not shown. The towns of Avon and Breckenridge both provide free circulator shuttles. However, because these systems do not cover many route miles, they are omitted from the TransCAD model. In many cases, the access provided by these routes is competitive with walking.

Figure A-19. Summit Stage Route Structure



Casino operators in Black Hawk and Central City contract with various private bus operators to provide service between the Front Range and the Gaming Area. These routes, shown in **Figure A-20**, generally run every 60 to 90 minutes and charge a nominal fare in return for coupons redeemable at the sponsoring casino. Note that most casino buses operate on US 6 through Clear Creek Canyon, giving their passengers a scenic view and avoiding the steep grades on I-70.

Figure A-20. Route Structure of Privately Operated Buses Between Gaming Area and Denver Metropolitan Area

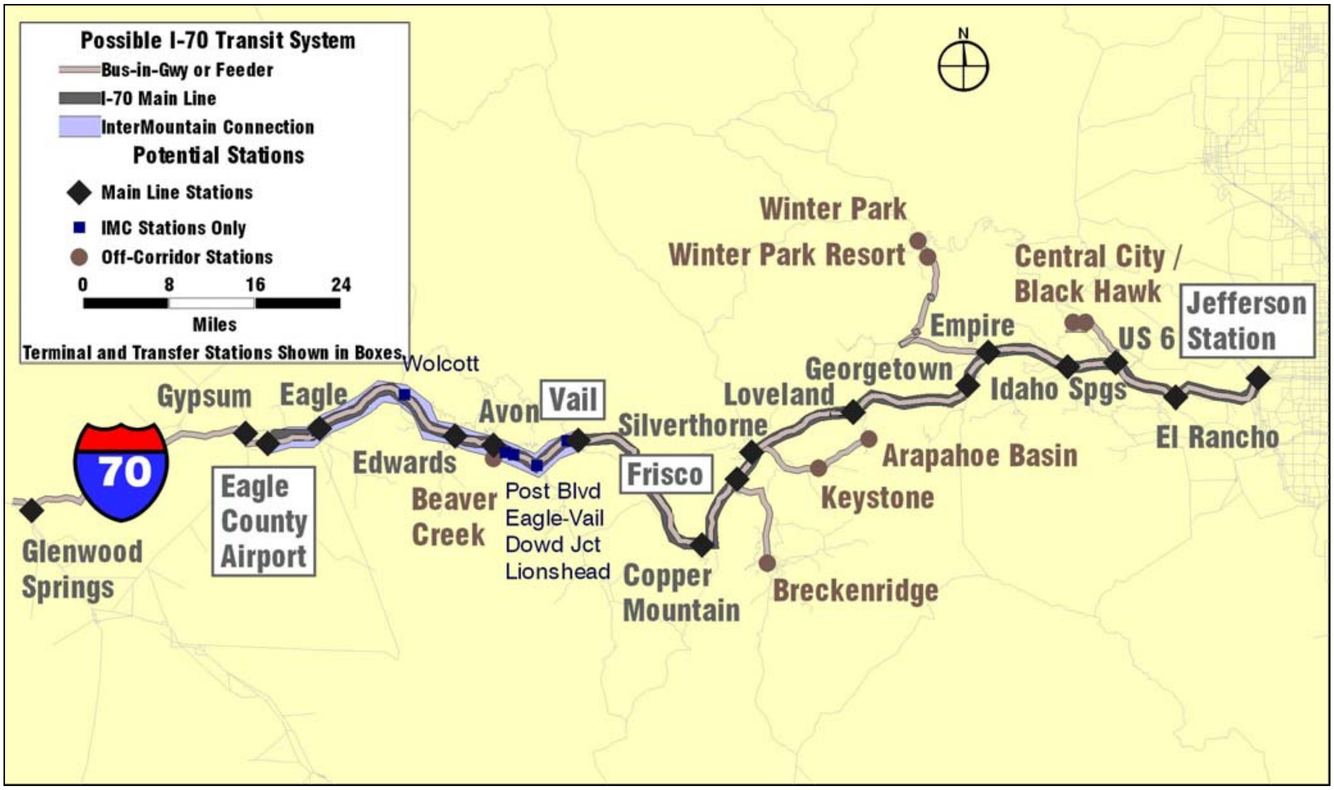
Routes developed for Transit alternatives are shown in **Figure A-21**. Major terminals or transfer points are shown in boxed text. To produce forecasts for Combination alternatives, the travel demand model requires specification of the component Transit alternative with the appropriate Highway alternative. For example, to project demand for the Combination Six-Lane Highway with Dual-Mode Bus in Guideway alternative, the analyst specify the combination of the Dual-Mode Bus in Guideway alternative as the Transit alternative and the Six-Lane Highway (55 mph) alternative as the Highway alternative.

For the Rail with IMC and AGS alternatives, high-capacity fixed-guideway transit is provided in the Corridor between Eagle County Airport and Jefferson Station, near the junctions of I-70 with C-470 and the 6th Avenue Expressway (US 6). Off-Corridor destinations are reached by transferring to several shuttle buses.

With the Bus in Guideway alternatives, the same vehicle provides service on I-70 and to off-Corridor destinations. A guideway between Silverthorne and Jefferson Station allows buses to maintain high speeds by avoiding congestion in the general traffic lanes and by having steering controlled by a device that tracks the guideway barrier.

All Transit alternatives assume the same zone fare structure. Headways and operating plans are developed to accommodate the forecast demand.

Figure A-21. Route Structure of I-70 Transit Alternatives



A maximum of 276 different routes can be selected for demand forecasting. **Table A-29** lists the transit routes that can be selected for the 2000 system. This includes 22 bus routes to and from the casinos in Black Hawk and Central City; private van shuttle services from Aspen, Eagle County Airport, Vail, Breckenridge, Winter Park, and other mountain communities; several proposed RTD routes that provide service to the proposed Jefferson Station; local service on RFTA, ECO Transit, Town of Vail Transit, and Summit Stage; and the ski train.

All of the 2000 routes are operational in 2025, in addition to the following 2025 alternatives as listed in **Table A-29**: (1) Minimal Action alternative (bus in mixed traffic), (2) Rail with IMC alternative, (3) AGS alternative, (4) Dual-Mode Bus in Guideway alternative, and (5) Diesel Bus in Guideway alternative. In **Table A-29** the legend for some of the systems shown is as follows:

- MIXED (gray) = bus routes for the Minimal Action alternative
- RAIL (orange) = core of both the AGS and Rail with IMC alternatives
- INTMTN = the Intermountain Connection
- GWAY_BUS (yellow) = a line in the Dual-Mode or Diesel Bus in Guideway alternative
- SHUTTLE (rose) = local bus service from the rail stations to mountain communities
- CMEX = Colorado Mountain Express, a private shuttle van service between DIA and EGE, and the resort communities of Eagle and Pitkin counties
- HJAMES = Home James, a private shuttle van service between DIA and Grand County
- RESEXP = Resort Express, a private shuttle van service between DIA and Summit County (now part of Colorado Mountain Express)

Each of these new transit modes uses three to seven routes serving Jefferson Station and going as far west as Eagle County Airport. Testing Combination alternatives is achieved by specifying the relevant transit and highway components constructed and in service by the forecast year. The model also allows testing the ridership impacts of a theoretical direct connection between DIA and Jefferson Station.

An equilibration step is used to adjust the headways of the new I-70 services to forecast demand. No standees are assumed by policy, and the seating capacity is 120 percent of the maximum load of each route. (This allows for special events that may result in higher than usual demand.)

Table A-29. Transit Routes for 2000 and 2025

Route Name	Name	Line	System
PlayersExpress: Casinos-Heritage	Gaming to Hogback	Gilpin-Gaming6*	CASINO
Ace: Casinos-Stapleton via I70&6	Gaming to Downtown	Gilpin-Gaming3*	CASINO
Ace: Stapleton-Casinos via 6th&6	Downtown to Gaming	Gilpin-Gaming	CASINO
PlayersExpress: Heritage-Casinos	Hogback to Gaming	Gilpin-Gaming6	CASINO
Ace: Chambers-CC	Coach USA/Ace	Chambers-CC	CASINO
Ace: CC-Thornton	Coach USA/Ace	CC-Thornton	CASINO
Ace: Thornton-CC	Coach USA/Ace	Thornton-CC	CASINO
Ace: CC-Chambers	Coach USA/Ace	CC-Chambers	CASINO
Ace: Sheridan-CC	Coach USA/Ace	Sheridan-CC	CASINO
Ace: CC-Sheridan	Coach USA/Ace	CC-Sheridan	CASINO
Players Exp: Buckingham-BH	PlayersExpress	CasinoTranspInc	CASINO
Players Exp: BH-Buckingham	PlayersExpress	CasinoTranspInc	CASINO
Peoples Ch: Marlee-BH	PeoplesChoice	Stampede	CASINO
Peoples Ch: BH-Marlee	PeoplesChoice	Stampede	CASINO
Peoples Ch: WheatRidge-CC	PeoplesChoice	Stampede	CASINO
Peoples Ch: CC-WheatRidge	PeoplesChoice	Stampede	CASINO
Peoples Ch: Littleton-CC	PeoplesChoice	Stampede	CASINO
Peoples Ch: CC-Littleton	PeoplesChoice	Stampede	CASINO
Players Exp: Martischang-BH	PlayersExpress	CasinoTranspInc	CASINO
Players Exp: BH-Martischang	PlayersExpress	CasinoTranspInc	CASINO
Ride and Win: Havana/Yale-BH	Ride&Win	Havana/Yale-BH	CASINO
Ride and Win: BH-Havana/Yale	Ride&Win	BH-Havana/Yale	CASINO
CME: DIA-Vail/BC	DIA to Eagle Co	Eagle Shuttle	CMEX
CME: Vail/BC-DIA	Eagle Co to DIA	Eagle Shuttle*	CMEX
CME: DIA-Aspen	DIA to Glenwood	I-70 Shuttle	CMEX
CME: Aspen-DIA	Glenwood Spr-DIA	I-70 Shuttle*	CMEX
CME: EGE-Vail/BC	Eagle-Vail/BC	Colo Mtn Express	CMEX
CME: Vail/BC-EGE	Vail/BC-Eagle	Colo Mtn Express	CMEX
CME: EGE-Aspen	Eagle-Aspen	Colo Mtn Express	CMEX
CME: Aspen-EGE	Aspen-Eagle	Colo Mtn Express	CMEX
ECO: Leadville-Vail (Navy Blue)	Leadville - Vail	Eagle-Nvy Blue	ECO
ECO: Vail-Gypsum (Gold)	Vail - Gypsum	Eagle-Gold*	ECO
ECO: Vail-Dotsero (Light Blue)	Vail - Dotsero	Eagle-Lt. Blue*	ECO
ECO: BeavrCk-Leadvl (Navy Blue)	Beaver Creek - L	Eagle-Nvy Blue2*	ECO
ECO: Gypsum-Vail (Gold)	Gypsum - Vail	Eagle-Gold	ECO
ECO: Minturn-Vail (Pink)	Minturn-Vail	Eagle-Pink	ECO

Table A-29. Transit Routes for 2000 and 2025

Route Name	Name	Line	System
ECO: Edwards-Vail no Med Ctr (Purple)	Edwards-Vail	Eagle-Purple	ECO
ECO: BeaverCreek-Minturn (Pink)	BeaverCk-Minturn	Eagle-Pink2	ECO
ECO: Vail-BeaverCreek (Red)	Vail-Beaver Cree	Eagle-Red	ECO
ECO: Dotsero-Vail (Light Blue)	Dotsero-Vail	Eagle-Lt. Blue	ECO
ECO: Vail-Leadville (Navy Blue)	Vail-Leadville	Eagle-Nvy Blue*	ECO
ECO: Leadville-BeaverCreek (Navy)	Leadville - Beav	Eagle-Nvy Blue2	ECO
ECO: Vail-Edwards no Med Ctr (Purple)	Vail-Edwards	Eagle-Purple	ECO
ECO: Beaver Creek-Vail (Red)	Beaver Creek-Vai	Eagle-Red	ECO
ECO: Edwards Med Ctr Loop IB (Purple)	Edwards Med Ctr	Eagle-Purple3	ECO
ECO: Edwards Med Ctr Loop OB (Purple)	Edwards Med Ctr	Eagle-Purple3	ECO
ECO: Vail-Minturn (Pink)	Vail-Minturn	Eagle-Pink	ECO
ECO: Minturn-BeaverCreek (Pink)	Minturn-BeaverCk	Eagle-Pink2	ECO
ECO: Vail-Glenwood (Light Blue)	Vail-Glenwood	Eagle-Light Blue	ECO
ECO: Glenwood-Vail (Light Blue)	Glenwood-Vail	Eagle-Light Blue	ECO
Bus 1W WB: Westminster-Central City	Wstmnstr-CC	Guideway Bus	GWAY_BUS
Bus 1W EB: Central City-Westminster	CC-Wstmnstr	Guideway Bus	GWAY_BUS
Bus 2T WB: Tech Center-Winter Pa	DTC-WP	Guideway Bus	GWAY_BUS
Bus 2T EB: Winter Park-Tech Cent	WP-DTC	Guideway Bus	GWAY_BUS
Bus 3T WB: Tech Center-Arapahoe	DTC-AB	Guideway Bus	GWAY_BUS
Bus 3T EB: Arapahoe Basin-Tech C	AB-DTC	Guideway Bus	GWAY_BUS
Bus 4W WB: Westminster-Breckenri	Wstmnstr-BR	Guideway Bus	GWAY_BUS
Bus 4W EB: Breckenridge-Westmins	BR-Wstmnstr	Guideway Bus	GWAY_BUS
Bus 5D WB: DIA-VTC	via FS CO	Guideway Bus	GWAY_BUS
Bus 5D EB: VTC-DIA	via CO FS	Guideway Bus	GWAY_BUS
Bus 6U WB: Union Station-Glenwood	DUS-GW	Guideway Bus	GWAY_BUS
Bus 6U EB: Glenwood-Union Station	GW-DUS	Guideway Bus	GWAY_BUS
Bus 7J WB: Jefferson-Frisco Loca	Jeff-FS	Guideway Bus	GWAY_BUS
Bus 7J EB: Frisco-Jefferson Loca	FS-Jeff	Guideway Bus	GWAY_BUS
Home James: GrandLake-DIA	Home James	GrandLake-DIA	HJAMES
Home James: DIA-GrandLake	Home James	DIA-GrandLake	HJAMES
IMC: EGE-Vail	Intermountain Co	EGE-Vail	INTMTN
IMC: Vail-EGE	Intermountain Co	Vail-EGE	INTMTN
BMT: Jefferson-Keystone	Jeffrsn-KS	Bus in Mixed Trf	MIXED
BMT: Keystone-Jefferson	KS-Jeffrsn	Bus in Mixed Trf	MIXED
BMT: Jefferson-Breckenridge	Jeffrsn-BR	Bus in Mixed Trf	MIXED
BMT: Breckenridge-Jefferson	BR-Jeffrsn	Bus in Mixed Trf	MIXED
BMT: Jefferson-Copper Mtn	Jeffrsn-CO	Bus in Mixed Trf	MIXED
BMT: Copper Mtn-Jefferson	CO-Jeffrsn	Bus in Mixed Trf	MIXED
BMT: Jefferson-Vail TC via IS	Jeffrsn-VTC	Bus in Mixed Trf	MIXED
BMT: Vail TC-Jefferson via IS	VTC-Jeffrsn	Bus in Mixed Trf	MIXED
BMT: Jefferson-Winter Park	Jeffrsn-WP	Bus in Mixed Trf	MIXED

Table A-29. Transit Routes for 2000 and 2025

Route Name	Name	Line	System
BMT: Winter Park-Jefferson	WP-Jeffrsn	Bus in Mixed Trf	MIXED
A Train WB: Jefferson-Vail TC	Jeff-VTC	Straight Creek	RAIL
A Train EB: Vail TC-Jefferson	VTC-Jeff	Straight Creek	RAIL
B Train WB: Jefferson-Frisco TC	Jeff-FTC	Straight Creek	RAIL
B Train EB: Frisco TC-Jefferson	FTC-Jeff	Straight Creek	RAIL
C Train WB: Jefferson-Frisco TC	Jeff-FTC	Straight Creek	RAIL
C Train EB: Frisco TC-Jefferson	FTC-Jeff	Straight Creek	RAIL
D Train WB: Jefferson-Vail TC	Jeff-VTC	Straight Creek	RAIL
D Train EB: Vail TC-Jefferson	VTC-Jeff	Straight Creek	RAIL
J Train WB: Jefferson-EGE	Jeff-EGE	Straight Creek	RAIL (AGS)
J Train EB: EGE-Jefferson	EGE-Jeff	Straight Creek	RAIL (AGS)
K Train WB: Jefferson-Frisco TC	Jeff-FTC	Straight Creek	RAIL (AGS)
K Train EB: Frisco TC-Jefferson	FTC-Jeff	Straight Creek	RAIL (AGS)
L Train WB: Jefferson-Vail TC	Jeff-VTC	Straight Creek	RAIL (AGS)
L Train EB: Vail TC-Jefferson	VTC-Jeff	Straight Creek	RAIL (AGS)
RE: DIA-DL/ST, KS	Denver-Keystone	Resort Express	RESEXP
RE: KS, DL/ST-DIA	Keystone-Denver	Resort Express	RESEXP
RE: DIA-FS, BR	Denver-Breckenridge	Resort Express	RESEXP
RE: BR, FS-DIA	Breckenridge-Den	Resort Express	RESEXP
RE: DIA-Copper Mtn	Denver-Copper Mt	Resort Express	RESEXP
RE: Copper Mtn-DIA	Copper Mtn-Denvr	Resort Express	RESEXP
RFTA: WoodyCreek-BrushCreek	Woody To BrshCrk	wtobc	RFTA
RFTA: Glenwood-Aspen Express	Glenwood To Aspen	gtoax	RFTA
RFTA: Glenwood Shuttle SB	Glenwood Shuttle	glnwd	RFTA
RFTA: ElJebel-Aspen Express	ElJebel To Aspen	etoax	RFTA
RFTA: Glenwood Shuttle to W Glen	To West Glnewood	dwnlg	RFTA
RFTA: Carbondale-Aspen Express	Carbondale To Aspen	ctoax	RFTA
RFTA: BrushCreek-WoodyCreek	Brsh&82 To Woody	bctow	RFTA
RFTA 8 Snowmass-Aspen	Snowmass To Aspen	stoa	RFTA
RFTA: Glenwood-Aspen	Glenwood to Aspe	gtoa	RFTA
RFTA: Carbondale-Aspen	Carbondale To As	ctoa	RFTA
RFTA 8 Aspen-Snowmass	Aspen To Snowmas	atos	RFTA
RFTA: Aspen-Glenwood	Aspen-Glenwood	atog	RFTA
RFTA: Aspen-ElJebel	Aspen-El Jebel	atoe	RFTA
RFTA: Aspen-Glenwood Express	Aspen-Glenwood X	atogx	RFTA
RFTA: Aspen-El Jebel Express	Aspen-El Jebel X	atoex	RFTA
RFTA: Aspen-Carbondale Express	Aspen-Carbondale	atocx	RFTA
RFTA 6 Highlands-Aspen	Highlands-Aspen	htoa	RFTA
RFTA 6 Aspen-Highlands	Aspen-Highlands	atoh	RFTA
RFTA 7 Buttermilk-Aspen	Buttermilk-Aspen	bmtoa	RFTA
RFTA 7 Aspen-Buttermilk	Aspen-Buttermilk	atobm	RFTA
RFTA: Rifle-Glenwood	Rifle-Glenwood	rtog	RFTA
RFTA: Glenwood-Rifle	Glenwood-Rifle	gtor	RFTA
RFTA: ElJebel-Aspen	ElJebel-Aspen	etoa	RFTA

Table A-29. Transit Routes for 2000 and 2025

Route Name	Name	Line	System
RFTA: Aspen-Carbondale	Aspen-Carbondale	atoc	RFTA
RTD West: Jeffrsn-DUS	Jeffrsn-DUS	West EB	RTD
RTD West: DUS-Jeffrsn	DUS-Jeffrsn	West WB	RTD
RTD East: DUS-DIA	DUS-DIA	East EB	RTD
RTD East: DIA-DUS	DIA-DUS	East WB	RTD
SkyRide AJ: DIA-Jefferson	DIA-Jeffrsn	AJ WB	RTDBUS
SkyRide AJ: Jefferson-DIA	Jeffrsn-DIA	AJ EB	RTDBUS
BR: Frisco-Breckenridge	Guideway Shuttle	Frisco-Breckenri	SHUTTLE
CB1: Jct US 6-Casinos	Guideway Shuttle	Jct US 6-Casinos	SHUTTLE
CB1: Casinos-Jct US 6	Guideway Shuttle	Casinos-Jct US 6	SHUTTLE
WP: Empire-Winter Park	Guideway Shuttle	Empire-Winter Pa	SHUTTLE
WP: Winter Park-Empire	Guideway Shuttle	Winter Park-Empi	SHUTTLE
MT EB: Jefferson-Arapahoe pnR	Guideway Shuttle	Jefferson-DTC	SHUTTLE
MT WB: Arapahoe pnR-Jefferson	Guideway Shuttle	DTC-Jefferson	SHUTTLE
MW EB: Jefferson-Westminster	Guideway Shuttle	Jefferson-Westmi	SHUTTLE
MW WB: Westminster-Jefferson	Guideway Shuttle	Westminster-Jeff	SHUTTLE
Ski Train: DUS-Winter Park	DUS-Winter Park	Ski Train	SKITRAIN
Ski Train: Winter Park-DUS	Winter Park-DUS	Ski Train	SKITRAIN
Summit: Boreas Pass EB	Warriors Mrk-Bor	Summit-Bore	SUMMIT
Summit: Boreas Pass WB1	Boreas Pass-Bell	Summit-Bore	SUMMIT
Summit: Boreas Pass WB2	Bell Twr-Warrior	Summit-Bore	SUMMIT
Summit: Breckenridge NB	Breckenridge-FTC	Summit-Breck	SUMMIT
Summit: Breckenridge SB	FTC-Breckenridge	Summit-Breck*	SUMMIT
Summit: Copper Mountain NB	Copper Mtn-FTC	Summit-Copper	SUMMIT
Summit: Copper Mountain SB	FTC-Copper Mtn	Summit-Copper	SUMMIT
Summit: Keystone EB	FTC-Keystone	Summit-Key	SUMMIT
Summit: Keystone WB	Keystone-FTC	Summit-Key	SUMMIT
Summit: Silverthorne NB	FTC-Willowbrook	Summit-Silver	SUMMIT
Summit: Silverthorne SB	Willowbrook-FTC	Summit-Silver	SUMMIT
Summit: Wildernest EB	Wildernest-3rd S	Summit-Wild	SUMMIT
Summit: Wildernest WB	3rd St-Wildernes	Summit-Wild	SUMMIT
Summit: Keystone-ABasin	Keystone-ABasin	Summit-ABasin	SUMMIT
Summit: ABasin-Keystone	ABasin-Keystone	Summit-ABasin	SUMMIT
Vail: East Vail Express EB (Blue)	VTC-East Vail	Vail-Blue	VAIL
Vail: East Vail Express WB (Blue)	East Vail-VTC	Vail-Blue	VAIL
Vail: Ford Park EB (Orange)	VTC-Ford Park	Vail-Orange	VAIL
Vail: Ford Park WB (Orange)	Ford Park-VTC	Vail-Orange	VAIL
Vail: Golf Course Loop CW (Yellow)	Golf Course Loop	Vail-Yellow*	VAIL
Vail: Golf Course Loop CCW (Yellow)	Golf Course Loop	Vail-Yellow	VAIL
Vail: In-Town/Lionhd EB (Gray)	Concert-Golden P	Vail-Gray*	VAIL
Vail: In-Town/Lionhd WB (Gray)	Gldn Pk-Concert	Vail-Gray	VAIL
Vail: Lionsridge EB (Pink)	Vail Point-VTC	Vail-Pink	VAIL
Vail: Lionsridge WB (Pink)	VTC-Vail Point	Vail-Pink	VAIL
Vail: Sandstone EB (Purple)	Sandstone/VVw-VT	Vail-Purple	VAIL

Table A-29. Transit Routes for 2000 and 2025

Route Name	Name	Line	System
Vail: Sandstone WB (Purple)	VTC-Sandstn/VVw	Vail-Purple	VAIL
Vail: West Vail EB (Green)	West Vail-VTC	Vail-Green	VAIL
Vail: West Vail EB (Red)	W Vail-VTC	Vail-Red	VAIL
Vail: West Vail WB (Green)	VTC-West Vail	Vail-Green	VAIL
Vail: West Vail WB (Red)	VTC-West Vail	Vail-Red	VAIL

Legend: AB = Arapahoe Basin
BC = Beaver Creek
BH = Black Hawk
BMT = Bus in Mixed Traffic
BR = Breckenridge
CC = Central City
CCW = Counter-clockwise
CME, CMEX = Colorado Mountain Express shuttle vans between DIA and EGE, and the resort communities of Eagle and Pitkin counties
CO = Copper Mountain
CW = Clockwise
DIA = Denver International Airport
DL = Dillon
DTC = Denver Tech Center
DUS = Denver Union Station (formerly DUT, Denver Union Terminal)
EB = Eastbound
ECO = Eagle County Regional Transportation Authority
EGE = Eagle County Airport
FS = Frisco
FTC = Frisco Station (formerly Frisco Transportation Center)
GW = Glenwood Springs
GWAY_BUS = routes in the Dual-Mode and Diesel Bus in Guideway alternatives
HJAMES = Home James, a private shuttle van service between DIA and Grand County
IB = Inbound
IMC, INTMTN = the Intermountain Connection
Jeff = Jefferson Station
KS = Keystone
MIXED = bus routes for the Minimal Action alternative
NB = Northbound
OB = Outbound
pnR = park-n-Ride (capitalization within the Regional Transportation District)
RAIL = line-haul routes for the AGS and Rail with IMC alternatives
RE, RESEXP = (Resort Express) Colorado Mountain Express shuttle vans between DIA and Summit County
RFTA = Roaring Fork Transportation Authority
RTD = Regional Transportation District
SB = Southbound
SHUTTLE = local bus service from the rail or AGS stations to mountain communities
ST = Silverthorne
VTC = Vail Transportation Center
VVw = Vail View Drive
WB = Westbound
WP = Winter Park

Access and Egress to the Transit Network

One difference between transit networks and highway networks is the need to consider access and egress to transit in greater detail. (In most cases, except for city centers where land is scarce, it is safe to assume that a driver is able to park very close to his or her origin and destination.) Because transit networks have a limited number of routes and stops, passengers must typically use a non-transit mode at both ends of their trip.

Drive Access

Because the I-70 Ridership Survey (see Appendix B) suggested that more than 80 percent of travelers prefered to drive to (or be dropped off at) a high-speed I-70 transit system, the demand model assumes that all travelers have access to a vehicle and reach the transit system by park-and-ride. The I-70 Ridership Survey does not have sufficient data to develop a station choice model; therefore, travelers are assumed to use the closest (in terms of driving time) station.

Walk Egress

At the other end of their journey, because transit riders no longer have their personal vehicle, egress is assumed to be by walking, either from the I-70 station or from a local feeder or circulator bus. Some existing transit systems (such as those run by the towns of Vail and Breckenridge) are already structured to provide this function.

No threshold on walking time or distance (for example, the familiar notion that most people are only willing to walk a quarter mile for a bus and a half mile for rail) is used to disqualify transit as a potential mode for a given OD journey. Instead, the full walking distance is input to the mode choice model. Because most travelers do not want to walk long distances, the model intuitively predicts transit has a negligible share for such OD pairs.

Transit Capacity

Defining transit capacity for each alternative is the number of seats in each vehicle (shown in **Table A-30**), the formation of vehicles into trains, and the number of vehicles per hour. It is the goal of many North American transit operators to provide sufficient capacity (as determined by the schedule or operating plan) so that the peak passenger load can be carried with little discomfort or crowding. Further, loading standards used by larger operators such as New York City Transit (NYCT) are inappropriate for the much longer recreational trips made in the I-70 Corridor. That is, passenger demand on a potential I-70 transit system is expected to usually be below transit vehicle capacity, and the number of passengers have little influences on the travel time of the transit vehicle. The demand model also makes this assumption, which is checked during the development of the operating plan. If insufficient capacity was provided, frequencies are increased to provide an 83 percent load factor (passengers per seat) on each model day.

Table A-30. Vehicle Seating Capacity

Alternative or Mode	Seats per Vehicle	Vehicles per Train (Peak)
Rail	60	10
IMC	75	2
AGS	96	2
Dual-Mode Bus in Guideway	65	1
Diesel Bus in Guideway	40	1
Bus in mixed traffic	40	1
Shuttle van	10	1
Tour bus	40	1

Source: TranSystems Colorado Maglev Project, J.F. Sato and Associates

Transit Speed

Speeds in Exclusive Guideways

Of the alternatives proposing new transit services in the I-70 Corridor, all but Minimal Action introduces exclusive guideways for transit vehicles, unimpeded by general traffic on I-70. RAILSIM® was used to determine station-to-station times and energy requirements of the transit vehicles for these alternatives. The simulation uses detailed data on vehicle weight, vehicle performance, and guideway geometry. The results include the maximum cruising speed, acceleration and deceleration to cruising speed, and dwell time at each station. For purposes of demand modeling, the average speeds (excluding dwells) derived from the simulations were used, as shown in **Table A-31**.

Table A-31. Guideway Transit Travel Speeds

Alternative	Maximum Cruise Speed (mph)	Average Speed (mph)
Rail	80	52.1
AGS	125	63.8
Dual-Mode Bus in Guideway	70	50.6
Diesel Bus in Guideway	65	50.4
Intermountain Connection (Diesel Multiple Unit)	60-80	48.5

Note: Maximum cruise speed of the Intermountain Connection reflects a range of currently available diesel multiple units.

Source: TranSystems, Intermountain Partnership

Note that with stations spaced about 9.5 miles apart, the average speed can be considerably slower than the maximum cruise speed. For example, the maglev technology assumed for the AGS alternative is capable of reaching 125 mph on plains, but averages about 64 mph in the Corridor. Similarly, the Rail with IMC alternative, with a maximum cruise speed of 80 mph, averages about 52 mph.

Rail with IMC. For the Intermountain Connection (IMC), the speeds and schedule described in *A proposal for RAILS & TRAILS to link the communities of the Vail and Eagle Valleys* by the Intermountain Partnership is used.

The Vail to Jefferson Station portion of the Rail with IMC alternative uses skip-stop operations (no train can pass another in the same direction) and the average headway between trains on the same track is 10 minutes.

Advanced Guideway System (AGS). The AGS alternative uses skip-stop operations (no train can pass another in the same direction) and the average headway between trains on the same track is 10 minutes.

Bus in Guideway. The Bus in Guideway alternatives includes both express and local services.

The Dual-Mode (diesel/electric) Bus in Guideway alternative is expected to operate nonstop in the guideway at speeds up to 70 mph. This results in an average speed of 50.6 mph along routes with several local stops and routes with few stops, a conservative approach that accounts for acceleration and deceleration on grades and near stations.

The Diesel Bus in Guideway alternative operates at slightly slower speeds than the Dual-Mode Bus in Guideway when in the guideway (up to 65 mph, with an average of 50.4 mph), and at faster speeds (due to a smaller, lighter vehicle) outside the guideway, as described in the following section.

Bus Speed Out of Guideway

Vehicle speed is related to: power; overall weight; the ability of the vehicle's wheels to adhere to the guideway; and passenger comfort during acceleration, deceleration, and while traveling on horizontal and vertical curves. Vehicle speed may be calculated including or excluding dwell time at stations.

Bus speed while in mixed traffic is the same as the calculated automobile speed after taking into consideration the effect of congestion on the traffic stream. Bus speed is also affected by grades as shown in **Table A-32**. The grades on I-70 in the travel demand model are shown in **Chart A-3**. This speed calculation is used for both existing operators in the Corridor (all of which use diesel buses) and for the new transit routes introduced as part of the Bus in Guideway alternatives.

Table A-32. Diesel Bus Speeds at Grade and Dual-Mode Bus Speeds Off Guideway

Grade	Diesel Bus (mph)	Dual-Mode Bus (mph)
Grade 0 to 0.99 percent	65	55
Grade 1 to 1.99 percent	60	50
Grade 2 to 2.99 percent	55	45
Grade 3 to 3.99 percent	50	40
Grade 4 to 4.99 percent	45	35
Grade 5 to 5.99 percent	40	30
Grade 6 to 6.99 percent	37	27
Grade 7 to 7.99 percent	35	25

Source: Based on model limitations believed by the TranSystems team to be appropriate speed after adjustment of raw data.

Station Dwell Time

Dwell time at each station is a combination of how many people get on and off each vehicle, the width of the doors, any elevation difference between the platform and the vehicle floor, and where baggage is stored and how accessible it is to passengers. For each Transit alternative, an average dwell time of just under 2 minutes is used at each stop, which is consistent with industry practice for intercity services.

Flight Time to Mountain Airports

The Corridor transit system introduces the possibility that out-of-state residents who currently fly to Eagle County or Aspen/Pitkin County airports may now choose to fly to DIA and transfer to RTD services, and then to the new system at Jefferson Station to reach their destination. This change is assumed to result in a 1-hour flight time saving each way.

Transit Frequency

Frequency (arrivals per hour) and headway (minutes between successive vehicles) are important measures of transit service because they affect the average wait time experienced by passengers. Most passengers are also more averse to this *frequency-headway* time than *in-vehicle* time. Headway varies by season and time of day. The lower the headway, the greater the capacity of a transit route, all other things (such as seats per vehicle) being equal.

The travel demand model allows the use of different headways during peak and off-peak periods—on different days of the week and by season—to correspond to actual and anticipated scheduling practice. In winter, the peak period is generally from 6:00 to 10:00 AM and 3:00 to 7:00 PM; in summer, it is all day from 8:00 AM to 8:00 PM.

Headways of existing operators were based on published schedules, averaged for the appropriate daytime period. For future scenarios, an initial guess of frequency was used and then modified as alternative operating plans were refined.

Transit Costs

For travelers deciding between driving and riding, the monetary cost of transit is generally limited to the fare. The I-70 travel demand model assumes fares are collected on an operator-by-operator basis. That is, free transfers are allowed between any two routes operated by the same entity. Because Corridor operators are assumed not to have any revenue-sharing agreement, switching to a new operator requires a new fare payment.

Fares may be classified either as (1) flat, the same fare is charged regardless of the distance the passenger travels, or (2) zone-based.

- Flat fares are charged by ECO Transit, Summit Stage, the municipalities, the casino buses, the ski train, and shuttle van operators with simple route structures.
- Zone fares are currently charged by RFTA and Colorado Mountain Express.
- The I-70 Transit alternatives charge a zone fare because of the distance covered by these systems.

All fares presented in this section, and used in the travel demand model, are in constant Year 2000 dollars. Fare structures of existing operators represent those in effect during 2000.

Flat Fares

Free. Summit Stage and the Town of Vail have the simplest fare structure because all of their routes are free. Considering rebate coupons, casino buses are essentially free. However, a nominal $5.00 fare on the casino buses is assumed to avoid predicting unreasonably high ridership on these services.

Under $5. ECO Transit has two types of routes for fare purposes: $2 on local routes and $3 on the I-70 Express between Vail and Beaver Creek and on routes leaving Eagle County. (Currently this is just the Leadville routes but may also include the proposed route to Glenwood Springs.)

RTD Light Rail may be used to access Jefferson Station or DIA from Denver Union Station. One-way fare is assumed to be $1.25, the prevailing peak local fare in 2000. No free transfer between lines is assumed to account for expected zone fare structures.

About $50. Resort Express (now branded as Colorado Mountain Express) offers shuttle van service between DIA and resorts in Summit County. The fare is $52 one-way. Home James provides shuttles from DIA to destinations in Grand County (including Winter Park) for $50 one-way. Ski Train offers two classes of service: $45 for coach, and $70 for club car seats. Because tickets are good for one day only, people staying overnight pay twice as much for roundtrip travel, compared to day recreation seekers. However, to calibrate the mode choice model and transit path choice procedure, the Ski Train fares were artificially lowered to $10 each way. That is, using the actual cash fare does not produce sufficient forecast Ski Train ridership to match observed levels. This fare reduction may account for employer-subsidized travel, or the scenic or nostalgic aspects of the Ski Train.

Zone Fares

RFTA operates a zone fare structure on its longer-distance valley routes so that fare or cost is proportional to the amount of service provided. Fares range from $1 to $9 as shown in **Table A-33**.

Table A-33. RFTA Year 2000 Zone Fare Structure

Fare Chart	Rifle	Silt	New Castle	Glenwood Springs	Carbondale	El Jebel	Basalt	Brush Creek and 82	Snowmass	Aspen
Rifle	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	9.00
Silt	2.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	8.00
New Castle	3.00	2.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	7.00
Glenwood Springs	4.00	3.00	2.00	1.00	2.00	3.00	4.00	5.00	6.00	6.00
Carbondale	5.00	4.00	3.00	2.00	1.00	2.00	3.00	5.00	5.00	5.00
El Jebel	6.00	5.00	4.00	3.00	2.00	1.00	2.00	3.00	4.00	4.00
Basalt	7.00	6.00	5.00	4.00	3.00	2.00	1.00	2.00	3.00	3.00

Fare Chart	Rifle	Silt	New Castle	Glenwood Springs	Carbondale	El Jebel	Basalt	Brush Creek and 82	Snowmass	Aspen
Brush Creek and 82	8.00	7.00	6.00	5.00	4.00	3.00	2.00	1.00	2.00	2.00
Snowmass	9.00	8.00	7.00	6.00	5.00	4.00	3.00	2.00	1.00	3.00
Aspen	9.00	8.00	7.00	6.00	5.00	4.00	3.00	2.00	3.00	Free

Source: RFTA

Colorado Mountain Express (CME) shuttle vans connect both DIA and Eagle County Airports to resorts in Eagle and Pitkin counties. One-way fares are shown in **Table A-34**.

Table A-34. CME Year 2000 Fare Structure

From Location	To DIA	To Vail or Beaver Creek	To Eagle County Airport	To Aspen or Snowmass
DIA	N/A	$62.00	$75.00	$102.00
Vail or Beaver Creek	62.00	N/A	44.00	62.00
Eagle County Airport	75.00	44.00	N/A	62.00
Aspen or Snowmass	102.00	62.00	62.00	N/A

Note: N/A = not applicable
Source: Colorado Mountain Express

The Corridor transit system assumes a fare structure averaging 10 cents per mile. However, a range of fares between 5 and 45 cents per mile was examined. Obviously, more ridership and less automotive congestion occur with lower fares. However, CDOT management did not want to consider a free transit system because the system requires large subsidies. The 10 cents per mile fare offers a balance between recovering some operating costs and providing a noticeable reduction of congestion on I-70. Further, it is roughly equal to the assumed automobile operating cost (36.5 cents per mile) divided by typical Corridor occupancies (up to an average of 2.6 persons per vehicle for some trip purposes). The 45 cents per mile level is similar to what private shuttle vans currently charge but provides negligible traffic reduction.

A zone fare structure following natural boundaries was desired. Corridor county boundaries often follow natural features, such as the Continental Divide or the divide between the Blue River watershed (Summit County) and the Eagle River watershed (Eagle County), so these were adopted as fare zone boundaries. Station-to-station fares were calculated at 10 cents per mile and then averaged within each zone-to-zone pair. Finally, these average fares were rounded to a convenient amount as shown in **Table A-35**.

Table A-35. I-70 Transit System Fare Structure

From Location	To Metro Denver	To Clear Creek/ Gilpin Counties	To Grand County	To Summit County	To Eagle County	To Garfield County
Metro Denver	N/A	$5.00	$7.00	$8.00	$14.00	$20.00
Clear Creek/Gilpin Counties	5.00	2.50	5.00	5.00	8.00	14.00
Grand County	7.00	5.00	2.50	7.00	10.00	16.00
Summit County	8.00	5.00	7.00	2.50	6.00	10.00
Eagle County	14.00	8.00	10.00	6.00	2.50	6.00
Garfield County	20.00	14.00	16.00	10.00	6.00	N/A

Note: Fares are presented in constant Year 2000 dollars. N/A = Not applicable.
Source: J.F. Sato and Associates

No Charges at Park-and-Ride Lots

Consistent with the policies of existing operators in or near the Corridor (ECO Transit, Summit Stage, RFTA, and RTD), no separate charge is made for parking at park-and-ride lots. Instead, the cost to provide parking incurred by transit operators is recovered from general fare receipts.

Mountain Airport Surcharge

As shown in **Table A-36**, flying to Eagle County Airport or Aspen/Pitkin County Airport costs about $100 more on each leg segment compared to flying to DIA. Therefore, Eagle County or Aspen/Pitkin County Airport passengers who switch to DIA to use the Corridor transit system save $100 each way or $200 round trip.

Table A-36. Typical Air Fares to Colorado Airports.

Visitor's Home Airport	Round-Trip Fare to DIA	Round-Trip Fare to Aspen/Pitkin County Airport	Surcharge to Aspen/Pitkin County Airport	Round-Trip Fare to Eagle County Airport	Surcharge to Eagle County Airport
Winter Season					
DFW – Dallas/Fort Worth International	$301	$464	$163	$400	$ 99
JFK – John F. Kennedy International (New York City)	308	579	271	512	204
LAX – Los Angeles International	208	528	320	437	229
ORD – O'Hare International (Chicago)	308	531	223	446	138
Average Round-Trip Surcharge			$244		$168
Average One-Way Surcharge			**$122**		**$ 84**
Summer Season					
DFW – Dallas/Fort Worth International	$301	$464	$163	$400	$ 99
JFK – John F. Kennedy International (New York City)	357	470	113	512	155
LAX – Los Angeles International	208	528	320	437	229
ORD – O'Hare International (Chicago)	308	531	223	446	138
Average Round-Trip Surcharge			$205		$155
Average One-Way Surcharge			**$102**		**$ 78**

Table A-36. Typical Air Fares to Colorado Airports.

Visitor's Home Airport	Round-Trip Fare to DIA	Round-Trip Fare to Aspen/Pitkin County Airport	Surcharge to Aspen/Pitkin County Airport	Round-Trip Fare to Eagle County Airport	Surcharge to Eagle County Airport
Mud Season					
DFW – Dallas/Fort Worth International	$301	$464	$163	$400	$ 99
JFK – John F. Kennedy International (New York City)	357	470	113	512	155
LAX – Los Angeles International	208	528	320	437	229
ORD – O'Hare International (Chicago)	308	531	223	446	138
Average Round-Trip Surcharge			$205		$155
Average One-Way Surcharge			**$102**		**$ 78**

Notes: Fares reflect lowest coach (economy) fares available with advance purchase for a seven-night stay including a Saturday night. Fares do not include taxes or fees.

Source: United.com

A.2.4 Socioeconomic Data

Population

Socioeconomic data is developed by each of the 728 spatially defined transportation analysis zones covering the entire study area, as shown in **Figure A-3**. For the area including and surrounding the Corridor, the zone data are estimates and forecasts made by the State Department of Local Affairs (DOLA) and local planners. For the Denver region (except near the Corridor), estimates and forecasts come from DRCOG. The Corridor is defined for the travel demand model as Jefferson County (west of the Hogback, between US 285 and US 6), Gilpin, Clear Creek, Summit, Eagle, Park, Lake, Garfield, Pitkin, and Grand counties. Within these counties, the zone system has been subdivided to provide data for at least each town, wilderness, or forest area. For projected areas near proposed transit stations, the zone system is very fine-grained to allow proper calculation of walking trips from these areas and surrounding affected subdivisions. The zones are specified by their ID value and range from 1 to 2,378. **Table A-37** and **Table A-38** provide data by county for population, households, and employment in the study area.

Assumptions

The following assumptions were used:

- Parcels from the parcel boundary layer from each of the counties of Clear Creek, Grand, Summit, Eagle, and Garfield, as well as a surrogate for Pitkin, were categorized into one of 12 categories of land use, listed in **Table A-39**.
- These 12 categories were developed to provide a uniform definition among all of the jurisdictions in the above-listed counties. Land uses were obtained from the Bureau of Land Management (BLM) and US Forest Service (USFS) boundary and land use zoning and master plan maps for each county and local government. Master plans for each jurisdiction were collected and used to define any special open space considerations not noted elsewhere. For each jurisdiction, the parcel aggregation of the urban land uses was used to define an urban growth boundary. The

resulting data defined where urban growth occurs and its relative density throughout each jurisdiction, for both 2000 and 2025.

- Each jurisdiction's population, households by four-income classes, and employment were forecast independently. Results were constrained to match forecasts at the county level from DOLA. In Eagle County, extra population, households, and employment were to reflect the community's expectation that further seasonal growth occurs in the area between Gypsum and Edwards. Permanent population, household, and employment forecasts were reviewed and revised with each jurisdiction, with input from the Northwest Colorado Council of Governments (NWCCOG).
- Jurisdictional values were distributed to the TAZ level proportionally to the density and area of each zoning category. For example, a TAZ with a certain area of R-4 zoning (dense urban residential) receives more population and households than another TAZ of the same acreage zoned as RE (residential estate, typical of rural plots).

Definitions

The data is collected into two databases for each analysis year, one for winter and one for summer. Different days for each season are then calculated from each database. For example, fewer work trips are made on weekends than on weekdays, while more recreation trips are made on weekends than on weekdays. The following definitions were used for the database information.

- Population: Total number of persons living in permanent plus temporary housing for the purpose of earning a living. Persons living in permanent housing may be living in either rental or owner-occupied housing units but stay year-round, and in 2000 were counted by the Census Bureau in the April/May time period. Persons living in temporary housing may also be living in rental or owner-occupied housing, but leave after the winter ski season or the summer construction season, and were not counted in the 2000 Census. Population is forecast independently from households.
- Households: Households include group quarters provided by some employers at mountain communities with ski and summer activities. Based on a template developed from the 1990 Census, households are divided into four family size categories: one person, two people, three people, and more than three people. Households are further subdivided into four income groups for a total of 16 categories. The four income groups are defined as follows for consistency with the DRCOG and RFV models:
  - Low Income Households (LIHH): Income from zero dollars to $25,000 per year.
  - Middle Income Households (MIHH): Income from $25,000 to $50,000 per year.
  - Upper Middle Income Households (UIHH): Income from $50,000 to $100,000 per year.
  - High Income Households (HIHH): Income over $100,000 per year.

Average household size is calculated by dividing the total households in each zone by the population. This value is used to subdivide the four household categories into 16 categories.

Colorado demographics are complicated by the presence of *undocumented workers*, who offer an inexpensive labor force for industries such as agriculture, landscaping, food services, and accommodations. These workers may migrate seasonally – for example, as different agricultural products become ready to harvest – and may be paid cash wages, making it difficult to accurately estimate the extent of the role these workers play in the state economy. Since these workers are not authorized to be in the US, they are unlikely to be counted in the census, for fear of deportation.

In his 2004 State of the Union Address, President George W. Bush proposed granting temporary legal status to an estimated 8 million undocumented workers in the country. According to Census 2000, Colorado population (about 4.3 million persons) represents about 1.5 percent of the US population (about 281 million). Assuming that undocumented workers are twice as likely as average to live in Colorado, about 240,000 undocumented workers (8 million times 1.5 percent times 2) are estimated to have been living in the state in 2000.

As an example of their impact on the Corridor, suppose that 1 percent of the undocumented workers in Colorado or about 2,400 individuals lived in the towns of Eagle and Gypsum. These workers represent about 960 households (assuming an average household size of 2.5), and a 30 percent increase beyond the documented 8,000 labor force for these two towns. By 2025, these two towns are projected to host about 10,000 undocumented workers. Other undocumented workers reside – and are expected to continue residing – in locations such as Garfield County, Lake County, and Park County. For modeling purposes, all undocumented workers are assumed to fall in the low income group.

No shift over time in people's ability to purchase more goods and services is assumed. The net effect of this assumption is that the same trip generation rates per household are for both 2000 and 2025, and there is no shift in the proportion of households by income.

Another unique aspect of I-70 Corridor communities is the large fraction of the housing stock maintained as *second homes* by residents of the Front Range, other portions of Colorado, other states, and even other nations. NWCCOG estimates that about two-thirds of the housing units in Summit County and about one-half the units in Eagle County are used as second homes. The proximity of a *primary residence* to the Corridor communities affects how often a second home may be occupied by its owner and how long the owner may stay. For example, Front Range residents may prefer to make frequent weekend stays at a second home, while out-of-state residents are more likely to make a few longer-duration trips (such as a one-week stay) to their second home. These different use patterns may also result in different patterns of local trip-making during a second home stay; for example, Front Range residents may bring groceries with them while out-of-state residents may prefer to shop in Corridor communities or eat more meals at restaurants.

A link between the NWCCOG second home estimates for four counties (Eagle, Grand, Pitkin, and Summit counties) and Census 2000 was desired so that second home counts in other counties are established and projections of 2025 second home levels made. As shown in **Table A-40**, the total number of vacant units plus renter-occupied units closely matches NWCCOG estimates. While some second homes may be rented under time-sharing arrangements or through management companies, any potential overestimate of second homes by using *all* rental properties was thought to offset the census undercount of total housing units. The split of second home ownership by Front Range residents and out-of-state residents used by the travel demand model is shown in **Table A-41**.

Table A-37. 2000 Socioeconomic Data by County

County	Population	Low Income HH	Middle Income HH	Upper Income HH	High Income HH	Total Households	Second Home Units	Basic Employment	Retail Employment	Service Employment	Total Employment
ADAMS CO	400,054	37,553	61,328	38,429	3,189	140,499	0	75,267	28,383	48,136	151,786
ARAPAHOE CO	524,687	49,388	68,765	70,415	17,012	205,580	0	82,984	48,401	154,198	285,583
BOULDER CO	290,662	30,070	37,153	40,650	8,669	116,542	0	59,309	36,324	91,892	187,525
CHAFFEE CO	17,490	2,210	2,794	1,679	263	6,946	0	2,073	2,191	4,915	9,179
CLEAR CREEK CO	9,324	1,026	1,324	1,504	169	4,023	2,069	1,509	568	1,432	3,509
DELTA CO	29,135	4,508	4,842	2,085	395	11,830	0	4,568	2,291	6,022	12,881
DENVER CO	502,710	79,448	84,810	49,581	12,839	226,678	0	156,000	59,962	261,588	477,550
DOUGLAS CO	186,506	7,187	16,085	31,313	9,707	64,292	0	16,595	18,797	22,697	58,089
EAGLE CO	42,440	2,996	4,991	4,359	6,428	18,774	12,462	11,007	6,734	15,530	33,271
EL PASO CO	523,086	44,968	62,076	72,533	19,826	199,403	0	71,607	53,135	184,832	309,574
FREMONT CO	46,856	6,395	6,053	3,210	662	16,320	0	4,470	3,269	11,301	19,040
GARFIELD CO	43,791	4,828	7,183	3,616	601	16,228	6,760	13,084	4,136	8,296	25,516
GILPIN CO	4,789	302	407	702	616	2,027	0	750	283	4,714	5,747
GRAND CO	12,447	1,409	2,223	1,255	138	5,025	7,433	3,726	1,162	4,393	9,281
GUNNISON CO	14,471	1,678	1,979	1,720	295	5,672	0	2,691	2,752	5,653	11,096
JACKSON CO	1,906	261	335	153	25	774	698	532	146	426	1,104
JEFFERSON CO	537,783	42,944	68,572	87,464	14,564	213,544	0	55,719	52,293	98,629	206,641
LAKE CO	7,807	935	1,285	687	68	2,975	1,884	1,054	191	1,140	2,385
LARIMER CO	250,717	24,401	27,770	35,468	9,937	97,576	0	42,605	29,446	72,905	144,956
MESA CO	122,944	15,795	18,249	12,412	2,407	48,863	0	19,365	14,337	34,689	68,391
MOFFAT CO	13,576	1,197	1,405	2,202	310	5,114	0	2,410	1,318	2,988	6,716
MONTROSE CO	34,187	4,084	4,968	3,751	712	13,515	0	7,492	3,383	8,559	19,434
PARK CO	14,523	1,667	2,727	1,639	208	6,241	5,531	1,879	614	438	2,391
PITKIN CO	14,871	1,317	1,804	2,421	1,262	6,804	6,069	4,819	3,935	10,440	19,194
PUEBLO CO	145,009	19,487	21,487	13,378	2,525	56,877	0	15,949	16,385	37,939	70,273
RIO BLANCO CO	7,404	645	870	1,080	184	2,779	0	1,390	477	1,893	3,760
ROUTT CO	19,390	1,669	2,164	3,038	795	7,666	5,712	5,195	3,918	9,075	18,188

County	Population	Low Income HH	Middle Income HH	Upper Income HH	High Income HH	Total Households	Second Home Units	Basic Employment	Retail Employment	Service Employment	Total Employment
SAGUACHE CO	6,564	1,223	802	251	108	2,384	0	1,285	262	1,071	2,618
SUMMIT CO	23,550	2,143	3,361	3,013	600	9,117	18,826	7,789	3,115	12,337	23,241
TELLER CO	22,896	2,110	2,730	3,221	794	8,855	0	1,933	1,517	6,195	9,645
WELD CO	159,475	25,147	27,216	12,391	1,756	66,510	0	24,851	16,526	20,435	61,812

Note: County totals may not exactly match those of Section 3.9 because of rounding as socioeconomic variables were allocated to TAZs.

Source: US Census Bureau, DOLA, DRCOG, RFV

Table A-38. 2025 Socioeconomic Data by County

County	Population	Low Income HH	Middle Income HH	Upper Income HH	High Income HH	Total Households	Second Home Units	Basic Employment	Retail Employment	Service Employment	Total Employment
ADAMS CO	659,082	24,988	52,462	153,581	15,376	246,407	0	135,888	47,376	156,283	339,547
ARAPAHOE CO	702,197	30,199	44,449	152,258	53,000	279,906	0	103,611	76,508	186,625	366,744
BOULDER CO	435,550	19,377	24,755	98,356	30,497	172,985	0	90,897	52,862	144,104	287,863
CHAFFEE CO	23,030	1,184	3,018	1,980	3,018	9,200	0	3,201	3,974	7,389	14,564
CLEAR CREEK CO	17,284	1,258	1,681	4,087	491	7,517	3,003	2,408	681	2,455	5,544
DELTA CO	44,221	2,548	5,936	3,461	5,936	17,881	0	4,346	3,608	8,655	16,609
DENVER CO	637,469	50,329	79,281	123,405	33,334	286,349	0	185,954	79,625	317,041	582,620
DOUGLAS CO	322,824	7,143	15,982	62,006	34,317	119,448	0	33,979	28,807	54,963	117,749
EAGLE CO	76,083	4,582	6,446	9,871	10,581	31,480	37,888	29,404	48,639	30,227	108,270
EL PASO CO	744,645	36,861	65,271	114,746	65,271	282,149	0	98,970	102,858	306,267	508,095
FREMONT CO	57,875	3,182	6,631	3,225	6,631	19,669	0	5,350	5,020	17,880	28,250
GARFIELD CO	80,881	22,470	8,936	13,546	2,273	47,225	9,801	25,966	4,856	10,091	40,913
GILPIN CO	11,401	1,189	1,307	1,878	1,827	6,201	0	750	283	10,891	11,924
GRAND CO	25,867	1,213	2,614	5,917	777	10,521	10,779	5,681	1,769	6,695	14,145
GUNNISON CO	21,831	1,343	2,816	1,736	2,816	8,711	0	3,860	4,320	8,960	17,140
JACKSON CO	2,362	89	265	382	265	1,001	1,012	664	37	291	992
JEFFERSON CO	694,736	21,826	35,337	171,727	51,294	280,184	0	76,605	64,325	137,531	278,461
LAKE CO	19,230	1,213	2,506	3,917	458	8,094	2,732	2,604	502	2,826	5,932
LARIMER CO	378,988	23,088	34,936	58,302	34,936	151,262	0	57,869	51,993	131,922	241,784
MESA CO	196,020	12,137	25,627	16,100	25,627	79,491	0	32,994	35,430	78,275	146,699
MOFFAT CO	17,709	590	1,448	3,335	1,448	6,821	0	2,820	2,253	4,650	9,723
MONTROSE CO	54,842	2,969	6,551	6,129	6,551	22,200	0	11,105	6,137	12,882	30,124
PARK CO	56,100	2,912	6,154	12,366	1,790	23,222	8,020	1,729	658	607	2,994
PITKIN CO	24,134	751	1,021	2,927	2,638	7,337	8,800	3,399	10,770	25,068	39,237
PUEBLO CO	192,572	18,709	21,952	12,236	21,952	74,849	0	16,577	31,814	64,959	113,350
RIO BLANCO CO	9,740	363	926	1,501	926	3,716	0	2,059	1,029	4,593	7,681
ROUTT CO	32,143	1,714	3,042	5,136	3,042	12,934	8,282	11,241	10,217	11,254	32,712

County	Population	Low Income HH	Middle Income HH	Upper Income HH	High Income HH	Total Households	Second Home Units	Basic Employment	Retail Employment	Service Employment	Total Employment
SAGUACHE CO	8,066	774	962	302	962	3,000	0	1,265	707	2,964	4,936
SUMMIT CO	43,739	1,816	3,030	9,614	2,491	16,951	27,275	20,557	3,389	20,316	44,262
TELLER CO	31,121	1,477	3,006	4,848	3,006	12,337	0	1,495	1,635	8,027	11,157
WELD CO	403,066	27,464	55,018	58,927	8,341	149,750	0	59,278	21,609	65,262	146,149

Note: County totals may not exactly match those of Section 3.9 because of rounding as socioeconomic variables were allocated to TAZs. Socioeconomic projections for Gilpin County include development induced by the Central City Parkway, which is not reflected in Section 3.9.

Source: DOLA, DRCOG, RFV, Corridor communities

Table A-39. Land Use Interpretation Key

Category	Description
Residential	
Residential Estate	1 unit per 20 acres or more
Rural	1 unit per 2 to 19 acres
Low Density	1 to 5 units per acre
Medium Density	6 to 10 units per acre
High Density	11 or more units per acre
Lodging	Hotels, motels, and resort lodging
Commercial	Service, retail, and office uses
Industrial	
Light Industrial	Light manufacturing
Heavy Industrial	Heavy manufacturing
Mining	Mining and related activities
Public facilities owned by the town or county	Town hall, town/county offices, cemeteries, libraries, schools
Mixed Use	Mixed residential and commercial area, typically associated with a downtown
Open Space	Natural areas that have been set aside for passive recreation or preservation
Parks and Urban Spaces	Town/county parks
Agricultural	Active agricultural or very low-density residential in an agricultural setting
Resource	Conservation/preservation areas
Planned Unit Development	Planned development that has been approved by the town/county
Public Lands	
Bureau of Land Management	Federally owned and managed land
White River National Forest	Federally owned and managed national forest
Arapaho and Roosevelt National Forests	Federally owned and managed national forest
Pike/San Isabel National Forest	Federally owned and managed national forest
State Lands	State Land Board and Colorado Division of Wildlife Areas

Source: J.F. Sato and Associates.

Table A-40. Comparison of Year 2000 Second Home Estimates

County	NWCCOG Second Home Estimate	Census 2000 Housing Units						
		Occupied			Vacant			Vacant Plus Renter Occupied
		by Owner	by Renter	Total	Seasonally	Total	Total	
Clear Creek	N/A	3,059	960	4,019	919	1,109	5,128	2,069
Eagle	12,539	9,649	5,499	15,148	5,932	6,963	22,111	12,462
Garfield	N/A	10,576	5,653	16,229	484	1,107	17,336	6,760
Grand	7,768	3,461	1,614	5,075	4,783	5,819	10,894	7,433
Jackson	N/A	447	214	661	391	484	1,145	698
Lake	N/A	2,029	948	2,977	585	936	3,913	1,884
Park	N/A	5,166	728	5,894	4,329	4,803	10,697	5,531
Pitkin	7,580	4,027	2,780	6,807	2,728	3,289	10,096	6,069
Routt	N/A	5,505	2,448	7,953	1,977	3,264	11,217	5,712
Summit	17,116	5,375	3,745	9,120	13,235	15,081	24,201	18,826
Totals	**45,003**	**49,294**	**24,589**	**73,883**	**35,363**	**42,855**	**116,738**	**67,444**
Eagle, Grand, Pitkin and Summit Only	**45,003**	**22,512**	**13,638**	**36,150**	**26,678**	**31,152**	**67,302**	**44,790**

Notes: N/A = Not available.

Sources: NWCCOG. Caliper Corporation "State Data CD with Census 2000 Data: Version 2 – Colorado."

Table A-41. Distribution of Second Home Ownership by County

Percent Ownership of Second Homes in County		
County	Front Range Residents	Out-of-State Residents
Clear Creek	80%	20%
Eagle	49%	51%
Garfield	40%	60%
Grand	79%	21%
Jackson	50%	50%
Lake	50%	50%
Park	80%	20%
Pitkin	34%	66%
Routt	40%	60%
Summit	51%	49%

Source: NWCCOG, J.F. Sato and Associates.

Employment

The travel demand model uses the same general categories for employment used by other models in the state: basic, retail, and services.

- Basic: Generally concerned with production and manufacturing of materials and includes farming, mining, and manufacturing for people outside of the local area; also includes most construction activities.
- Retail: Includes wholesale and retail sale of goods and services, generally to people in the local area. Employment at gas stations and grocery stores falls in this category.

- Service: Includes services provided to people in the local area such as vehicle repair, ski resorts, and guide services.

Table A-42 shows how broad groups of enterprises defined by the 1997 North American Industry Classification System (NAICS, the successor to the Standard Industrial Classification or SIC system) correspond to the three categories used by the travel demand model.

Table A-42. Correspondence Between 1997 NAICS and Travel Demand Model Employment Categories

NAICS	Description	Category
11	Agriculture, Forestry, Fishing, and Hunting: 111. Crop Production 112. Animal Production 113. Forestry and Logging 114. Fishing, Hunting, and Trapping 115. Support Activities for Agriculture and Forestry	 Basic Basic Basic Basic Service
21	Mining	Basic
22	Utilities	Basic
23	Construction	Basic
31-33	Manufacturing	Basic
42	Wholesale Trade	Retail
44-45	Retail Trade	Retail
48-49	Transportation and Warehousing	Basic
51	Information: 511. Publishing Industries 512. Motion Picture and Sound Recording Industries 513. Broadcasting and Telecommunications 514. Information Services and Data Processing	 Basic Service Basic Service
52	Finance and Insurance	Service
53	Real Estate and Rental and Leasing	Service
54	Professional, Scientific, and Technical Services	Service
55	Management of Companies and Enterprises	Service
56	Administrative and Support and Waste Management and Remediation Services	Service
61	Educational Services	Service
62	Health Care and Social Assistance	Service
71	Arts, Entertainment, and Recreation	Service
72	Accommodation and Food Services: 721. Accommodation 722. Food Services and Drinking Places	 Service Retail
81	Other Services (except Public Administration)	Service
92	Public Administration	Service

Sources: US Department of Commerce, Census Bureau; J.F. Sato and Associates.

Recreation

The Corridor is unique because its most severe congestion occurs during weekends, when recreational travel is highest. The nine recreational purposes are classified as follows:

- Day Recreation:
  - Day Gaming
  - Front Range Day Recreation to Corridor attractions

- Corridor Day Recreation by:
  - Corridor residents
  - Front Range residents staying overnight at second homes and resorts
  - Out-of-state residents staying overnight at second homes and resorts
- Stay Overnight Recreation:
  - Front Range trips to hotels, resorts, and forests
  - Resort-to-Resort trips
  - Front Range trips to second homes in the Corridor
  - Out-of-state air passenger trips to resorts
- Colorado Non-Work:
  - Stay overnight visiting friends and family
  - Corridor trips to airports and Front Range destinations

Approach

One of the challenges of working with recreational trips is the limited data available. For example, privately owned resorts are reluctant to release patronage data for fear it gives their competitors an advantage. Although USFS conducts surveys of forest users, results are aggregated by Forest District rather than by campsite or trailhead. USFS surveys are also generally aggregated over the entire year and therefore do not provide the seasonal data needed by the I-70 travel demand model.

The theoretically pure approach is to relate trip ends to beds, condominiums, and ski area statistics (skiable acres, vertical drop, lift capacity). However, this relation may not completely explain recreational travel. Instead, person trips ending in each zone are used – with Saturday as a base day – and travel factored for days other than Saturday. Care must be taken because some variable names in the PEIS socioeconomic databases sound like units of land use (second homes, hotel beds), but in fact represent trips.

Types of Variables

Recreation trips into, out of, and within the Corridor are forecast directly and are based on industry marketing surveys, then compared on an order-of-magnitude basis with other data such as hotel beds by town or second homes by town. Particularly in the summer, data does not exist that clearly defines all trips made in the Corridor. Different trips can be made on the same day (for example, a hotel trip from Denver to Breckenridge, then a Corridor Day Recreation trip from Breckenridge to Keystone and back to Breckenridge). Because no OD survey is available for a particular day (and given the properties of the Corridor), such data is of limited use. Such trips are far less stable than for an urban area, making it impossible to know whether all trips are properly allocated to each category. However, this set of categories does provide a typology of trips that can be discussed with local tourism bureaus and others to determine the reasonableness of each estimate. **Table A-43** through **Table A-46** provide estimates for 2000 and 2025 recreation trips in summer and winter.

Resort to Resort: These trips, shown in **Table A-43** through **Table A-46**, are total resort to resort trips. About 40 percent of these trips remain in each town and never affect I-70 traffic. However, trips that do affect I-70 traffic can travel either from town to town or from campground to campground, generally in about a week's tour, according to the Longwood Report.

Table A-43. 2000 Socioeconomic Data by County, Summer Saturday Recreation

County	Campsites	Forest Area (mi^2)	Resort to Resort Productions	Front Range Day Recreation Attractions	Corridor to Airport or Front Range Productions	Out-of-State Air Attractions	Front Range to Hotel Attractions	Gaming Devices	Corridor Day Recreation Attractions	Out-of-State Automobile to Resort Attractions
BOULDER CO	256	325.5	0	0	0	0	0	0	0	0
CHAFFEE CO	208	775.0	0	0	0	0	0	0	0	0
CLEAR CREEK CO	70	288.5	20,000	5,000	0	45	0	0	2,471	0
DELTA CO	141	304.1	0	0	0	0	0	0	0	0
DENVER CO	0	0	0	0	3,000	0	0	0	0	0
DOUGLAS CO	43	246.9	0	0	0	0	0	0	0	0
EAGLE CO	245	963.8	5,200	2,581	400	1,500	986	0	23,000	1,473
EL PASO CO	55	192.7	0	0	198	0	0	0	0	0
FREMONT CO	11	174.0	0	0	0	0	0	0	0	0
GARFIELD CO	269	831.2	13,000	0	0	0	0	0	0	0
GILPIN CO	91	93.1	0	0	0	0	0	10,600	0	0
GRAND CO	619	938.8	10,000	20,000	0	4,409	5,000	0	895	2,372
GUNNISON CO	235	2,120.9	0	0	0	0	0	0	0	0
JACKSON CO	148	646.3	0	0	0	0	0	0	0	0
JEFFERSON CO	69	180.0	0	30,000	0	0	0	0	0	0
LAKE CO	498	266.9	0	0	0	0	0	0	0	0
LARIMER CO	882	1,296.1	0	0	0	0	0	0	0	0
MESA CO	204	887.2	2,000	0	0	0	0	0	0	0
MOFFAT CO	23	65.6	0	0	0	0	0	0	0	0
MONTROSE CO	18	544.0	0	0	0	0	0	0	0	0
PARK CO	350	1,172.7	0	0	0	0	0	0	0	0
PITKIN CO	268	808.5	17,000	0	306	6,046	2,712	0	33,043	3,186
RIO BLANCO CO	100	579.7	1,000	0	0	0	0	0	0	0
ROUTT CO	256	967.9	0	0	89	2,470	242	0	972	0
SUMMIT CO	486	605.8	10,500	18,200	0	5,530	1,949	0	22,591	3,072
TELLER CO	218	236.5	0	0	0	0	0	0	0	0
Total	**5,763**	**15,511.4**	**60,700**	**75,781**	**3,993**	**20,000**	**10,889**	**10,600**	**82,972**	**10,103**

Notes: Omitted counties have zero values for all attributes shown above. Corridor to Airport or Front Range trips are produced at airports or Front Range activities.

Table A-44. 2000 Socioeconomic Data by County, Winter Saturday Recreation

County	Resort to Resort Productions	Front Range Day Recreation Attractions	Corridor to Airport or Front Range Productions	Out-of-State Air Attractions	Front Range to Hotel Attractions	Corridor Day Recreation Attractions	Out-of-State Automobile to Resort Attractions
CLEAR CREEK CO	0	6,061	0	0	0	1,691	0
DENVER CO	0	0	3,000	0	0	0	0
EAGLE CO	23,000	9,840	189	6,169	840	56,355	944
EL PASO CO	0	0	198	0	0	0	0
GARFIELD CO	5,000	0	0	0	0	0	0
GRAND CO	6,500	12,422	0	1,495	484	18,007	605
MESA CO	5,000	0	0	0	0	0	0
PITKIN CO	20,000	0	144	4,971	177	44,827	887
RIO BLANCO CO	5,000	0	0	0	0	0	0
ROUTT CO	0	0	42	3,846	137	34,690	687
SUMMIT CO	19,000	42,412	0	9,226	996	82,437	507
Total	**83,500**	**70,735**	**3,630**	**25,707**	**2,634**	**238,007**	**3,630**

Notes: Omitted counties have zero values for all attributes shown above. Corridor to Airport or Front Range trips are produced at airports or Front Range activities. A negligible number of camping trips is assumed to be generated in winter. The number of gaming devices is the same as for Summer 2000.

Table A-45. 2025 Socioeconomic Data by County, Summer Saturday Recreation

County	Resort to Resort Productions	Front Range Day Recreation Attractions	Corridor to Airport or Front Range Productions	Out-of-State Air Attractions	Front Range to Hotel Attractions	Gaming Devices	Corridor Day Recreation Attractions	Out-of-State Automobile to Resort Attractions
CLEAR CREEK CO	2,900	7,250	0	633	0	0	3,583	0
DENVER CO	0	0	5,471	0	0	0	0	0
EAGLE CO	7,450	3,742	1,164	14,700	1,430	0	33,350	2,136
EL PASO CO	0	0	365	0	0	0	0	0
GARFIELD CO	18,850	0	0	0	0	0	0	0
GILPIN CO	0	0	0	0	0	25,400	0	0
GRAND CO	14,500	29,000	0	19,635	7,250	0	1,298	3,439
JEFFERSON CO	0	48,500	0	0	0	0	0	0
MESA CO	2,900	0	0	0	0	0	0	0
PITKIN CO	24,650	0	503	26,928	3,932	0	47,912	4,620
RIO BLANCO CO	1,450	0	0	0	0	0	0	0
ROUTT CO	0	0	145	8,338	351	0	1,409	0
SUMMIT CO	15,225	26,390	0	24,626	2,827	0	32,757	4,455
Total	**88,015**	**114,882**	**7,648**	**94,860**	**15,790**	**25,400**	**120,309**	**14,650**

Note: Omitted counties have zero values for all attributes shown above. Corridor to Airport or Front Range trips are produced at airports or Front Range activities. The number of campsites and acres of forest is assumed to be the same as for Summer 2000. Out-of-State Air Attractions shown are balanced (scaled) to more reliable production estimates based on enplanement forecasts.

Table A-46. 2025 Socioeconomic Data by County, Winter Saturday Recreation

County	Resort to Resort Productions	Front Range Day Recreation Attractions	Corridor to Airport or Front Range Productions	Out-of-State Air Attractions	Front Range to Hotel Attractions	Corridor Day Recreation Attractions	Out-of-State Automobile to Resort Attractions
CLEAR CREEK CO	0	8,788	0	79	155	2,854	0
DENVER CO	0	0	5,471	0	0	0	0
EAGLE CO	33,350	14,268	1,098	9,413	4,212	78,918	1,370
EL PASO CO	0	0	365	0	0	0	0
GARFIELD CO	7,250	0	0	0	1,450	0	0
GRAND CO	9,425	18,012	0	1,891	1,813	26,376	878
MESA CO	7,250	0	0	0	0	0	0
PITKIN CO	29,000	0	475	6,668	1,612	62,055	1,288
RIO BLANCO CO	7,250	0	0	0	0	0	0
ROUTT CO	0	0	137	5,379	351	47,139	996
SUMMIT CO	27,550	61,497	0	11,590	1,847	120,947	733
Total	**121,075**	**102,565**	**7,546**	**35,020**	**11,440**	**338,289**	**5,265**

Note: Omitted counties have zero values for all attributes shown above. Corridor to Airport or Front Range trips are produced at airports or Front Range activities. A negligible number of camping trips is assumed to be generated in winter. The number of gaming devices is the same as for Summer 2025. Out-of-State Air Attractions shown are balanced (scaled) to more reliable production estimates based on enplanement forecasts.

- These trips are defined as made in a tour starting at one location and proceeding to another, usually one per day lasting an average of six days. People on the tour can stay at a campground, hotel, or second home (as a short-term rental or owner-occupied). The Longwood Report for 2000 suggests that about 2,590,000 trips per year are made for the purpose of sightseeing in Colorado — about 15 percent use the Corridor.
- Front Range Day Recreation: These trips are defined as made from the Colorado Front Range to a resort or trailhead and returning to their primary residence, usually lasting a single day. These have been estimated during the winter to match annual skier visit data collected from Colorado Ski Country, an industry trade association. **Table A-43** through **Table A-46** show estimates of skier trips to each resort, aggregated by county. Summer travel was focused on shorter-distance trips made from the Denver region to mountain parks and outdoor areas in Jefferson and Clear Creek counties, and to the mountain communities closer in that sponsor festivals and other day activities.
- Corridor Day Recreation: These trips are defined as made from hotels, second homes, or primary homes located in the Corridor, lasting for a single day. Corridor Day Recreation includes sports, music festivals, shopping at specialized shops, eating, and drinking — especially for guests at or near major mountain resort communities. For trips from an outlying area such as a second home in Edwards, 2 to 4 trips to Vail might be made for these purposes from a single second home unit.
- Front Range trips to Stay at Second Homes: These trips are defined for the purpose of accessing a household's second home. Currently, more of theses trips are concentrated in Grand and Summit counties and fewer in Eagle and Pitkin counties. Saturday trips to second homes are predicted using the rates (trips per second home units) shown in **Table A-47**. After the household arrives at the second home, succeeding trips made from the home fall in the categories of Corridor Day Recreation, Home-Based Other, or Non-Home Based.

Table A-47. Saturday Trip Rates per Front Range-Owned Second Home Units

Zone Type	Area Type	Summer Trip Rate	Winter Trip Rate
Roaring Fork Valley	Suburban	0.20	0.25
	Rural	0.11	0.13
	Resort	1.91	1.74
Corridor	Suburban	0.28	1.76
	Rural	0.13	0.28
	Resort	1.18	2.53
North or South of Corridor	All	0.14	0.09

Note: All TAZs with second homes north or south of the Corridor are classified as rural.

- Trips to Stay Visiting Friends and Family: Trips for this purpose are made by residents of the Corridor, the Front Range, and the Roaring Fork Valley to homes of people they know. Once the visitors arrive at the host home, succeeding trips they make fall in the categories of Corridor Day Recreation, Home-Based Other, or Non-Home Based.
- Front Range trips to Stay at Hotels, Resorts or Forests: These trips are defined for the purpose of accessing lodging owned by others. This lodging may be owned by national hotel chains, local operators, second-home owners renting their property through a management and reservation company, or the USDA Forest Service. More of theses trips are concentrated in Grand and Summit counties and fewer in Eagle and Pitkin counties during 2000. After the household arrives at the hotel room, condominium, or campsite, succeeding trips made from the home fall in the categories of Corridor Day Recreation, Home-Based Other (in this study, hotels and resort

condominiums are considered to be "temporary" homes, which also generate trips), or Non-Home Based.

- As part of the Front Range trips to Stay at Hotels, Resorts or Forests purpose, Sunday trips to or from forests or campgrounds are calculated based on the number of campsites, forest area (a proxy for wilderness destinations), and the attraction rates shown in **Table A-48**. During the trip generation process (see **section A.2.5**), trips on other model days are factored from Sunday camping attractions.

Table A-48. Rates to Convert Campsites and Forest Area to Sunday Camping Attractions

Season and Forecast Year	Location of Forest or Campsite	Trips per Campsite	Trips per Square Mile of Forest
Summer 2000	Corridor, DRCOG region or Roaring Fork Valley	5.41	1.66
	North or South of Corridor	2.75	0.62
Summer 2025	Corridor, DRCOG region or Roaring Fork Valley	7.48	2.41
	North or South of Corridor	3.99	0.90

Notes: Negligible camping trips are assumed to be made during the winter season.

Sources: USDA Forest Service, Colorado State Parks.

- Corridor resident trips to Airports and the Front Range: These trips are defined as from primary households in the Corridor that are bound primarily for shopping, attendance at a recreational event, or to use DIA for a flight out of state. This is a small number of trips in the I-70 traffic stream and they are not likely to be made during periods known to be congested.
- "Destination" resort and recreation trips made by Out-of-State Air passengers and Out-of-State Automobile passengers: These trips involve residents of other states (or the extreme southern and eastern parts of Colorado, which are outside of the model study area) coming to Corridor attractions. Out-of-State Air passenger trips are factored from Saturday attractions, which are determined by the rates shown in **Table A-49**.

Table A-49. Out-of-State Air Passenger Attraction Rates

Location of Second Home	Summer Saturday Attractions per Out-of-State Owned Second Home	Winter Saturday Attractions per Out-of-State Owned Second Home
Roaring Fork Valley	0.60	0.58
Corridor	0.60	0.98
North or South of Corridor	0.46	0.80

Notes: Attraction rates shown are relative because Out-of-State Air passenger trips are balanced to more reliable estimates based on enplanements, which are the productions for this trip purpose.

- Gaming: These trips are defined as day trips to Black Hawk and Central City for the purpose of gaming. A limited numbers of these trips are also made for sightseeing, shopping, and work. Most of these trips are assumed to originate from the Denver region. The Gaming EIS has estimated the number of gaming devices that will exist in the year 2025. The trip rate per device is assumed to be similar in 2000 and 2025.

Table A-50 shows growth in persons 40 to 74 years of age between 2000 and 2025. This age group represents the major group of people who gamble. The table shows that a 68 percent growth is expected. A survey by Deloitte and Touche suggests that with improved access to Black Hawk, present and future gamers would increase their trips for gaming by 19 percent. The data then suggest that devices will double between 2000 and 2025. A survey was made of the casinos in Black Hawk and Central City that confirms the expectation that gaming trips would double between 2000 and 2025.

Table A-50. Growth in Persons 40 to 74 Years of Age in Denver Region

Age Bracket	Persons in Year 2000	Persons in Year 2025	Percent Growth
40–44	272	246	-9.56
45–49	231	230	-0.43
50–54	163	236	44.79
55–59	124	281	126.61
60–64	96	292	204.17
65–69	78	251	221.79
70–74	65	194	198.46
Total	**1029**	**1730**	**68.12**

Source: Year 2000 State Profile, Woods and Poole and Deloitte Touche, Gaming Access Survey.

Notes: Year 2000 and 2025 persons are shown in 1,000s in DRCOG model region.

Notes: Assume 19% increase for higher accessibility due to a gaming access build alternative, a result inferred from the Deloitte Touche study. Growth equals 168.12% times 1.19 or 100% growth from 2000.

Aviation

Out-of-state trips from airports are forecast directly from each of the five airports in the study area. Each airport has access to the major resorts and other Corridor activities. Trips from each of the airports were calculated as described below.

Front Range Hub Airports (DIA and COS)

In 2000, about 20 million people boarded a plane at the two Front Range hub airports, Denver International Airport (locally called DIA, although its FAA location identifier is DEN) and Colorado Springs Airport (COS). Of the roughly 18 million enplanements at DIA (see **Table A-51**), about 45 percent (8.3 million) were connecting planes. Another 37 percent (6.7 million) of enplanements were made by Colorado residents, and the remaining 18 percent were out-of-state visitors. The DRCOG passenger survey suggests that about 15 percent of these visitors come from attractions in the Corridor, and about 8 percent of the residents are from Corridor counties.

Table A-51. 2000 Annual Enplanements and Forecast 2025 Annual Enplanements

Airport Name (Identifier)	2000 Enplanements	2025 Enplanements	Percent Growth
Aspen/Pitkin County Airport (ASE)	215,091	587,000	173%
Colorado Springs Airport (COS)	1,205,552	2,150,000	78%
DIA: Denver International Airport (DEN)	18,382,940	38,400,000	109%
Eagle County Airport (EGE)	188,745	582,000	208%
Yampa Valley Regional Airport (HDN)	114,760	212,000	85%

Sources: FAA ACAIS Database, airport managers, J.F. Sato and Associates

Data in **Table A-52** and **Table A-53** are the result of interviews with people in the tourist industry. **Table A-53** shows about 2,950,000 skier visits (skier visit is one skier day) with an average duration of 6.2 days for each trip. Therefore, about 476,000 people used these airports to go skiing, making 952,000 total person trips between the airports and the I-70 resorts.

About 5.9 percent of out-of-state air visits occur in early February, and 29 percent of those early February trips occur on Saturday (the base day of the week), for a total of about 16,000 person trips. About two-thirds of these winter trips are believed go to DIA and one-third go to Colorado Springs, for 10,900 and 5,400 year 2000 person trips respectively.

Since 476,000 of the roughly 713,000 enplanements made by out-of-state visitors to the Corridor occur during the winter ski season, about 237,000 enplanements by these visitors occur during the remainder of the year. The summer peak period from July through August is only half as long as the winter peak period from Thanksgiving to April 15. Consequently, 11.8 percent (twice the winter 5.9 percent) of these out-of-state air visits might occur during the model week in August. Again, 29 percent of these weekly enplanements occurs on Saturday, for about 16,300 person trips. In the summer, 80 percent of out-of-state air visitors are assumed to use DIA, and the remaining 20 percent use COS. Therefore, the split of person trips between the two airports is about 13,000 person trips at DIA and about 3,300 at COS. For the year 2025, winter out-of-state visitors to the Corridor using DIA and COS airports are projected to increase by about 25 percent.

In addition, Corridor residents are assumed to make 3,000 person trips to DIA and about 200 person trips to COS each summer Saturday and winter Saturday in 2000. By 2025, this number is forecast to have increased about 80 percent (in proportion to Corridor region population growth) to 5,500 and 370 person trips each Saturday. Overall, annual enplanements at COS increase by 78 percent from 2000 to 2025 (see **Table A-51**) and annual DIA enplanements increase by 109 percent during the same time.

Eagle County Airport (EGE)

Eagle County Airport provides extensive private aircraft operations as well as passenger service, primarily during the winter. **Table A-51** shows that during 2000, a total of 189,000 enplanements were made at EGE. By 2025, the airport projects about 582,000 annual enplanements are projected, which is roughly triple the year 2000 level.

Table A-53 shows about 630,000 skier visits with an average duration of 6.2 days for each trip. Therefore, about 102,000 people use this airport during the winter season to go skiing, making 204,000 total person trips from the airport to I-70 resorts. About 1.7 percent (5.9 percent times 29 percent) of these trips occurs on the winter Saturday model day, amounting to about 3,500 out-of-state air passenger trips to Corridor resorts. Out-of-state visitors make about 17,000 additional enplanements here during the summer season (about 1,200 person trips on the summer Saturday model day).

An average of about one enplanement per year for each resident of the general area is expected in 2000. Considering parts of Garfield County, the affected population might be 70,000 persons, for 70,000 enplanements. For the summer, enplanements are anticipated to be slightly higher than the annual average (70,000 divided by 365 is roughly 192), so 200 enplanements for 100 days or 20,000 enplanements during summer are assumed. Each enplanement generates one person trip to EGE and one return trip, so therefore 400 Corridor to Airport or Front Range person trips are made to EGE each summer Saturday.

The annual total of out-of-state air visitor enplanements (102,000 plus 17,000 is 119,000) and enplanements by local residents (70,000) is about 189,000, matching the observed enplanements for 2000.

For the year 2025, annual EGE enplanements are expected to triple, but skier visits by Out-of-State Air passengers are expected to remain near their 2000 level. During this 25-year period, the population of Eagle County is expected to double, while the population of Garfield County increases by a lesser percentage than Eagle County. Therefore, to account for the substantial increase in enplanements, one or more of the following must take place:

- Residents of the EGE feeder area increase their air travel frequency from an average of one air trip per year in 2000.
- Winter Out-of-State Air visits continue to increase, but these people make fewer ski visits during their stay in Colorado.

- Out-of-State Air visits increase during the summer season (or possibly during the mud and hunting seasons), to account for a much larger proportion of annual enplanements.

Each of these predictions is reasonable, and all three are used to determine the trip variables shown in **Table A-45** and **Table A-46**. In 2025, Colorado residents account for 35 percent of EGE enplanements, compared to 37 percent in 2000. The fraction of Out-of-State Air visitors traveling during the winter season falls from 86 percent in 2000 to 54 percent in 2025. That is, EGE is anticipated to become a year-round facility, rather than one focused on winter operations.

Aspen/Pitkin County Airport (ASE)

Most flights to Aspen/Pitkin County Airport are in small planes coming from or going to DIA, but overall annual enplanements in 2000 were actually higher than Eagle County Airport – about 215,000 enplanements at ASE to 189,000 at EGE, as shown in **Table A-51**.

Table A-44 and **Table A-53** show about 670,000 skier visits with an average duration of 6.2 days for each trip. Therefore, about 108,000 use this airport to go skiing, making 216,000 total round trips from the airport to I-70 resorts.

Winter Saturday person trips are calculated using the same fraction of annual enplanements as for DIA and EGE, or a total of about 3,700 skiers. Similar values as for DIA and EGE are used for the summer at ASE, given the extensive airline schedule between July and August and national and international interest in the Aspen Music Festival and other cultural and recreational activities.

About 25 percent of the 215,000 annual enplanements at Aspen/Pitkin County Airport are made by local residents. Assuming the same seasonal distribution of these trips as at Eagle County Airport, about 300 trips are projected to be made by locals on summer Saturday, and about 290 trips on winter Saturday.

For the year 2025, winter Out-of-State Air ski and other recreation trips might increase by 25 percent. Pitkin County population is expected to increase by about 65 percent during the same period, and therefore Corridor to Airport or Front Range trips to ASE are expected to increase by a similar percentage. The remainder of the 587,000 enplanements projected for 2025 at ASE are summer Out-of-State Air visitors.

Yampa Valley Regional Airport (HDN)

The Yampa Valley Regional Airport serves mainly the Steamboat Springs area and other areas north of the Corridor. In 2000, about 115,000 passengers enplaned here.

Given the estimate of 410,000 skier visits (about 66,000 enplanements during the ski season), the early February Saturday volume of Out-of-State Air person trips might be about 2,300. The same number of out-of-state visitor trips are assumed to be made during the summer Saturday model day. Therefore, summer visitors account for another 33,000 enplanements.

Colorado residents account for about 16,000 annual enplanements at HDN, about 14 percent of the total. Using the same annualization factors as for EGE and ASE, locals are estimated to make about 90 person trips to HDN on summer Saturday and about 85 person trips on winter Saturday.

For the year 2025, winter Out-of-State Air recreation trips are projected to increase by 25 percent to about 2,800 trips on winter Saturday, or 83,000 enplanements for the winter season. The resident population is expected to increase by about 63 percent during the same period. If resident air travel increases proportionally to population, residents account for over 25,000 enplanements in 2025. As with ASE, the remaining 104,000 of the annual 212,000 enplanements are attributed to summer Out-of-State Air visitors, which is roughly triple the number of summer Out-of-State Air enplanements made in 2000.

Table A-52. Percentage of Annual Visitors, by Resort, for 1999–2000 Season

Ski Area	Total Ski Visits	Front Range Day Skiers Who Drive (percent)	Corridor Day Skiers Who Drive (percent)	Corridor Day Skiers Who Walk or Bus (percent)	Front Range Overnight Skiers Who Drive (percent)	Out-of-State Skiers Who Drive (percent)	Out-of-State Skiers Who Fly into DIA and COS (percent)	Out-of-State Skiers Who Fly into EGE (percent)	Out-of-State Skiers who Fly into ASE (percent)	Out-of-State Skiers Who Fly into HDN (percent)	Total percent
Arapahoe Basin	220,945	64	30	0	5	1	0	0	0	0	100
Aspen Mountain (Ajax)	331,121	0	7	13	2	10	10	8	50	0	100
Aspen Highlands	127,389	0	7	13	2	10	10	8	50	0	100
Beaver Creek	586,004	2	15	6	5	10	41	20	1	0	100
Breckenridge	1,444,365	30	7	7	4	2	50	0	0	0	100
Buttermilk	158,194	0	7	13	1	10	10	8	50	0	100
Copper Mountain	803,312	30	7	7	4	2	50	0	0	0	100
Keystone	1,192,198	35	7	7	4	2	45	0	0	0	100
Loveland	225,896	78	15	0	0	2	5	0	0	0	100
Snowmass	707,600	0	7	13	2	10	10	8	50	0	100
Steamboat	1,024,832	0	7	13	2	10	15	13	0	40	100
Vail	1,371,702	20	7	5	7	6	35	20	0	0	100
Winter Park	902,827	40	5	7	8	10	30	0	0	0	100
Total Visits	**9,096,385**										

Sources: Tourist industry representatives, J.F. Sato and Associates

Table A-53. Actual Number of Annual Visitors, by Resort, for 1999-2000 Season

Ski Area	Front Range Day Skiers Who Drive	Corridor Day Skiers Who Drive	Corridor Day Skiers Who Walk or Bus	Front Range Overnight Skiers Who Drive	Out-of-State Skiers Who Drive	Out-of-State Skiers Who Fly into DIA and COS	Out-of-State Skiers Who Fly into EGE	Out-of-State Skiers Who Fly into ASE	Out-of-State Skiers Who Fly into HDN	Total Ski Visits
Arapahoe Basin	141,405	66,284	0	11,047	2,209	0	0	0	0	220,945
Aspen Mountain (Ajax)	0	23,598	43,826	6,742	33,712	33,712	26,970	168,561	0	331,121
Aspen Highlands	0	8,917	16,561	2,548	12,739	12,739	10,191	63,695	0	127,389
Beaver Creek	11,720	87,901	35,160	29,300	58,600	240,262	117,201	5,860	0	586,004
Breckenridge	433,310	101,106	101,106	57,775	28,887	722,183	0	0	0	1,444,365
Buttermilk	0	11,074	20,565	3,164	15,819	15,819	12,656	79,097	0	158,194
Copper Mountain	240,994	56,232	56,232	32,132	16,066	401,656	0	0	0	803,312
Keystone	417,269	83,454	83,454	47,688	23,844	536,489	0	0	0	1,192,198
Loveland	176,199	33,884	0	0	4,518	11,295	0	0	0	225,896
Snowmass	0	49,532	91,988	14,152	70,750	70,760	56,608	353,800	0	707,600
Steamboat	0	71,738	133,228	20,497	102,483	153,725	133,228	0	409,933	1,024,832
Vail	274,340	96,019	68,585	96,019	82,302	480,096	274,430	0	0	1,371,702
Winter Park	361,131	45,141	63,198	72,226	90,283	270,848	0	0	0	902,827
Total Visits	**2,056,367**	**734,460**	**713,122**	**393,170**	**541,624**	**2,948,983**	**630,714**	**668,012**	**409,933**	**9,096,385**
Total In-State Visits				**3,897,120**	**Total Out-of-State Visits**				**5,199,265**	

Note: Totals may not add due to rounding.

Source: J.F. Sato and Associates

Table A-54. Number of 2000 Winter Saturday Person Trips, by Resort

Ski Area	TAZs	Front Range Day Skiers Who Drive	Corridor Day Skiers Who Drive	Corridor Day Skiers Who Walk or Bus	Front Range Overnight Skiers Who Drive	Out-of-State Skiers Who Drive	Out-of-State Skiers Who Fly into DIA (TAZ 206) and COS (TAZ 470)	Out-of-State Skiers Who Fly into EGE (TAZ 1515)	Out-of-State Skiers Who Fly into ASE (TAZ 1860)	Out-of-State Skiers Who Fly into HDN (TAZ 2210)	Total Corridor Day Recreation Trips (a)
Arapahoe Basin	2030	4,864	2,280	0	(b) 74	(b) 15	0	0	0	0	2,691
Aspen Mountain (Ajax)	2083	0	797	1,481	44	222	183	146	914	0	11,208
Aspen Highlands	2082	0	307	570	17	85	70	56	352	0	4,321
Beaver Creek	2070	403	3,024	1,209	196	393	1,326	647	32	0	19,377
Breckenridge	1272, 1274, 1275, 1279	14,905	3,478	3,478	387	194	3,986	0	0	0	34,341
Buttermilk	2081	0	381	707	21	106	87	70	437	0	5,355
Copper Mountain	2050	8,290	1,934	1,934	215	108	2,217	0	0	0	19,100
Keystone	2020	14,393	2,871	2,871	320	160	2,961	0	0	0	26,306
Loveland	2010	6,061	1,166	0	0	(c) 30	62	0	0	0	1,691
Snowmass	2080	0	1,704	3,164	95	474	391	312	1,953	0	23,952
Steamboat	2210	0	2,468	4,583	137	687	848	735	0	2,263	34,690
Vail	1406, 1407, 1410, 1415	9,437	3,303	2,359	644	552	2,650	1,514	0	0	36,978
Winter Park	2000	12,422	1,553	2,174	484	605	1,495	0	0	0	18,007
Total Trips		**70,735**	**25,264**	**24,530**	**2,636**	**3,631**	**16,276**	**3,484**	**3,687**	**2,263**	**238,007**

Notes: (a) Total Corridor Day Recreation Trips is calculated as Corridor Day Skiers (who drive, walk or take bus), plus 4.6 (days per average stay) times Front Range Overnight Skiers and Out-of-State Skiers who Drive, plus 6.2 (days per average stay) times Out-of-State Skiers who fly (into any airport).

(b) Overnight skiers visiting Arapahoe Basin are assumed to stay in lodging at Keystone.

(c) Out-of-State skiers who drive to Loveland are assumed to stay in lodging in Silverthorne (TAZ 1200).

Totals may not add due to rounding.

Source: J.F. Sato and Associates

A.2.5 Determining the Numbers of Trips

The first step of the four-step process involves determining the number of trips that begin or end in a particular area. Trip generation involves estimating the number of trip ends based on characteristics of areas such as population, employment, and income. Trip generation rates are often established from a travel survey. When forecasting future travel demands, congestion levels substantially higher or lower than were typical when trip generation rates were established may lead to suppressed or induced travel, respectively. That is, people may make more trips or take the same trips more frequently if congestion improves markedly from their expectations and experience.

2000 Travel Propensities

Trip generation deals with estimating the ends of each trip regardless of where it goes or by which mode. Trip ends can be either an origin or a destination, generally either at the household end (called Productions in the following tables) or at the activity end (called Attractions in the following tables). The model considers the 21 trip purposes described in **Driver and Vehicle Characteristics**.

The trip generation module first splits the four household income groups into 16 categories of four income categories classified into each of four household sizes: single, couple, three-person, or four-or-more person households, based on the average household size in the TAZ (population per household) and the distribution shown in **Table A-55**.

Table A-55. Percentage of Four Household Family Sizes by Average Household Size

Average Household Size	Single Household	Couple Household	Three-Person Household	Household with Four or More Persons
1.0000	100.0%	0.0%	0.0%	0.0%
1.1000	90.0	8.0	1.5	0.5
1.2000	83.0	14.5	2.0	0.5
1.3000	75.0	20.5	3.0	1.5
1.4000	70.5	23.5	4.0	2.0
1.5000	64.5	27.5	5.5	2.5
1.6000	59.5	30.5	6.5	3.5
1.7000	54.5	32.5	7.5	5.5
1.8000	50.0	34.5	8.5	7.0
1.9000	45.5	36.0	10.0	8.5
2.0000	41.5	37.0	11.5	10.0
2.1000	37.5	37.5	13.0	12.0
2.2000	33.5	38.0	14.5	14.0
2.3000	30.5	37.5	15.5	16.5
2.4000	27.5	37.0	17.0	18.5
2.5000	25.0	36.0	18.5	20.5
2.6000	22.0	35.0	19.5	23.5
2.7000	19.5	33.5	20.5	26.5
2.8000	17.0	32.5	21.0	29.5
2.9000	15.0	31.5	21.5	32.0
3.0000	12.5	30.5	22.0	35.0
3.1000	11.0	29.0	22.0	38.0
3.2000	9.5	27.5	22.0	41.0
3.3000	8.5	26.0	21.5	44.0
3.4000	7.0	24.5	21.5	47.0
3.5000	5.5	23.0	21.0	50.5
3.6000	4.5	21.5	20.5	53.5
3.7000	3.5	19.5	20.0	57.0
3.8000	2.5	17.5	19.0	61.0

Table A-55. Percentage of Four Household Family Sizes by Average Household Size

Average Household Size	Single Household	Couple Household	Three-Person Household	Household with Four or More Persons
3.9000	2.0	15.5	17.5	65.0
4.0000	1.5	14.0	15.5	69.0
4.1000	1.0	13.0	13.5	72.5
4.2000	0.5	12.0	11.5	76.0
4.3000	0.0	10.0	10.0	80.0
4.4000	0.0	7.5	8.5	84.0
4.5000	0.0	5.0	7.0	88.0
4.7000	0.0	2.0	3.0	95.0
Greater than 4.7	0.0	0.0	0.0	100.0

Source: US Census Bureau, DRCOG

The assumed Corridor-wide distribution of the four household size groups and the four income groups is shown in **Table A-56**. County totals of low, medium, upper, and high income households are known, as is the population by TAZ. A proportional balancing program splits the four income levels for each zone so they add up to the total 16 categories, and they also add up to the total households by zone. This is an iterative balance program that balances controls by column (the 16 control totals for the entire Corridor) and controls by row (the zone totals). The 16 factors that split the households by the Corridor came from the 1990 Census.

Table A-56. Corridor-Wide Distribution of Four Household Sizes and Four Income Groups

	Single Household	Couple Household	Three-Person Household	Household with Four or More Persons	Totals
Low Income	8.90%	4.30%	1.10%	0.70%	15.00%
Middle Income	14.20%	14.10%	7.00%	9.70%	45.00%
Upper (Middle) Income	1.55%	7.05%	4.40%	7.00%	20.00%
High Income	1.55%	7.05%	4.40%	7.00%	20.00%
Totals	26.20%	32.50%	16.90%	24.40%	100.00%

Source: US Census Bureau

Table A-57 (referred to as a cross-classification table) shows the number of summer Thursday trip productions that originate at the household end of a trip. The values are split into area, income, and family size. Note that work trip rates for Mountain External and Front Range External counties are considerably lower than those for Corridor counties. Work trip rates for these external counties have been adjusted to reflect trips made only by those workers commuting to the Corridor, Roaring Fork Valley, and Front Range. That is, Work trips within external counties are excluded from analysis. As a consequence of this simplifying assumption, the PEIS travel demand model (as specified) underestimates travel in these external counties. Other Production rates are shown in **Table A-58** for summer Friday, **Table A-59** for summer Saturday, **Table A-60** for summer Sunday, and **Table A-61** for winter Saturday.

Table A-57. Trip Productions for Summer Thursdays

Area (Zone Type)	Household Size	Home-Based Work Productions				Home-Based Other Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	1	0.8082	0.9628	1.5892	1.3834	1.5086	1.2931	1.2931	1.4008
DRCOG	2	1.2404	1.8293	2.4830	2.0944	3.1249	3.1249	3.1249	3.3404
DRCOG	3	1.1965	2.2143	2.9796	2.4900	4.5257	4.7412	4.8490	5.2800
DRCOG	4	1.6539	2.2143	2.9796	2.4900	7.4351	7.7584	7.7584	8.5126
Roaring Fork Valley	1	1.3600	1.7392	2.7829	3.0436	2.5160	2.2198	2.1314	2.1314
Roaring Fork Valley	2	2.0871	3.3044	4.3480	4.6077	6.2606	4.3155	3.4643	3.4643
Roaring Fork Valley	3	2.0130	3.9999	5.2175	5.4785	6.1226	6.7153	6.4038	6.4038
Roaring Fork Valley	4	2.7825	3.9999	5.2175	5.4785	10.6052	11.1979	10.8682	10.8682
Corridor	1	1.3600	1.7392	2.7829	3.0436	2.5160	2.2198	2.1314	2.1314
Corridor	2	2.0871	3.3044	4.3480	4.6077	6.2606	4.3155	3.4643	3.4643
Corridor	3	2.0130	3.9999	5.2175	5.4785	6.1226	6.7153	6.4038	6.4038
Corridor	4	2.7825	3.9999	5.2175	5.4785	10.6052	11.1979	10.8682	10.8682
Mountain External counties	1	0.0345	0.0434	0.0431	0.0438	0.0000	0.0000	0.0000	0.0000
Mountain External counties	2	0.0639	0.0740	0.0991	0.0991	0.0000	0.0000	0.0000	0.0000
Mountain External counties	3	0.0797	0.1000	0.1118	0.1118	0.0000	0.0000	0.0000	0.0000
Mountain External counties	4	0.1036	0.1077	0.1118	0.1118	0.0000	0.0000	0.0000	0.0000
Front Range External counties	1	0.0345	0.0434	0.0431	0.0438	0.0000	0.0000	0.0000	0.0000
Front Range External counties	2	0.0639	0.0740	0.0991	0.0991	0.0000	0.0000	0.0000	0.0000
Front Range External counties	3	0.0797	0.1000	0.1118	0.1118	0.0000	0.0000	0.0000	0.0000
Front Range External counties	4	0.1036	0.1077	0.1118	0.1118	0.0000	0.0000	0.0000	0.0000

Area (Zone Type)	Household Size	Resort to Resort Productions				Front Range Day Recreation Productions				Gaming Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	1	0.0010	0.0016	0.0016	0.0016	0.1	0.1	0.1	0.1	0.0050	0.0050	0.0050	0.0050
DRCOG	2	0.0023	0.0028	0.0028	0.0028	0.1	0.1	0.1	0.1	0.0050	0.0050	0.0050	0.0050
DRCOG	3	0.0023	0.0028	0.0028	0.0028	0.1	0.1	0.1	0.1	0.0050	0.0050	0.0050	0.0050

Area (Zone Type)	Household Size	Resort to Resort Productions				Front Range Day Recreation Productions				Gaming Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	4	0.0033	0.0052	0.0052	0.0052	0.1	0.1	0.1	0.1	0.0050	0.0050	0.0005	0.0050
Roaring Fork Valley	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0005	0.0005	0.0005	0.0005
Corridor	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0005	0.0005	0.0005	0.0005
Mountain External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000
Front Range External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000

Area (Zone Type)	Household Size	Stay at Second Home Productions				Stay at Hotel, Resort or Forest Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	1	0.0000	0.0005	0.0080	0.0430	0.0015	0.0025	0.0060	0.0045
DRCOG	2	0.0000	0.0010	0.0080	0.0820	0.0030	0.0050	0.0060	0.0080
DRCOG	3	0.0000	0.0010	0.0150	0.0820	0.0030	0.0050	0.0115	0.0080
DRCOG	4	0.0000	0.0015	0.0000	0.1515	0.0050	0.0090	0.0115	0.0150
Roaring Fork Valley	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Corridor	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mountain External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Front Range External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Area (Zone Type)	Household Size	Stay Visiting Friends and Family Productions				Recreation Vehicle Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	Any	0.007	0.007	0.007	0.007	0.06	0.06	0.06	0.06
Roaring Fork Valley	Any	0.007	0.007	0.007	0.007	0.06	0.06	0.06	0.06
Corridor	Any	0.007	0.007	0.007	0.007	0.06	0.06	0.06	0.06
Mountain External counties	Any	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00
Front Range External counties	Any	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00

Table A-58. Trip Productions for Summer Fridays

Area (Zone Type)	Household Size	Home-Based Work Productions				Home-Based Other Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	1	0.8241	0.9817	1.6203	1.4106	1.4957	1.2820	1.2820	1.3889
DRCOG	2	1.2647	1.8651	2.5317	2.1354	3.0982	3.0982	3.0982	3.3119
DRCOG	3	1.2199	2.2577	3.0380	2.5388	4.4871	4.7007	4.8076	5.2349
DRCOG	4	1.6864	2.2577	3.0380	2.5388	7.3716	7.6921	7.6921	8.4400
Roaring Fork Valley	1	1.3866	1.7733	2.8374	3.1033	2.4946	2.2008	2.1132	2.1132
Roaring Fork Valley	2	2.1280	3.3692	4.4332	4.6981	6.2071	4.2787	3.4347	3.4347
Roaring Fork Valley	3	2.0524	4.0784	5.3198	5.5859	6.0704	6.6580	6.3492	6.3492
Roaring Fork Valley	4	2.8370	4.0784	5.3198	5.5859	10.5147	11.1023	10.7754	10.7754
Corridor	1	1.3866	1.7733	2.8374	3.1033	2.4946	2.2008	2.1132	2.1132
Corridor	2	2.1280	3.3692	4.4332	4.6981	6.2071	4.2787	3.4347	3.4347
Corridor	3	2.0524	4.0784	5.3198	5.5859	6.0704	6.6580	6.3492	6.3492
Corridor	4	2.8370	4.0784	5.3198	5.5859	10.5147	11.1023	10.7754	10.7754
Mountain External counties	1	0.0352	0.0442	0.0446	0.0446	0.0000	0.0000	0.0000	0.0000
Mountain External counties	2	0.0651	0.0754	0.1011	0.1011	0.0000	0.0000	0.0000	0.0000
Mountain External counties	3	0.0812	0.1019	0.1140	0.1140	0.0000	0.0000	0.0000	0.0000
Mountain External counties	4	0.1057	0.1098	0.1140	0.1140	0.0000	0.0000	0.0000	0.0000
Front Range External counties	1	0.0352	0.0442	0.0446	0.0446	0.0000	0.0000	0.0000	0.0000
Front Range External counties	2	0.0651	0.0754	0.1011	0.1011	0.0000	0.0000	0.0000	0.0000
Front Range External counties	3	0.0812	0.1019	0.1140	0.1140	0.0000	0.0000	0.0000	0.0000
Front Range External counties	4	0.1057	0.1098	0.1140	0.1140	0.0000	0.0000	0.0000	0.0000

Area (Zone Type)	Household Size	Resort to Resort Productions				Front Range Day Recreation Productions				Gaming Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	1	0.0009	0.0014	0.0014	0.0014	0.1	0.1	0.1	0.1	0.0050	0.0050	0.0050	0.0050
DRCOG	2	0.0021	0.0025	0.0025	0.0025	0.1	0.1	0.1	0.1	0.0050	0.0050	0.0050	0.0050
DRCOG	3	0.0021	0.0025	0.0025	0.0025	0.1	0.1	0.1	0.1	0.0050	0.0050	0.0050	0.0050

Area (Zone Type)	Household Size	Resort to Resort Productions				Front Range Day Recreation Productions				Gaming Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	4	0.0030	0.0047	0.0047	0.0047	0.1	0.1	0.1	0.1	0.0050	0.0050	0.0005	0.0050
Roaring Fork Valley	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0005	0.0005	0.0005	0.0005
Corridor	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0005	0.0005	0.0005	0.0005
Mountain External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000
Front Range External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000

Area (Zone Type)	Household Size	Stay at Second Home Productions				Stay at Hotel, Resort or Forest Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	1	0.0000	0.0005	0.0040	0.0430	0.0015	0.0025	0.0030	0.0045
DRCOG	2	0.0000	0.0010	0.0080	0.0820	0.0030	0.0050	0.0060	0.0080
DRCOG	3	0.0000	0.0010	0.0080	0.0820	0.0030	0.0050	0.0060	0.0080
DRCOG	4	0.0000	0.0015	0.0150	0.1515	0.0050	0.0090	0.0115	0.0150
Roaring Fork Valley	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Corridor	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mountain External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Front Range External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Area (Zone Type)	Household Size	Stay Visiting Friends and Family Productions				Recreation Vehicle Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	Any	0.007	0.007	0.007	0.007	0.06	0.06	0.06	0.06
Roaring Fork Valley	Any	0.007	0.007	0.007	0.007	0.06	0.06	0.06	0.06
Corridor	Any	0.007	0.007	0.007	0.007	0.06	0.06	0.06	0.06
Mountain External counties	Any	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00
Front Range External counties	Any	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00

Table A-59. Trip Productions for Summer Saturdays

Area (Zone Type)	Household Size	Home-Based Work Productions				Home-Based Other Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	1	0.3147	0.4024	0.6439	0.7042	1.7710	1.5180	1.5180	1.6445
DRCOG	2	0.4828	0.7646	1.0060	1.0661	3.6685	3.6685	3.6685	3.9215
DRCOG	3	0.4658	0.9255	1.2072	1.2676	5.3130	5.5660	5.6925	6.1985
DRCOG	4	0.6438	0.9255	1.2072	1.2676	8.7285	9.1080	8.1080	9.9935
Roaring Fork Valley	1	0.4531	0.5795	0.9272	1.0140	2.9537	2.6059	2.5023	2.5023
Roaring Fork Valley	2	0.6954	1.1010	1.4487	1.5353	7.3495	5.0662	4.0669	4.0669
Roaring Fork Valley	3	0.6707	1.3327	1.7384	1.8253	7.1878	7.8835	7.5178	7.5178
Roaring Fork Valley	4	0.9271	1.3327	1.7384	1.8253	12.4502	13.1459	12.7589	12.7589

Area (Zone Type)	Household Size	Home-Based Work Productions				Home-Based Other Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
Corridor	1	0.4531	0.5795	0.9272	1.0140	2.9537	2.6059	2.5023	2.5023
Corridor	2	0.6954	1.1010	1.4487	1.5353	7.3495	5.0662	4.0669	4.0669
Corridor	3	0.6707	1.3327	1.7384	1.8253	7.1878	7.8835	7.5178	7.5178
Corridor	4	0.9271	1.3327	1.7384	1.8253	12.4502	13.1459	12.7589	12.7589
Mountain External counties	1	0.0137	0.0173	0.0174	0.0174	0.0000	0.0000	0.0000	0.0000
Mountain External counties	2	0.0254	0.0293	0.0394	0.0394	0.0000	0.0000	0.0000	0.0000
Mountain External counties	3	0.0317	0.0397	0.0444	0.0444	0.0000	0.0000	0.0000	0.0000
Mountain External counties	4	0.0411	0.0428	0.0444	0.0444	0.0000	0.0000	0.0000	0.0000
Front Range External counties	1	0.0137	0.0173	0.0174	0.0174	0.0000	0.0000	0.0000	0.0000
Front Range External counties	2	0.0254	0.0293	0.0394	0.0394	0.0000	0.0000	0.0000	0.0000
Front Range External counties	3	0.0317	0.0397	0.0444	0.0444	0.0000	0.0000	0.0000	0.0000
Front Range External counties	4	0.0411	0.0428	0.0444	0.0444	0.0000	0.0000	0.0000	0.0000

Area (Zone Type)	Household Size	Resort to Resort Productions				Front Range Day Recreation Productions				Gaming Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	1	0.0040	0.0059	0.0059	0.0059	3.0	3.0	3.0	3.0	0.0050	0.0050	0.0050	0.0050
DRCOG	2	0.0085	0.0105	0.0105	0.0105	1.0	1.0	1.0	3.0	0.0050	0.0050	0.0050	0.0050
DRCOG	3	0.0085	0.0105	0.0105	0.0105	1.0	1.0	1.0	3.0	0.0050	0.0050	0.0050	0.0050
DRCOG	4	0.0125	0.0197	0.0197	0.0197	1.0	1.0	1.0	3.0	0.0050	0.0050	0.0005	0.0050
Roaring Fork Valley	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0005	0.0005	0.0005	0.0005
Corridor	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0005	0.0005	0.0005	0.0005
Mountain External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000
Front Range External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000

Area (Zone Type)	Household Size	Stay at Second Home Productions				Stay at Hotel, Resort or Forest Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	1	0.0000	0.0005	0.0040	0.0430	0.0015	0.0025	0.0030	0.0045
DRCOG	2	0.0000	0.0010	0.0080	0.0820	0.0030	0.0050	0.0060	0.0080
DRCOG	3	0.0000	0.0010	0.0080	0.0820	0.0030	0.0050	0.0060	0.0080
DRCOG	4	0.0000	0.0015	0.0150	0.1515	0.0050	0.0090	0.0115	0.0150
Roaring Fork Valley	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Corridor	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mountain External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Front Range External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Area (Zone Type)	Household Size	Stay Visiting Friends and Family Productions				Recreation Vehicle Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	Any	0.007	0.007	0.007	0.007	0.06	0.06	0.06	0.06
Roaring Fork Valley	Any	0.007	0.007	0.007	0.007	0.06	0.06	0.06	0.06
Corridor	Any	0.007	0.007	0.007	0.007	0.06	0.06	0.06	0.06
Mountain External counties	Any	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00
Front Range External counties	Any	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00

Table A-60. Trip Productions for Summer Sundays

Area (Zone Type)	Household Size	Home-Based Work Productions				Home-Based Other Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	1	0.1150	0.1470	0.2353	0.2574	0.5796	0.4968	0.4968	0.5382
DRCOG	2	0.1764	0.2794	0.3676	0.3896	1.2006	1.2006	1.2006	1.2834
DRCOG	3	0.1702	0.3382	0.4412	0.4632	1.7388	1.8216	1.8630	2.0286
DRCOG	4	0.2352	0.3382	0.4412	0.4632	2.8566	2.9808	2.9808	3.2706
Roaring Fork Valley	1	0.1656	0.2118	0.3388	0.3706	0.9667	0.8528	0.8189	0.8189
Roaring Fork Valley	2	0.2541	0.4023	0.5294	0.5611	2.4053	1.6581	1.3310	1.3310
Roaring Fork Valley	3	0.2451	0.4870	0.6353	0.6670	2.3523	2.5800	2.4604	2.4604
Roaring Fork Valley	4	0.3388	0.4870	0.6353	0.6670	4.0746	4.3023	4.1756	4.1756
Corridor	1	0.1656	0.2118	0.3388	0.3706	0.9667	0.8528	0.8189	0.8189
Corridor	2	0.2541	0.4023	0.5294	0.5611	2.4053	1.6581	1.3310	1.3310
Corridor	3	0.2451	0.4870	0.6353	0.6670	2.3523	2.5800	2.4604	2.4604
Corridor	4	0.3388	0.4870	0.6353	0.6670	4.0746	4.3023	4.1756	4.1756
Mountain External counties	1	0.0050	0.0063	0.0063	0.0064	0.0000	0.0000	0.0000	0.0000
Mountain External counties	2	0.0093	0.0107	0.0144	0.0144	0.0000	0.0000	0.0000	0.0000
Mountain External counties	3	0.0115	0.0145	0.0162	0.0162	0.0000	0.0000	0.0000	0.0000
Mountain External counties	4	0.0150	0.0156	0.0162	0.0162	0.0000	0.0000	0.0000	0.0000
Front Range External counties	1	0.0050	0.0063	0.0063	0.0064	0.0000	0.0000	0.0000	0.0000
Front Range External counties	2	0.0093	0.0107	0.0144	0.0144	0.0000	0.0000	0.0000	0.0000
Front Range External counties	3	0.0115	0.0145	0.0162	0.0162	0.0000	0.0000	0.0000	0.0000
Front Range External counties	4	0.0150	0.0156	0.0162	0.0162	0.0000	0.0000	0.0000	0.0000

Area (Zone Type)	Household Size	Resort to Resort Productions				Front Range Day Recreation Productions				Gaming Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	1	0.0036	0.0053	0.0053	0.0053	3.0	3.0	3.0	3.0	0.0050	0.0050	0.0000	0.0050
DRCOG	2	0.0076	0.0094	0.0094	0.0094	1.0	1.0	2.0	3.0	0.0050	0.0050	0.0050	0.0050
DRCOG	3	0.0076	0.0094	0.0094	0.0094	1.0	1.0	2.0	3.0	0.0050	0.0050	0.0050	0.0050
DRCOG	4	0.0112	0.0176	0.0176	0.0176	1.0	1.0	2.0	3.0	0.0050	0.0050	0.0005	0.0050

Area (Zone Type)	Household Size	Resort to Resort Productions				Front Range Day Recreation Productions				Gaming Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
Roaring Fork Valley	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0005	0.0005	0.0005	0.0005
Corridor	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0005	0.0005	0.0005	0.0005
Mountain External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000
Front Range External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000

Area (Zone Type)	Household Size	Stay at Second Home Productions				Stay at Hotel, Resort or Forest Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	1	0.0000	0.0005	0.0040	0.0430	0.0015	0.0025	0.0030	0.0045
DRCOG	2	0.0000	0.0010	0.0080	0.0820	0.0030	0.0050	0.0060	0.0080
DRCOG	3	0.0000	0.0010	0.0080	0.0820	0.0030	0.0050	0.0060	0.0080
DRCOG	4	0.0000	0.0015	0.0150	0.1515	0.0050	0.0090	0.0115	0.0150
Roaring Fork Valley	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Corridor	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mountain External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Front Range External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Area (Zone Type)	Household Size	Stay Visiting Friends and Family Productions				Recreation Vehicle Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	Any	0.007	0.007	0.007	0.007	0.06	0.06	0.06	0.06
Roaring Fork Valley	Any	0.007	0.007	0.007	0.007	0.06	0.06	0.06	0.06
Corridor	Any	0.007	0.007	0.007	0.007	0.06	0.06	0.06	0.06
Mountain External counties	Any	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00
Front Range External counties	Any	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00

Table A-61. Trip Productions for Winter Saturdays

Area (Zone Type)	Household Size	Home-Based Work Productions				Home-Based Other Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	1	0.3730	0.4769	0.7631	0.8346	1.3637	1.1689	1.1689	1.2663
DRCOG	2	0.5723	0.9061	1.1923	1.2636	2.8247	2.8247	2.8247	3.0196
DRCOG	3	0.5520	1.0969	1.4308	1.5023	4.0910	4.2858	4.3832	4.7728
DRCOG	4	0.7630	1.0969	1.4308	1.5023	6.7209	7.0132	7.0132	7.6950
Roaring Fork Valley	1	0.5370	0.6868	1.0989	1.2018	2.2743	2.0065	1.9268	1.9268
Roaring Fork Valley	2	0.8242	1.3049	1.7170	1.8196	5.6591	3.9010	3.1315	3.1315
Roaring Fork Valley	3	0.7949	1.5795	2.0604	2.1634	5.5346	6.0703	5.7887	5.7887
Roaring Fork Valley	4	1.0988	1.5795	2.0604	2.1634	9.5867	10.1223	9.8244	9.8244
Corridor	1	0.5370	0.6868	1.0989	1.2018	2.2743	2.0065	1.9268	1.9268
Corridor	2	0.8242	1.3049	1.7170	1.8196	5.6591	3.9010	3.1315	3.1315
Corridor	3	0.7949	1.5795	2.0604	2.1634	5.5346	6.0703	5.7887	5.7887
Corridor	4	1.0988	1.5795	2.0604	2.1634	9.5867	10.1223	9.8244	9.8244
Mountain External counties	1	0.0162	0.0204	0.0203	0.0206	0.0000	0.0000	0.0000	0.0000
Mountain External counties	2	0.0300	0.0348	0.0467	0.0467	0.0000	0.0000	0.0000	0.0000
Mountain External counties	3	0.0375	0.0470	0.0526	0.0526	0.0000	0.0000	0.0000	0.0000
Mountain External counties	4	0.0488	0.0507	0.0526	0.0526	0.0000	0.0000	0.0000	0.0000
Front Range External counties	1	0.0162	0.0204	0.0203	0.0206	0.0000	0.0000	0.0000	0.0000
Front Range External counties	2	0.0300	0.0348	0.0467	0.0467	0.0000	0.0000	0.0000	0.0000
Front Range External counties	3	0.0375	0.0470	0.0526	0.0526	0.0000	0.0000	0.0000	0.0000
Front Range External counties	4	0.0488	0.0507	0.0526	0.0526	0.0000	0.0000	0.0000	0.0000

Area (Zone Type)	Household Size	Resort to Resort Productions				Front Range Day Recreation Productions				Gaming Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	1	0.0043	0.0063	0.0063	0.0063	3.0	3.0	3.0	3.0	0.0050	0.0050	0.0000	0.0050
DRCOG	2	0.0090	0.0111	0.0111	0.0111	1.0	1.0	1.0	3.0	0.0050	0.0050	0.0050	0.0050
DRCOG	3	0.0090	0.0111	0.0111	0.0111	1.0	1.0	1.0	3.0	0.0050	0.0050	0.0050	0.0050

Area (Zone Type)	Household Size	Resort to Resort Productions				Front Range Day Recreation Productions				Gaming Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	4	0.0133	0.0209	0.0209	0.0209	1.0	1.0	1.0	3.0	0.0050	0.0050	0.0005	0.0050
Roaring Fork Valley	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0005	0.0005	0.0005	0.0005
Corridor	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0005	0.0005	0.0005	0.0005
Mountain External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000
Front Range External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.0000

Area (Zone Type)	Household Size	Stay at Second Home Productions				Stay at Hotel, Resort or Forest Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	1	0.0000	0.0005	0.0040	0.0430	0.0015	0.0025	0.0030	0.0045
DRCOG	2	0.0000	0.0010	0.0080	0.0820	0.0030	0.0050	0.0060	0.0080
DRCOG	3	0.0000	0.0010	0.0080	0.0820	0.0030	0.0050	0.0060	0.0080
DRCOG	4	0.0000	0.0015	0.0150	0.1515	0.0050	0.0090	0.0115	0.0150
Roaring Fork Valley	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Corridor	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mountain External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Front Range External counties	Any	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Area (Zone Type)	Household Size	Stay Visiting Friends and Family Productions				Recreation Vehicle Productions			
		Low Income	Middle Income	Upper Income	High Income	Low Income	Middle Income	Upper Income	High Income
DRCOG	Any	0.007	0.007	0.007	0.007	0.06	0.06	0.06	0.06
Roaring Fork Valley	Any	0.007	0.007	0.007	0.007	0.06	0.06	0.06	0.06
Corridor	Any	0.007	0.007	0.007	0.007	0.06	0.06	0.06	0.06
Mountain External counties	Any	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00
Front Range External counties	Any	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00

Some trip purposes predict trip productions from various equations, rather than from a cross-classification table of trip rates associated with each income group and household size. The Home-Based Other (HBO) purpose actually uses both techniques: first, HBO trips associated with primary residences are calculated from the cross-classification table. However, second homes, hotels, and resorts may also produce HBO trips. The total number of HBO productions is therefore a linear combination of households, second homes, hotels, and Out-of-State Air Passenger trips to resort, using the factors shown in Table A-47. The table also shows trip production factors for Corridor Day Recreation, Resort to Resort, Out-of-State Air, and Out-of-State Automobile trips. The Single-Unit Truck Internal-External and Through, and the Combination-Unit Truck Internal-External and Through trip purposes also use this approach to determine productions of internal-external trips.

Table A-62. Other Trip Production Rates

Home-Based Other Trip Productions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Trips Calculated from Households and Cross-Classification Table	1.00	1.00	0.25	0.25	0.50
Summer Sunday Trips to Hotels	0.47	0.32	0.25	0.23	0.39
Saturday Trips to Second Homes	0.47	0.51	0.25	0.23	0.39
Winter Saturday Out-of-State Air Trips to Resorts	0.47	0.46	0.12	0.11	0.39

Corridor Day Recreation Trip Productions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Total Households in Roaring Fork Valley	0.4	0.5	0.4	0.4	0.4
Total Households in Corridor	0.4	0.6	0.4	0.4	0.4
Summer Sunday Trips to Hotels	2.0	1.3	2.0	3.0	2.0
Saturday Trips to Second Homes	2.0	2.6	2.0	3.0	3.0
Corridor Resort to Resort Productions	1.0	1.2	1.0	1.0	1.0
Winter Saturday Out-of-State Air Trips to Resorts	2.0	2.8	2.0	2.0	2.0
Sunday Trips to Campgrounds	0.4	0.5	0.4	0.4	0.0
Saturday Out-of-State Automobile Person Trips to Resorts	2.0	2.4	2.0	2.0	2.0

Resort to Resort Trip Productions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Trips Calculated from Households and Cross-Classification Table	0.70	0.70	0.70	0.80	0.25
Corridor Resort to Resort Productions	0.73	0.78	0.83	0.95	0.23

Out-of-State Air Trip Productions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Saturday Out-of-State Air Trips via Eagle County Airport	1.00	0.93	1.00	1.00	1.00
Saturday Out-of-State Air Trips via Other Airports	0.14	0.12	1.00	1.00	1.00

Out-of-State Automobile Trip Productions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Saturday Out-of-State Automobile Vehicle Trips for Recreation	0.71	0.72	1.00	1.01	1.00
Non-Recreation Saturday Out-of-State Automobile Vehicle Trips	1.01	1.46	1.00	1.01	1.00

Single-Unit Truck Internal-External and Through Trip Productions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Weekly Average Single-Unit Truck Internal-External Trips	1.0	1.0	1.0	0.9	1.0

Combination-Unit Truck Internal-External and Through Trip Productions	Summer Thursda y	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Weekly Average Combination-Unit Truck Internal-External Trips	1.0	1.0	1.0	0.9	1.0

The other end of the trip, the Attraction end, is usually associated with employment or some other activity, such as ski lift capacity or wilderness hiking trails. This end has been estimated either as a function of employment or directly by database information provided by USFS. **Table A-63** shows the Attraction rates used in the travel demand model. When trip Attractions are forecast directly, they are forecast for Saturday both in the winter and in the summer. Other days are factored from Saturday as a proportion of Saturday, as shown in the table. In such a case, the table shows a factor of 1.0 applied to a particular variable for winter or summer Saturday.

Table A-63. Attraction Trip Rates per Unit of Households or Employment

Low Income Work Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Roaring Fork Households	0.026	0.028	0.013	0.013	0.013
Corridor Households	0.026	0.028	0.013	0.013	0.013
DRCOG Households	0.026	0.028	0.013	0.013	0.013
Black Hawk/Central City Households	0.026	0.031	0.013	0.013	0.013
Roaring Fork Basic Employment	0.452	0.484	0.0452	0.0452	0.0452
Corridor Basic Employment	0.452	0.387	0.0452	0.0452	0.0452
DRCOG Basic Employment	0.452	0.484	0.0452	0.0452	0.0452
Black Hawk/Central City Basic Employment	0.452	0.537	0.0452	0.0452	0.0452
Roaring Fork Retail Employment	0.332	0.355	0.365	0.365	0.365
Corridor Retail Employment	0.332	0.355	0.365	0.365	0.365
DRCOG Retail Employment	0.332	0.355	0.365	0.365	0.365
Black Hawk/Central City Retail Employment	0.332	0.394	0.365	0.365	0.365
Roaring Fork Service Employment	0.452	0.484	0.226	0.226	0.226
Corridor Service Employment	0.452	0.484	0.226	0.226	0.226
DRCOG Service Employment	0.452	0.484	0.226	0.226	0.226
Black Hawk/Central City Service Employment	0.452	0.537	0.226	0.226	0.226
Roaring Fork Second Homes	0.026	0.028	0.013	0.013	0.013
Corridor Second Homes	0.026	0.028	0.013	0.013	0.013
Black Hawk/Central City Second Homes	0.026	0.031	0.013	0.013	0.026

Middle Income Work Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Roaring Fork Households	0.055	0.059	0.0275	0.0275	0.0275
Corridor Households	0.055	0.059	0.0275	0.0275	0.0275
DRCOG Households	0.055	0.059	0.0275	0.0275	0.0275
Black Hawk/Central City Households	0.055	0.065	0.0275	0.0275	0.0275
Roaring Fork Basic Employment	0.970	1.038	0.097	0.097	0.097
Corridor Basic Employment	0.776	0.664	0.077	0.077	0.077
DRCOG Basic Employment	0.970	1.038	0.097	0.097	0.097
Black Hawk/Central City Basic Employment	0.970	1.152	0.097	0.097	0.097

Middle Income Work Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Roaring Fork Retail Employment	0.712	0.762	0.7832	0.7832	0.7832
Corridor Retail Employment	0.640	0.685	0.6265	0.7832	0.6000
DRCOG Retail Employment	0.712	0.762	0.7832	0.7832	0.7832
Black Hawk/Central City Retail Employment	0.712	0.846	0.7832	0.7832	0.7832
Roaring Fork Service Employment	0.970	1.038	0.485	0.485	0.485
Corridor Service Employment	0.873	0.934	0.388	0.485	0.350
DRCOG Service Employment	0.970	1.038	0.485	0.485	0.485
Black Hawk/Central City Service Employment	0.970	1.152	0.485	0.485	0.485
Roaring Fork Second Homes	0.17	0.182	0.085	0.085	0.085
Corridor Second Homes	0.17	0.182	0.085	0.085	0.085
Black Hawk/Central City Second Homes	0.17	0.182	0.085	0.085	0.085

Upper Income Work Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Roaring Fork Households	0.05	0.054	0.025	0.025	0.025
Corridor Households	0.05	0.054	0.025	0.025	0.025
DRCOG Households	0.05	0.054	0.025	0.025	0.025
Black Hawk/Central City Households	0.05	0.060	0.025	0.025	0.025
Roaring Fork Basic Employment	1.0	1.07	0.10	0.10	0.10
Corridor Basic Employment	0.6	0.64	0.08	0.08	0.02
DRCOG Basic Employment	1.0	1.07	0.10	0.10	0.10
Black Hawk/Central City Basic Employment	1.0	1.19	0.10	0.10	0.10
Roaring Fork Retail Employment	0.30238	0.3235	0.333	0.333	0.333
Corridor Retail Employment	0.27214	0.3203	0.266	0.276	0.333
DRCOG Retail Employment	0.30238	0.3235	0.333	0.333	0.333
Black Hawk/Central City Retail Employment	0.30238	0.3591	0.333	0.333	0.333
Roaring Fork Service Employment	0.730	0.781	0.365	0.365	0.365
Corridor Service Employment	0.352	0.415	0.146	0.292	0.200
DRCOG Service Employment	0.730	0.781	0.365	0.365	0.365
Black Hawk/Central City Service Employment	0.730	0.867	0.365	0.365	0.365
Roaring Fork Second Homes	0.5	0.54	0.25	0.25	0.25
Corridor Second Homes	0.5	0.59	0.25	0.25	0.25
Black Hawk/Central City Second Homes	0.5	0.60	0.25	0.25	0.25

High Income Work Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Roaring Fork Households	0.08	0.086	0.04	0.04	0.04
Corridor Households	0.08	0.086	0.04	0.04	0.04
DRCOG Households	0.08	0.086	0.04	0.04	0.04
Black Hawk/Central City Households	0.08	0.095	0.04	0.04	0.04
Roaring Fork Basic Employment	1.453	1.555	0.1453	0.1453	0.1453
Corridor Basic Employment	1.017	1.085	0.1017	0.1017	0.1017
DRCOG Basic Employment	1.453	1.555	0.1453	0.1453	0.1453
Black Hawk/Central City Basic Employment	1.453	1.726	0.1453	0.1453	0.1453

High Income Work Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Roaring Fork Retail Employment	1.066	1.141	1.173	1.173	1.173
Corridor Retail Employment	0.746	0.958	0.821	0.821	0.900
DRCOG Retail Employment	1.066	1.141	1.173	1.173	1.173
Black Hawk/Central City Retail Employment	1.066	1.267	1.173	1.173	1.173

High Income Work Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Roaring Fork Service Employment	1.453	1.555	0.7265	0.7265	0.7265
Corridor Service Employment	1.017	1.194	0.5085	0.5085	0.6085
DRCOG Service Employment	1.453	1.555	0.7265	0.7265	0.7265
Black Hawk/Central City Service Employment	1.453	1.726	0.7265	0.7265	0.7265
Roaring Fork Second Homes	1.5	1.61	0.75	0.75	0.75
Corridor Second Homes	1.5	1.77	0.75	0.75	0.75
Black Hawk/Central City Second Homes	1.5	1.79	0.75	0.75	0.75

Note: Second homes are assumed not to exist in the DRCOG region.

Home-Based Other Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Roaring Fork Households	0.38862	0.38862	0.38862	0.38862	0.508
Corridor Households	0.38862	0.38862	0.38862	0.38862	0.508
DRCOG Area Type 1 or 2 Households	0.25400	0.25400	0.25400	0.25400	0.254
DRCOG Area Type 3 Households	0.50800	0.50800	0.50800	0.50800	0.508
DRCOG Area Type 4 or 5 Households	0.63500	0.63500	0.63500	0.63500	0.635
Black Hawk/Central City Households	0.20000	0.22200	0.20000	0.20000	0.200
Roaring Fork Basic Employment	0.25019	0.25019	0.25019	0.25019	0.254
Corridor Basic Employment	0.25019	0.25019	0.25019	0.25019	0.254
DRCOG Area Type 1 or 2 Basic Employment	0.12700	0.12700	0.12700	0.12700	0.127
DRCOG Area Type 3 Basic Employment	0.25400	0.25400	0.25400	0.25400	0.254
DRCOG Area Type 4 or 5 Basic Employment	0.50800	0.50800	0.50800	0.50800	0.508
Black Hawk/Central City Basic Employment	0.10000	0.11100	0.10000	0.10000	0.100
Roaring Fork Retail Employment	5.207	5.207	5.207	5.207	5.207
Corridor Retail Employment	5.207	6.248	5.207	5.207	5.207
DRCOG Area Type 1 Retail Employment	1.397	1.397	1.397	1.397	1.397
DRCOG Area Type 2 Retail Employment	2.921	2.921	2.921	2.921	2.921
DRCOG Area Type 3 Retail Employment	5.207	5.207	5.207	5.207	5.207
DRCOG Area Type 4 or 5 Retail Employment	9.906	9.906	9.906	9.906	9.906
Black Hawk/Central City Retail Employment	0.600	0.666	0.600	0.600	0.600
Roaring Fork Service Employment	2.380	2.380	2.378	2.378	2.286
Corridor Service Employment	2.380	2.500	2.378	2.378	2.286
DRCOG Area Type 1 or 2 Service Employment	1.143	1.143	1.143	1.143	1.143
DRCOG Area Type 3 Service Employment	2.286	2.286	2.286	2.286	2.286
DRCOG Area Type 4 or 5 Service Employment	4.953	4.953	4.953	4.953	4.953
Black Hawk/Central City Service Employment	0.600	0.666	0.056	0.600	0.600

Non-Home-Based Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Roaring Fork Households	0.24	0.29	0.21	0.19	0.11
Corridor Households	0.24	0.29	0.21	0.19	0.11
DRCOG Area Type 1 or 2 Households	0.10	0.12	0.09	0.08	0.05
DRCOG Area Type 3, 4, or 5 Households	0.29	0.36	0.26	0.24	0.14
Mountain Resort Households	0.24	0.23	0.21	0.19	0.22

Non-Home-Based Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Roaring Fork Basic Employment	0.147	0.157	0.132	0.12	0.069
Corridor Basic Employment	0.147	0.118	0.132	0.12	0.069
DRCOG Area Type 1 Basic Employment	0.098	0.098	0.088	0.08	0.046
DRCOG Area Type 2 or 3 Basic Employment	0.294	0.304	0.264	0.24	0.138
DRCOG Area Type 4 or 5 Basic Employment	0.490	0.510	0.440	0.40	0.230
Mountain Resort Basic Employment	0.147	0.157	0.132	0.12	0.138
Roaring Fork Retail Employment	3.53	4.31	3.17	2.88	1.66
Corridor Retail Employment	3.53	4.31	3.17	2.88	1.66
DRCOG Area Type 1 Retail Employment	0.88	1.08	0.79	0.72	0.41
DRCOG Area Type 2 Retail Employment	1.96	2.45	1.76	1.60	0.92
DRCOG Area Type 3 Retail Employment	2.35	2.94	2.11	1.92	1.10
DRCOG Area Type 4 Retail Employment	4.31	4.90	3.87	3.52	2.02
DRCOG Area Type 5 Retail Employment	4.31	4.51	3.87	3.52	2.02
Mountain Resort Retail Employment	0.98	0.98	0.88	0.80	0.92
Roaring Fork Service Employment	0.98	0.98	0.88	0.80	0.46
Corridor Service Employment	0.98	1.08	0.88	0.80	0.46
DRCOG Area Type 1 Service Employment	0.59	0.59	0.53	0.48	0.28
DRCOG Area Type 2 Service Employment	0.69	0.69	0.62	0.56	0.32
DRCOG Area Type 3 Service Employment	0.88	0.88	0.79	0.72	0.41
DRCOG Area Type 4 or 5 Service Employment	1.67	1.76	1.50	1.36	0.78
Mountain Resort Service Employment	0.98	0.98	0.88	0.80	0.92
Roaring Fork Second Homes	0.0	0.1	0.0	0.0	0.0
Corridor Second Homes	0.0	0.1	0.0	0.0	0.0
Mountain Resort Second Homes	2.9	3.0	2.6	2.4	5.5
Summer Sunday Hotel Trips	2.9	2.0	2.6	2.4	3.7

Note: Second homes are assumed not to exist in the DRCOG region.

Day Gaming Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Gaming Trips per Device	2.8	4.2	8.0	8.5	8.7

Front Range Day Recreation Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Saturday Front Range Day Recreation Trip Factor	0.10	0.09	1.00	1.00	1.00

Corridor Day Recreation Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Saturday Corridor Day Recreation Trips to Corridor	0.14	0.28	1.0	0.9	1.0
Saturday Corridor Day Recreation Trips Outside Corridor	0.14	0.23	1.0	0.9	1.0

Out-of-State Air Passenger Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Saturday Factor for Corridor	0.111	0.222	1.0	1.0	1.0
Saturday Factor for Roaring Fork Valley	0.111	0.222	1.0	1.0	1.0

Corridor to Airport or Front Range Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Corridor Households	1.00	1.00	1.00	1.00	0.010
Corridor Employment	0.14	0.14	0.14	0.14	0.005

Stay at Hotel, Resort, or Forest Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Summer Sunday Hotel Trip Factor	0.1	0.28	0.59	1.0	0.88
Sunday Campground Trip Factor	0.1	0.65	0.59	1.0	0.00

Stay at Second Home Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Saturday Trips to Corridor Second Homes	0.09	2.81	1.0	1.53	1.0
Saturday Trips to Roaring Fork Valley Second Homes	0.09	2.81	1.0	1.53	1.0
Saturday Trips to Second Homes North and South of Corridor	0.00	1.79	1.0	1.53	1.0

Note: Second homes are assumed not to exist in the DRCOG region.

Stay Visiting Friends and Family Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Visiting Friends and Relatives Household Factor	0.057	1.316	0.194	0494	0.157

Out-of-State Automobile Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Total Households Rate	0.291	0.291	0.291	0.291	0.291
Basic Employment Rate	0.124	0.124	0.124	0.124	0.124
Retail Employment Rate	0.321	0.321	0.321	0.321	0.321
Service Employment Rate	0.249	0.249	0.249	0.249	0.249
Saturday Out-of-State Automobile Recreational Trip Factor	0.4	1.0	1.0	0.9	1.0

Note: The above factors are applied only to DRCOG, Roaring Fork Valley, and Corridor TAZs.

Recreational Vehicle Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Corridor Resort to Resort Productions	0.0021	0.0037	0.0047	0.0042	0.0000
Front Range Day Recreation Attractions	0.0010	0.0013	0.0018	0.0016	0.0063
Stay at Hotel, Resort or Forest Attractions	0.0010	0.0013	0.0018	0.0016	0.0125
Applied to All Zones?	yes	yes	yes	yes	DRCOG, RFV and Corridor only

Single-Unit Truck Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Total Employment Rate (Applied only to DRCOG, Corridor, and Roaring Fork Valley)	0.200	0.300	0.134	0.086	0.100

Single-Unit Truck Internal-External and Through Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Total Employment Rate	0.020	0.030	0.005	0.005	0.005

Combination-Unit Truck Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Total Employment Factor for DRCOG Area	0.150	0.200	0.096	0.060	0.070
Total Employment Factor for Corridor and Roaring Fork Valley	0.140	0.200	0.134	0.086	0.075

Combination-Unit Truck Internal-External and Through Trip Attractions	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday	Winter Saturday
Total Employment Rate	0.060	0.075	0.040	0.040	0.040

Figure A-22 through **Figure A-26** help illustrate the relationships among trip productions, trip attractions, and various socioeconomic variables. The figures also illustrate different trip purposes that may make up a visitor's trip chain or tour.

Figure A-22 shows a tour a Front Range resident might make to the Corridor on a winter weekend. Arrows on the figures indicate individual trips, which are labeled with their purpose and order. Squares with A or P indicate whether an attraction or production is associated with a particular trip end, and what socioeconomic variable is used to predict the trip. In this example, the Front Range resident drives from home to a Corridor resort for a day of skiing, stopping for coffee along the way. This visitor eats a meal at a restaurant during the day of recreation, then drives home. This tour therefore involves two Front Range Day Recreation trips and two Non-Home Based trips.

Note that the travel demand model predicts recreation trips from resident households and Corridor activities, but cannot readily reflect on route stops for coffee, refueling, or other reasons. The restaurant trip at the resort can be modeled as a Non-Home Based trip between attractions (note that Non-Home Based trips do not have productions) associated with service employment at the resort (such as lift operators, ski instructors, and equipment rental staff) and with the retail employment of the restaurant.

An overnight camping tour is shown in **Figure A-23**. Here the trips between the Front Range and the Corridor are for the Stay Overnight at Hotel, Resort, or Forest purpose. However, like Front Range Day Recreation trips, these trips are also produced by households and attracted to an activity variable ("Camping") in the Corridor. This same variable is also used to predict productions of Corridor Day Recreation trips – in this example, between the campground and fishing hole. Therefore, although the PEIS travel demand model does not explicitly model tours, it does implicitly account for tour-making behavior in its relationships between trip purposes and the variables used to calculate trip ends.

Figure A-24 shows the trip chain of a Front Range resident who travels to a friend's residence in the Corridor the night before a skiing trip. After the first day of skiing, this resident makes a Home-Based Other trip to get groceries for meals during his or her stay.

An out-of-state resident's automobile tour of Colorado is shown in **Figure A-25**. This person drives to one resort – perhaps Vail – for a day of skiing. The following morning, this visitor drives to another resort – say Keystone – to snowboard. Separate socioeconomic variables account for Out-of-State Automobile traveler trips to resorts and within-Corridor Resort to Resort trips.

The trip chain of an out-of-state resident arriving at DIA is shown in **Figure A-26**. On the day of arrival, this visitor rents a vehicle to drive to the Corridor and check in at a resort. The following day is spent skiing, with dinner at one of the resort restaurants. (This cycle of trips may be repeated for each day the guest stays.) At the end of the tour, the visitor checks out from the resort, returns the rental vehicle to DIA, and flies home. Notice that the attraction variable for the Out-of-State Air trips is also used for Corridor Day Recreation and Home-Based Other productions.

Figure A-22. Example of Trips Associated with a Front Range Day Skier's Chain

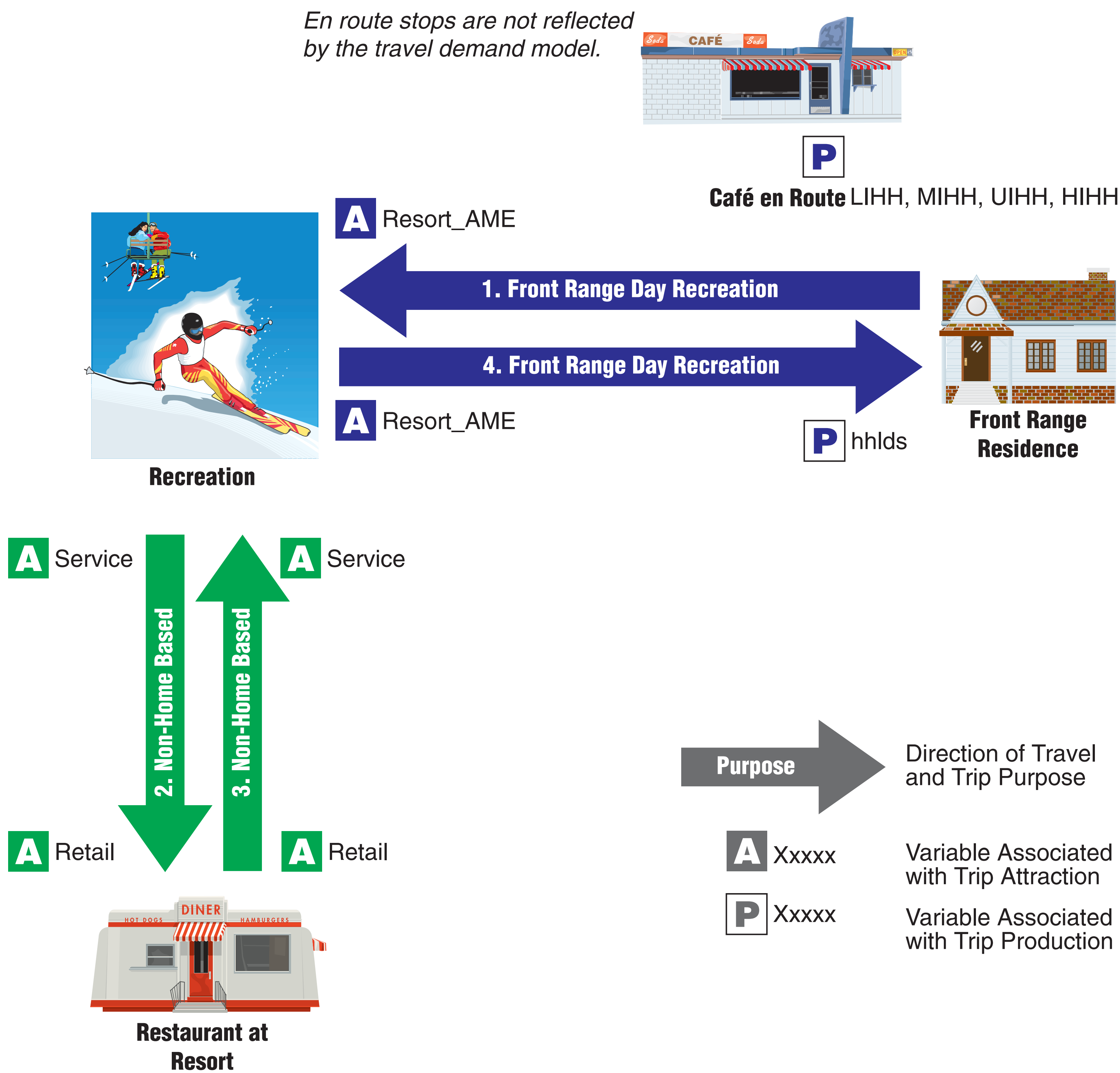


Figure A-23. Example of Trips Associated with a Front Range Camper's Chain

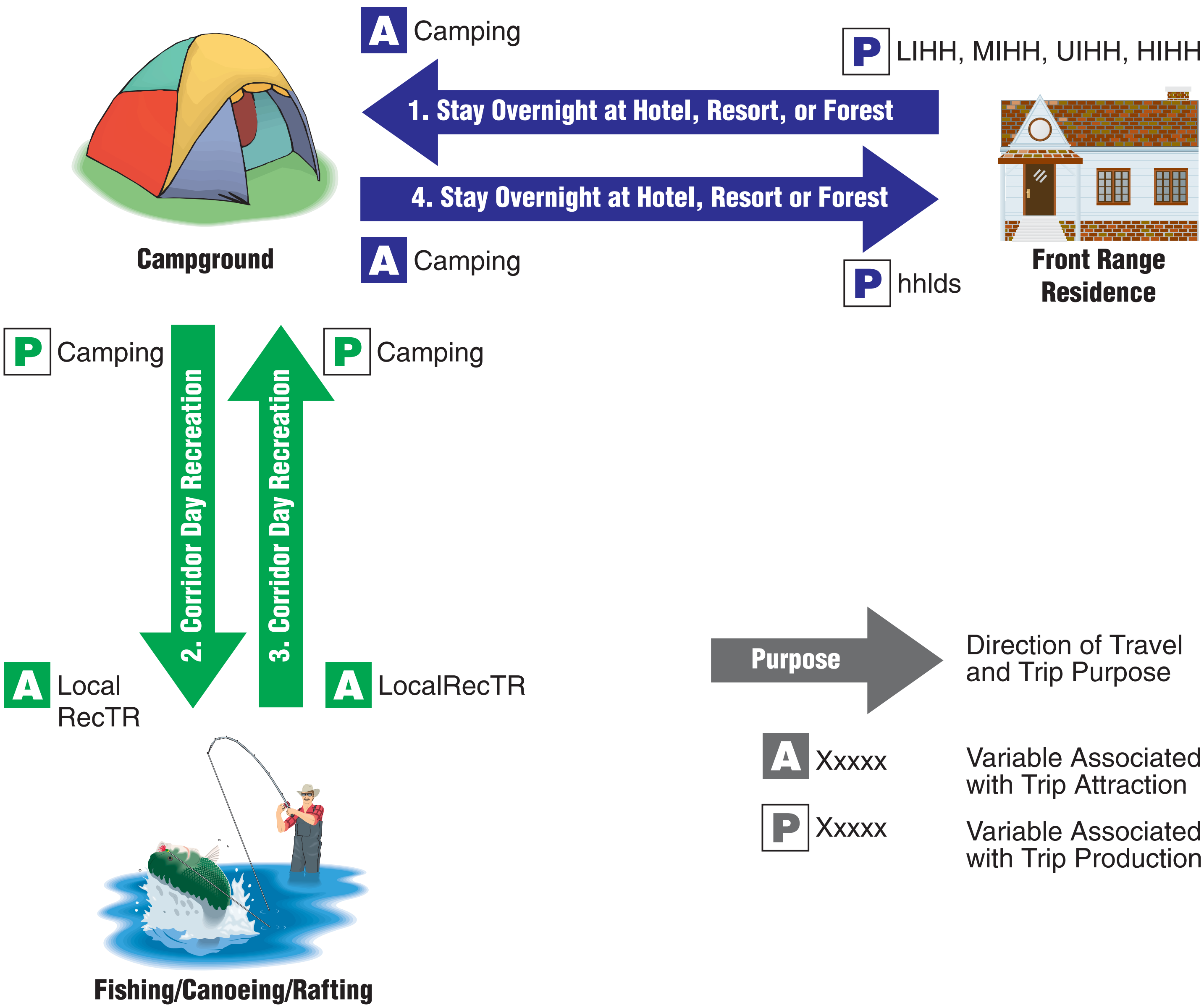


Figure A-24. Example of Trips Associated with a Front Range Resident's Overnight Recreation Chain

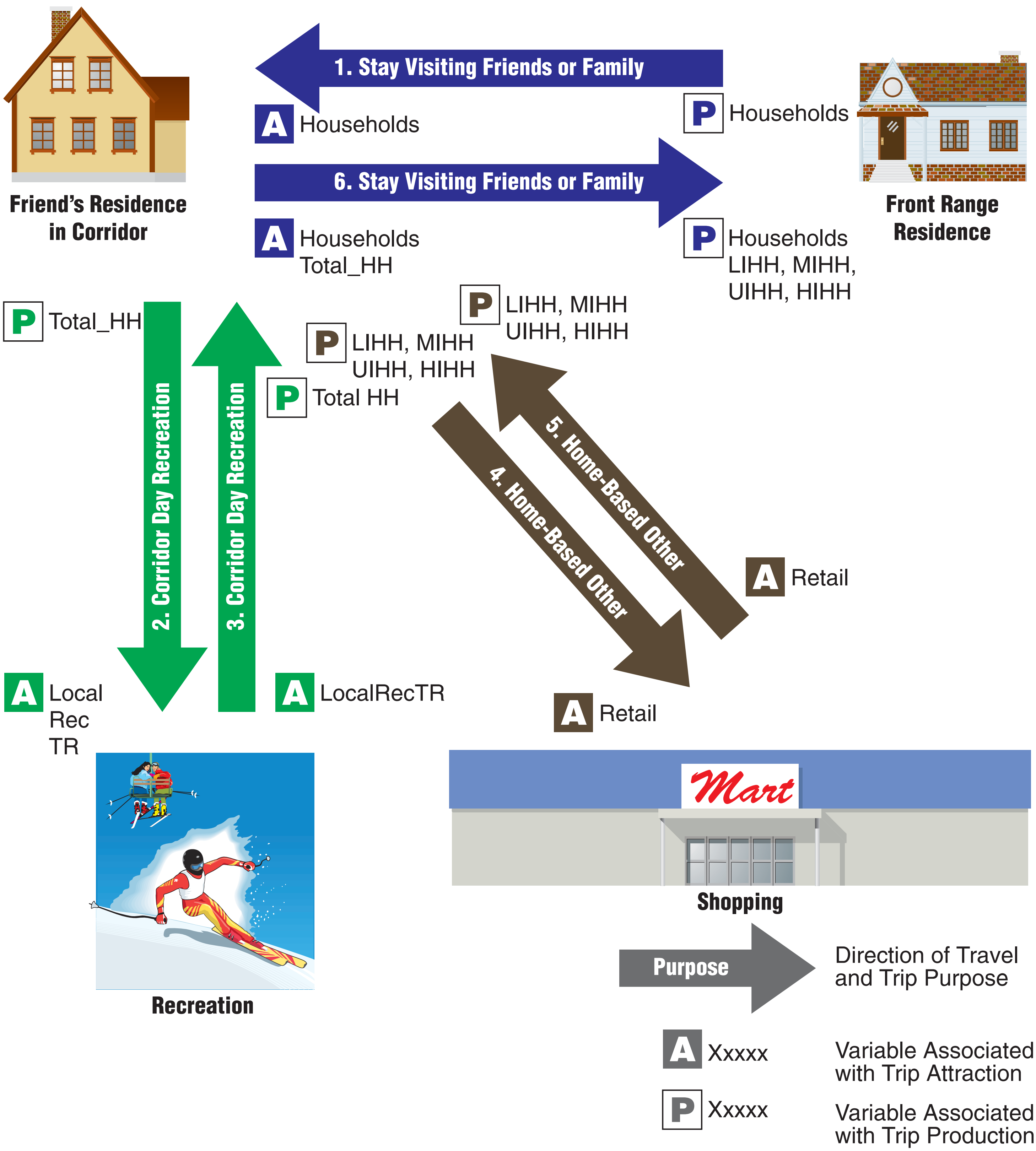


Figure A-25. Example of Trips Associated with an Out-of-State Auto Traveler's Chain

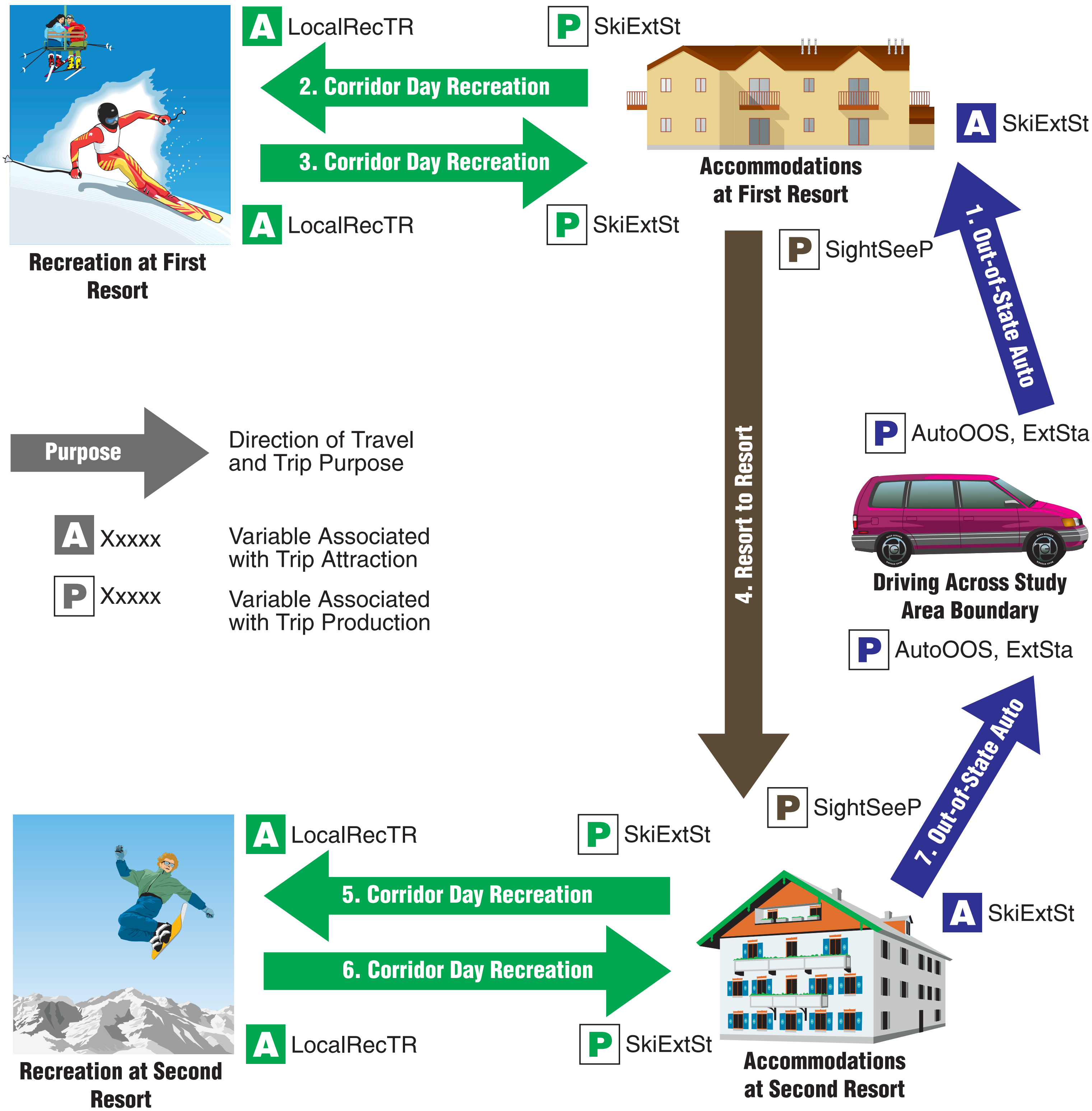
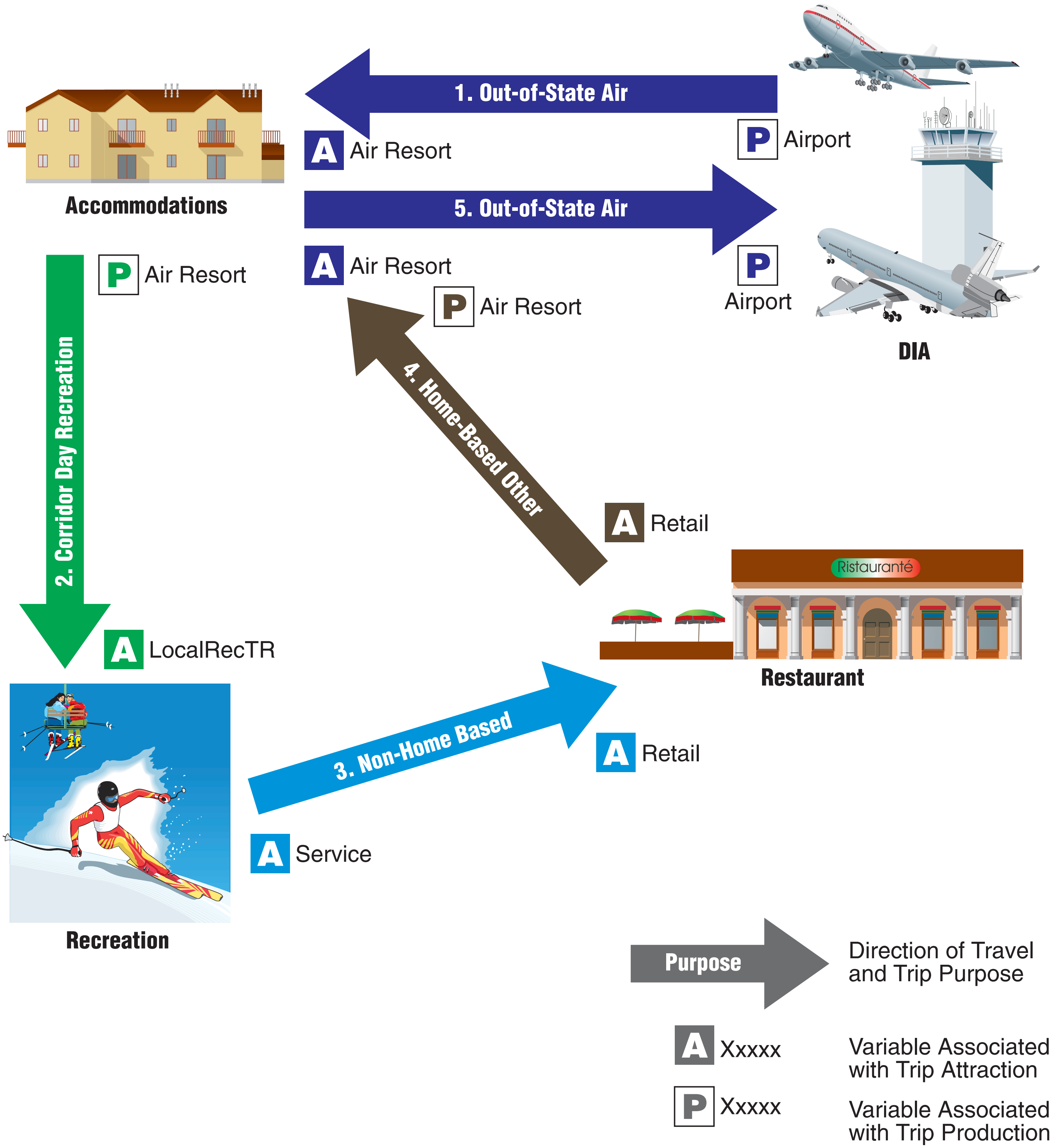


Figure A-26. Example of Trips Associated with an Out-of-State Air Visitor's Chain



Balancing Productions and Attractions

As seen in the previous section, forecast numbers of trips are calculated from two types of formulas.

- Trip productions often involve the home end, so trips are a function of the number of households by size and income.
- Trip attractions are calculated from employment by sector or from other specialized variables.

For some trip purposes such as Non-Home-Based (for example, a trip from work to a restaurant for lunch), it is difficult to assign unique production and attraction ends, so a single formula is used for both. Because trip productions and trip attractions are (for most purposes) calculated from completely independent equations, there is no guarantee that total regional productions equals total regional attractions.

Because each trip must have one production and one attraction, an extra step called *balancing* is used to factor productions and attractions to a regional control total. For different purposes, the control total may be based on total productions, total attractions, or some combination depending on the confidence associated with each trip generation formula. For example, for home-based other trips, household surveys often result in more confidence concerning the number of other trips made per household member, relative to trips made per retail employee. Therefore, home-based other trips are balanced to productions.

Trip balancing rules for each purpose are shown in **Table A-64**.

Table A-64. Trip Generation and Time-of-Day Summary by Purpose

Group	Purpose	Balanced To	Zones Produced in	Zones Attracted to	Time-of-Day Pattern
Work	Low-Income Home-Based Work	Productions	All	DMA, RFV & Corridor	Work
	Middle-Income Home-Based Work	Productions	All	DMA, RFV & Corridor	
	Upper-Middle-Income Home-Based Work	Productions	All	DMA, RFV & Corridor	
	High-Income Home-Based Work	Productions	All	DMA, RFV & Corridor	
Local Non-Work	Home-Based Other	Productions	DMA, RFV & Corridor	DMA, RFV & Corridor	HBO
	Non-Home Based	Either[a]	DMA, RFV & Corridor		NHB
Day Gaming		Attractions	DMA, RFV & Corridor	Gaming Area	Game
Day Recreation	Front Range Day Recreation	Attractions	DMA	Corridor (Resorts)	Ski
	Corridor Day Recreation	Attractions	Eagle, Summit & Pitkin Counties	Resorts	HBO

Group		Purpose	Balanced To	Zones Produced in	Zones Attracted to	Time-of-Day Pattern
Stay Over and Colorado Non-Work	Colorado Non-Work	Corridor to Airport or Front Range	Productions	DIA	RFV & Corridor	HBO
		Stay Visiting Friends or Family	Attractions	DMA, RFV & Corridor	DMA, RFV & Corridor	Stay
	Stay Overnight	Stay at Hotel, Resort, or Forest	Attractions	DMA	RFV, Corridor, Routt County	Ski
		Stay at Second Home	Attractions	DMA	Resorts, Garfield & Routt Counties	Stay
		Resort to Resort	Either[a]	DMA, Wilderness Areas, Resorts, Mesa County		Ski
		Out-of-State Air	Productions	Airports	Resorts	Ski
Truck RV External		Recreational Vehicles	Attractions	DMA, RFV & Corridor	All	Ski
		Out-of-State Automobile (Internal-External & Through)	Productions	External Stations	DMA, RFV, Corridor & I-70 External Stations	Out-of-State Automobile
		Single-Unit Trucks	Either[a]	DMA, RFV & Corridor		Truck
		Single-Unit Truck Internal-External and Through	Productions	External Stations	DMA, RFV, Corridor & I-70 External Stations	
		Combination-Unit Trucks	Either[a]	All		
		Combination-Unit Truck Internal-External and Through	Productions	External Stations	DMA, RFV, Corridor & I-70 External Stations	

Legend:

[a] For these purposes, a single value is calculated and used for both productions and attractions.
DIA = Denver International Airport.
DMA = Denver Metropolitan Area.
RFV = Roaring Fork Valley.

Through Trips

Though technically performed in the same module as trip distribution, the I-70 travel demand model allows the specification of a number of through trips by different vehicle types. Through trips by automobile, RV, and trucks are shown for each of six model days in **Table A-65**. As expected, through automobile trips are added to the Out-of-State Automobile purpose and through RVs to the RV purpose. Through trucks are added to the Combination-Unit Truck Internal-External purpose.

Table A-65. Through Trips

Automobiles	Summer			Winter		
Year	Thursday	Saturday	Sunday	Thursday	Saturday	Sunday
2000	500	500	500	400	500	500
2025	700	700	700	550	750	750
Recreational Vehicles	Summer			Winter		
Year	Thursday	Saturday	Sunday	Thursday	Saturday	Sunday
2000	300	300	300	75	150	150
2025	420	420	420	125	250	250
Through Trucks	Summer			Winter		
Year	Thursday	Saturday	Sunday	Thursday	Saturday	Sunday
2000	1,200	600	500	500	250	200
2025	2,400	1,200	1,000	1,000	500	400

Suppressed Travel

The issue of suppressed travel involves analyzing three conditions: trip suppression, induced trips, and induced growth.

Travel changes in the model result from changes in one or more of the six model modules: trip generation, mode choice, trip distribution, time of day and day of week, route choice, and additional growth of socioeconomic attributes.

The model is able with the appropriate travel times to show factors with route choice and mode choice. The induced demand factors are used for trip generation. The shift from one day to another (such as going for the day less and going for the weekend more but less frequently) is reflected in changes to trip generation rates. Additional growth is discussed as a set of additional land use scenarios. For trip suppression and trip inducement, factors derived from the mode choice model are applied to change overall demand by origin and destination. This process is used as a surrogate for calculating revised trip generation rates.

Under the No Action and Minimal Action alternatives, the trip matrix (demand level) is reduced (suppressed) until a highway trip can travel the distance from C-470 to Silverthorne or from Silverthorne to Glenwood Canyon at 35 mph. Under the Transit alternatives, the trip matrix is reduced until a highway trip can travel the distance from C-470 to Silverthorne or from Silverthorne to Glenwood Canyon at 30 mph.

Induced Travel

Induced travel demand represents the idea that if a transportation system is improved and provides higher quality than previously, the system will attract additional users. For example, if I-70 were widened from 4 lanes to 6 lanes or if a new transit system opened in the Corridor, then on the day the new facilities began operation, one expects faster travel times on I-70. But then additional users are attracted to the Corridor because of at least one of six reasons:

- Users make longer distance trips in the same amount of time.
- Users divert from another facility to this facility.
- Users divert from transit to the freeway.

- Users move near the facility because it now can provide better service to other areas.
- Users adjust their travel times and now go closer to their desired time of arrival.
- Users choose to make more trips.

While it is also true that improved transportation infrastructure in the Corridor may also encourage residents and businesses to locate in the Corridor in amounts greater than expected, this phenomenon is induced development, which is not discussed here. The PEIS analysis uses a process to account for each of the six induced travel phenomena described above.

- The trip distribution module (**section A.2.6**) adjusts each trip's trip length as a function of travel time.
- The mode choice module (**section A.2.7**) adjusts the use of each mode.
- The time of day module adjusts demand between periods, and ramp profile factors (**section A.2.9**) can be used to adjust demand within a period.
- The traffic assignment module calculates the minimum time path for different routes and can place more trips on routes with faster times due to transportation improvements.
  - Development forecasts adjust for the effect of improved accessibility to an area. In this study, induced development is assumed to be offset by changes in trip-making frequency. That is, the mobility results expected with induced development are similar to those forecasted by using the 2025 Baseline socioeconomic database and the trip inducement associated with an alternative.

The trip generation and inducement module to determine whether people make more trips was developed from responses to the Ridership Survey. As part of the Ridership Survey, people were asked whether they travel more if they were to choose a particular alternative. This survey information was then used to calibrate a model that calculates the potential for growth in the number of trips given improvements in transit or highway systems between today (2000) and the future (2025). This information is then used to adjust the future year origin-destination matrices for each purpose to account for the higher frequency of trip-making.

Computations

The trip inducement module is based on a repeated choice structure. That is, the number of trips taken during a particular period of time – for example, the last three months, or the winter season – can be written as the product of the number of trip *opportunities* and the probability of traveling at any particular opportunity. The probability of traveling is calculated from a binary logit form, so the number of trips made in a season equals

(exp(Utility of Traveling)/[1+ exp(Utility of Traveling)])*Opportunities in Season

where the Utility of Traveling is

Purpose Constant + (Seasonal Coefficient + Corridor Coefficient)*Modal Utility Value

The values for the Seasonal Coefficient are: Winter 0.3083, Mud 0.4, and Summer 0.5836.

The values for the Corridor Coefficient are: Winter 0.0008, Mud 0.04, and Summer 0.0846. The Corridor Coefficient only applies to the Corridor Day Recreation within the Corridor.

The values for the Purpose Constant are shown in **Table A-66**. The Modal Utility Value is the utility calculated from the mode choice model, which is described in **section A.2.7**. Note that the utility of traveling is calibrated so that the utility of not traveling has a value of zero. (Recall exp(0)=1.)

Table A-66. Induced Travel Model Purpose Constants

Purpose	Constant
Resort to Resort	-2.5990
Front Range Day Recreation	-1.8840
Corridor Day Recreation	-1.3650
Corridor to Airport or Front Range	-1.0470
Stay at Second Home	-2.0230
Stay at Hotel, Resort, or Forest	-2.5990
Stay Visiting Friends and Family	-2.4960

Before the trip inducement module is applied, travel demand forecasts are based on the year 2000 travel propensities; that is, the trip generation rates shown in 2000 Travel Propensities. If the cost of (dis)utility of traveling is the same in the year 2025 as it was in 2000, there is no inducement. Otherwise, trip volumes projected for the year 2025 using 2000 travel propensities need to be adjusted based on the relative trip-making propensities. Mathematically,

$$\text{2025 Trips after Inducement} = \text{2025 Trips before Inducement}\left(\frac{\text{2025 Travel Propensity}}{\text{2000 Travel Propensity}}\right)$$

$$= \text{2025 Trips before Inducement}\left(\frac{\exp(\text{2025 Utility of Travel})/[1+\exp(\text{2025 Utility of Travel})]}{\exp(\text{2000 Utility of Travel})/[1+\exp(\text{2000 Utility of Travel})]}\right)$$

The inducement module is applied separately for the highway and transit modes to reflect the relative attractiveness of each mode.

An example of this model follows for the Combination Six-Lane Highway with AGS alternative. This example involves a winter Saturday Front Range Day Recreation trip from Denver to Breckenridge. The steps to calculate the induced demand are:

1. Calculate the year 2000 automobile utility for the OD pair:

In 2000, the travel characteristics from Denver to Breckenridge were (see the tables in Appendix B):

- Denver to C-470: 20 minutes (15 miles at 45 mph)
- C-470 to Loveland Pass Interchange: 73 minutes (44 miles)
- Loveland Pass Interchange to Frisco: 15.4 minutes (15 miles)
- Frisco to Breckenridge: 15 minutes (10 miles at 40 mph)
- No parking fees at Breckenridge (park in free day skier lot)

The total travel time is 123.4 minutes and the distance traveled is 84 miles. From the mode choice coefficients in **Table A-69**, the total 2000 utility is shown below:

(–0.02134)*0.365 dollars per mile*84 miles + (–0.00778)*123.4 minutes, or –1.614.

2. Calculate the 2000 utility of traveling:

The utility of making trips in 2000 is then:

–1.8840+0.3083*(–1.63456)= –2.382

3. Calculate the year 2025 automobile utility for this Combination alternative:

The travel characteristics are forecast as:

- Denver to C-470: 20 minutes (15 miles at 45 mph)
- C-470 to Loveland Pass Interchange: 78 minutes (44 miles)
- Loveland Pass Interchange to Frisco: 12.4 minutes (15 miles)
- Frisco to Breckenridge: 15 minutes (the same time as in 2000)
- No parking fees at Breckenridge (park in free day skier lot)

In 2025, the total travel time is 125.4 minutes, or two minutes slower than in 2000. Using the same mode choice coefficients from **Table A-69**, the 2025 automobile utility is shown below:

(–0.02134)*0.365 dollars per mile*84 miles + (–0.00778)*125.4 minutes, or –1.630.

4. Calculate the 2025 utility of traveling by automobile and the overall inducement:

The utility of making this trip by automobile in 2025 then is:

–1.8840+0.3083*(–1.630)= –2.386

which is 0.004 utility units less than the 2000 utility of traveling. The inducement module predicts negative inducement – that is, suppression – of:

$$\frac{\exp(-2.386)/[1+\exp(-2.386)]}{\exp(-2.382)/[1+\exp(-2.382)]} \approx -0.4\%$$

However, the trip inducement macro has an option not to use the trip inducement model results to estimate trip suppression. Because a different method is used to determine suppressed travel, this option is chosen and the trip inducement module is not modifying the number of highway trips in this example.

5. Calculate the year 2025 transit utility for this alternative:

The travel characteristics by transit are projected to be:

- Drive from Denver to Jefferson Station to access the AGS: 20 minutes
- The fare from Jefferson Station to Frisco Station is $8.00
- Each of the three AGS routes (J, K, and L) stop at Frisco Station. The combined headway on a winter Saturday is 5 minutes (see the operating plan in Appendix E)
- The time spent in the AGS from Jefferson Station to Frisco Station is 72.14 minutes (see Appendix B)
- Transfer to the Summit Stage Breckenridge route at Frisco Station. Summit Stage has no fare.
- The headway for the Summit Stage Breckenridge bus is projected to be 7.5 minutes (see Appendix E)
- The time spent on board the Summit Stage bus is assumed to be the same as in 2000, which is 45 minutes according to Summit Stage schedules.

The total fare for this journey is $8.00 and the total headway is 12.5 minutes. The total elapsed time for the journey is 137.14 minutes; however, the mode choice model indicates that the access time to Jefferson Station (20 minutes) is perceived to be three times as onerous as in-vehicle time. Therefore, the weighted time for this journey is:

3*20 minutes + 72.14 minutes + 45 minutes = 177.14 minutes

Using the mode choice coefficients of **Table A-69** gives a utility of:

(–0.05060)*$8.00 + (–0.00778)*177.14 weighted minutes + (–0.0722)*12.5 minutes headway
+ 0.76849 [AGS constant] + 0.11988 [AGS in winter]

which is about –0.985 utility units. Notice that although the elapsed time for the AGS journey is about 12 minutes longer than the elapsed time for automobile in 2025, the 2025 transit utility is about 0.65 utility units *greater* than the 2025 automobile utility (–1.630).

6. Calculate the 2025 utility of making a trip by transit, and the overall inducement:

The utility of making this trip by transit in 2025 then is:

–1.8840+0.3083*(–0.985)= –2.188

which is about 0.19 utility units greater than the utility of making a trip in 2000. Note that since no Corridor-wide transit system was available in 2000, the 2025 utility of traveling by transit is compared to the 2000 utility of a trip by automobile.

The inducement projected is then:

$$\frac{\exp(-2.188)/[1+\exp(-2.188)]}{\exp(-2.382)/[1+\exp(-2.382)]} \approx 19.3\%$$

meaning that the 2025 level of transit travel is 19.3 percent more than predicted by using the 2000 trip generation rates alone.

A.2.6 Trip Distribution

After the numbers of trip ends are established, trip ends need to be linked to form a trip. This process is sometimes called trip distribution or destination choice. Matrices of the number of trips between a specified origin and destination (technically between production and attraction) are developed as a function of the intensity of activities in the origin and destination zones, and of the travel involved between the two zones.

The Gravity Model

The most familiar trip distribution model is known as the gravity model. It is based on Newton’s law of gravity, where the gravitational force between two objects is proportional to the product of their masses and inversely proportional to the square of the distance between them.

Over the years, practitioners theorize that a state’s population is analogous to the mass of an object, the number of trip ends came to replace mass, and travel time (or a combination of time, distance, and cost) came to be used as the measure of separation. Experiments showed the best fit emerged when the number of trips was proportional to the product of productions and attractions and inversely proportional to the antilogarithm of travel time. Theorists showed that this specification was consistent with certain behavioral assumptions, and the model also came to be known as the entropy model (after one of the assumptions).

TransCAD offers a general specification of the gravity model:

$$N_{ij} = P_i \frac{A_j f(t_{ij})}{\sum_{\text{all zones } z} A_z f(t_{iz})}$$

where N_{ij} is the number of trips from zone i to zone j, P_i is the number of trip productions from zone i, A_j is the number of trip attractions to zone j, and t_{ij} is the travel time between zones i and j. The I-70 travel demand model uses a relation called the gamma function for $f(t_{ij})$, the friction factor. According to this function:

$$f(t_{ij}) = a t_{ij}^{-b} e^{-c t_{ij}}$$

where a, b, and c are parameters to be estimated, and e is the base of natural logarithms. (Note that the parameter a cancels out in the calculation of trips; its purpose is to prevent computational overflows and underflows.) Note that for $b > 0$ and $c > 0$, $f(t_{ij})$ is a decreasing function of t_{ij}. That is, all else equal, closer zones get more trips than farther zones.

Values of the coefficients a, b, and c are shown in Table A-67. However, these values do not have much inherent meaning by themselves; instead, a more common way of calibrating a gravity model is to examine the resulting distribution of trip lengths or times. Of course, the distribution of socioeconomic variables and therefore trip ends also influence the trip-length distribution.

Table A-67. Trip Distribution Gamma Function Coefficients

Purpose	a	b	c
Work	5,000	0.90	0.04
Local Non-Work (HBO + NHB) Corridor Day Recreation Out-of-State Automobiles	200,000	1.15	0.07
Recreation (excluding Corridor Day Recreation) RVs	1	0.25	0.01
All Trucks	100,000	1.15	0.04

Source: J.F. Sato and Associates

The I-70 travel demand model uses travel time on the highway system to distribute all trips for both highway and transit trips. This assumption is reasonable given the low mode shares in the Corridor. Trip distribution is run twice, to reflect the variance in travel times during the course of a day. Peak-hour highway travel times are used to produce a peak trip table and free-flow travel times are used to produce an off-peak trip table. In winter, trips in the AM peak and PM peak periods come from the peak trip table, while the midday and night periods use the off-peak trip table. In summer, the AM peak, midday, and PM peak periods all use the peak trip table.

Trip-Length Distributions

A trip-length distribution shows what percentage of trips travel for how long or how far. Because the trip distribution step is based on highway travel time, travel time is shown on the x axes of the trip-length distributions shown in **Chart A-5** through **Chart A-12**.

Chart A-5 shows the year 2000 distribution of work trips by duration. About 55 percent of work trips are 45 minutes or shorter, and about 80 percent of commutes are completed within an hour. The 30- to 45-minute interval also reflects the greatest fraction of work trips among the 15-minute intervals. However, a small fraction of work trips take up to three hours and 15 minutes to complete.

Chart A-5. 2000 Summer Thursday Work Trip-Length Distribution

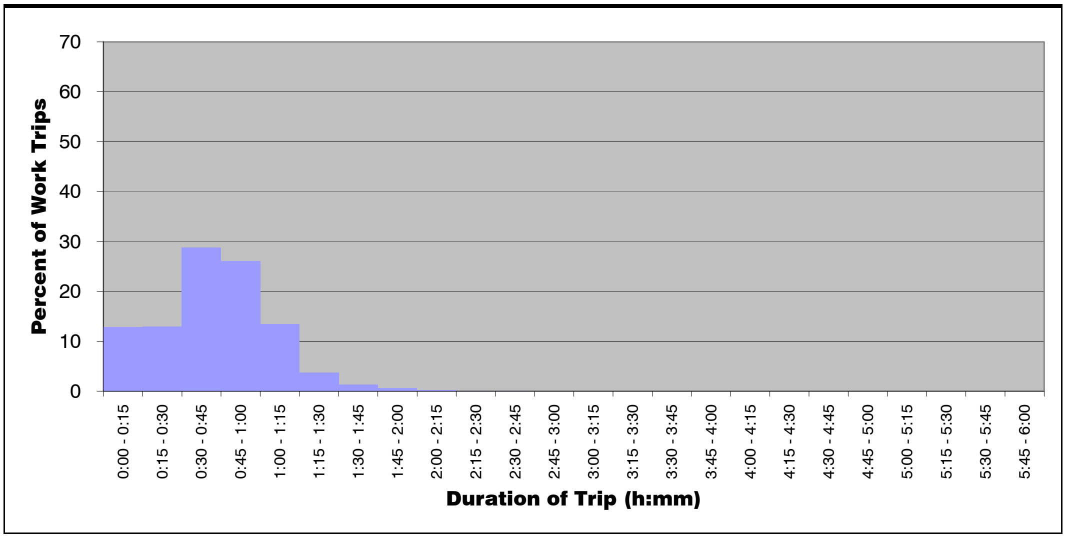


Chart A-6 shows that local non-work trips are shorter, on average, than work trips. The median Local Non-Work trip length is less than 30 minutes. About 83 percent of Local Non-Work trips are completed within 45 minutes, and about 96 percent within an hour.

Chart A-6. 2000 Summer Thursday Local Non-Work Trip-Length Distribution

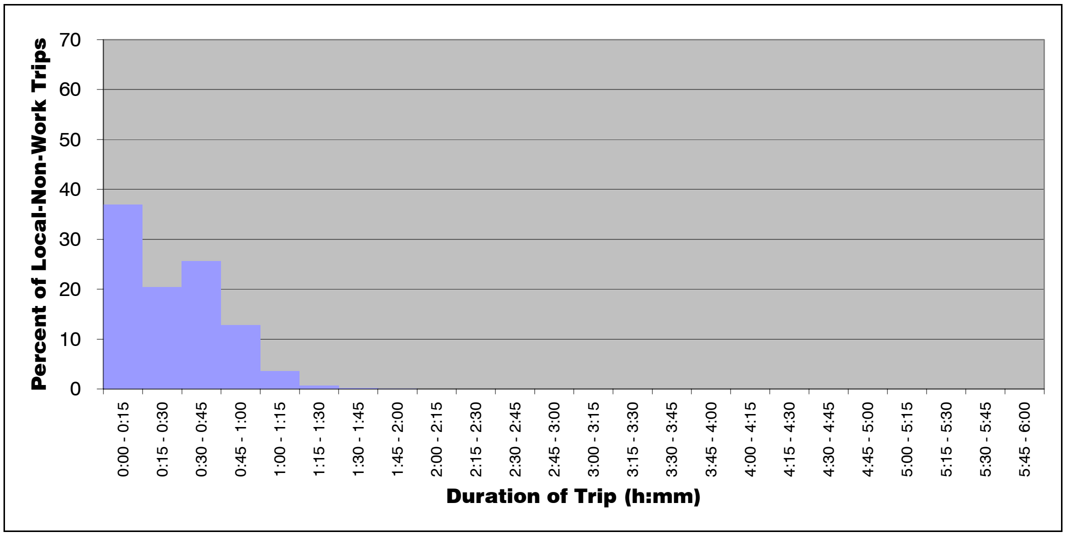


Chart A-7 shows the trip-length distribution for a year 2000 summer Sunday. Longer trip durations are expected for the Day Recreation purpose, which involves travel between Front Range homes and Corridor attractions. The table has two distinct peaks. Over one-fifth of all summer day recreation trips take between 45 minutes and an hour. Another sixth take between an hour and 45 minutes to two hours. However, the scarcity of trips taking one hour to an hour and a half reflects the lack of recreation destinations in the Corridor this far from the Denver metropolitan area. The median summer day recreation trip duration is somewhere between an hour and a half, and an hour and 45 minutes. Over 95 percent of these summer day trips take less than two and a half hours one way.

Chart A-7. 2000 Summer Sunday Front Range Day Recreation Trip-Length Distribution

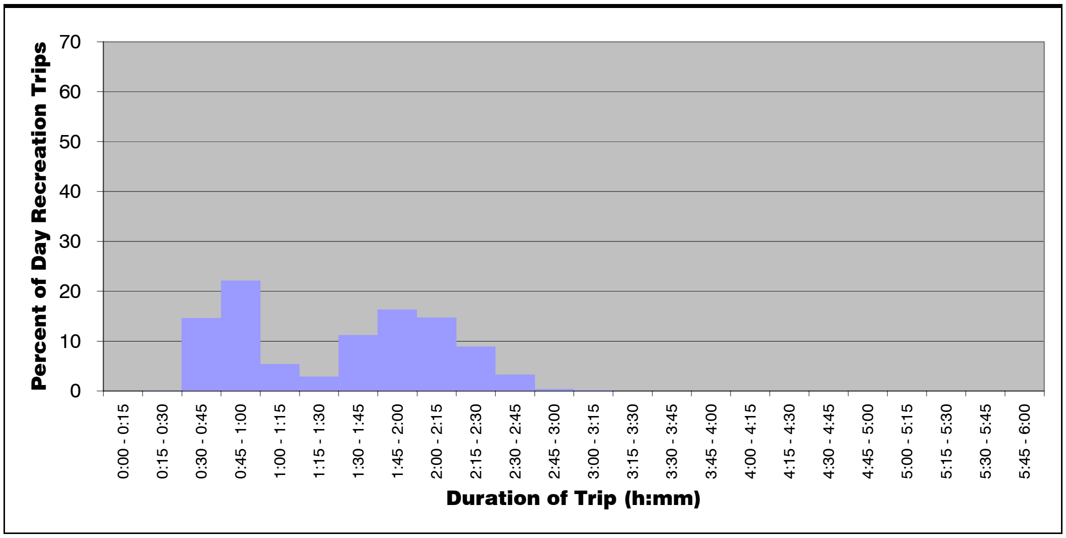


Chart A-8 shows that in winter, day recreation trips have a much tighter or clustered distribution. The 15-minute interval with the greatest number of trips is for trips of an hour and a half to an hour and 45 minutes. The median winter day recreation trip duration also falls within this interval. These winter trips take at least 45 minutes and no trip take more than three hours. Over 98 percent of these trips are completed within two hours and 15 minutes, a shorter time than for the corresponding sample of summer day recreation trips.

Chart A-8. 2000 Winter Saturday Front Range Day Recreation Trip-Length Distribution

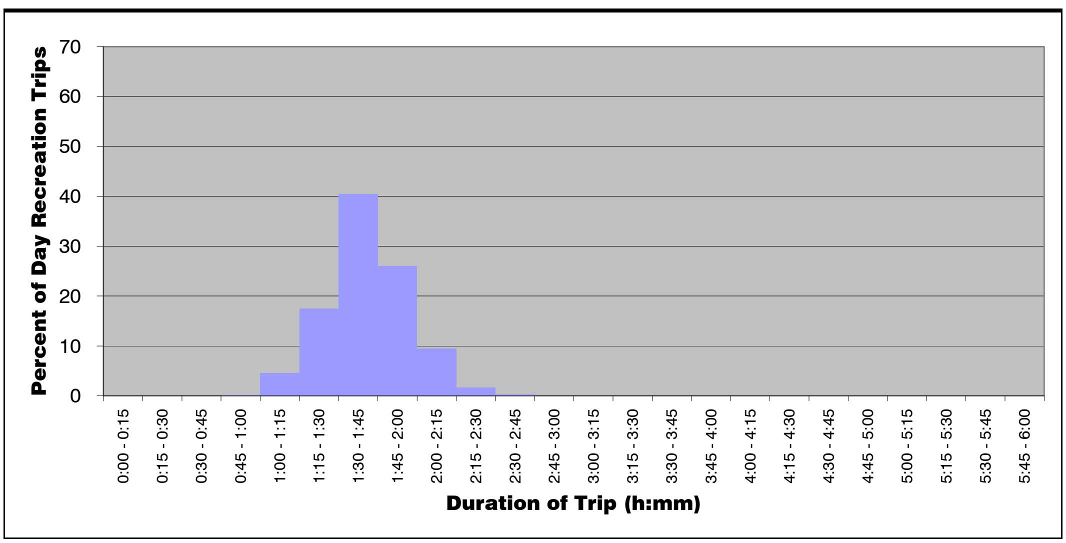


Chart A-9 shows that almost 70 percent of summer Corridor Day Recreation trips terminate within 15 minutes of their origin and almost 90 percent take no longer than half an hour. The trip distribution model also predicts a very small number of summer Corridor Day Recreation trips lasting up to 4.5 hours (about the time to travel from one end of the Corridor to the other).

Chart A-9. 2000 Summer Sunday Corridor Day Recreation Trip-Length Distribution

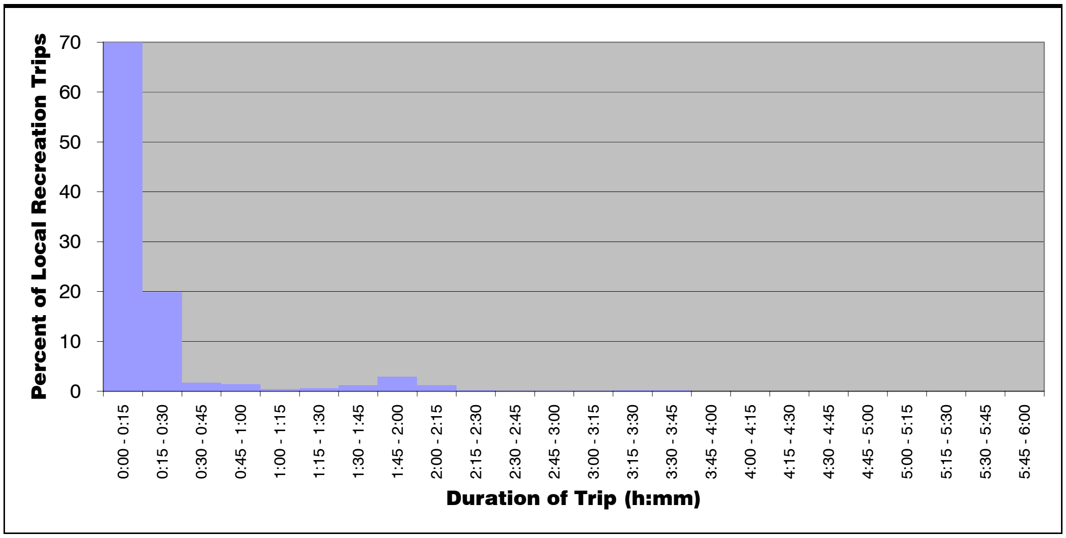
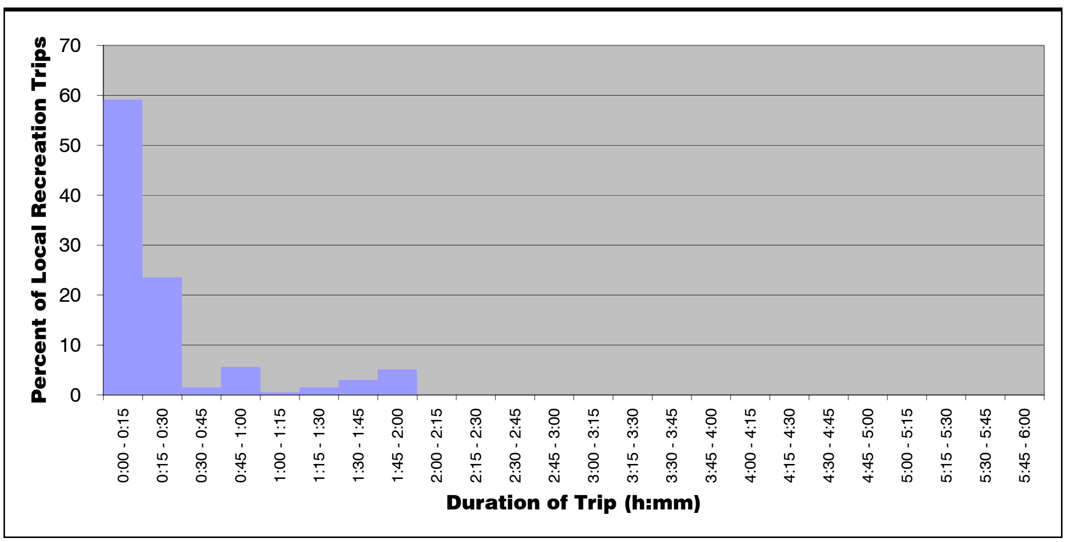


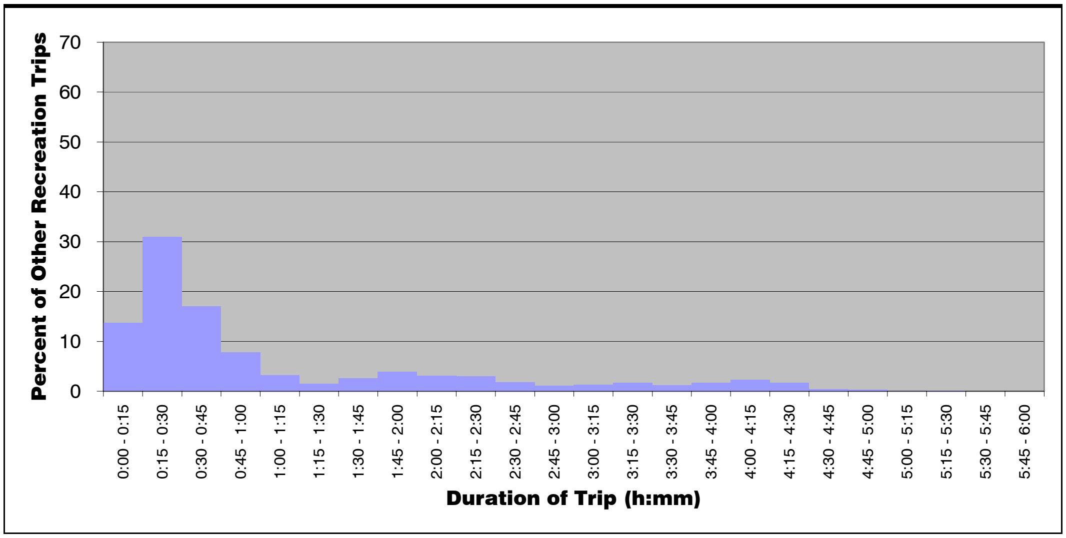
Chart A-10 shows that Corridor Day Recreation trips made in winter have a somewhat flatter distribution. Just under 60 percent of these trips (over ten percent less than summer trips) are completed within 15 minutes. Eighty percent of winter trips are completed within 30 minutes (again, about ten percent less than winter trips of the same duration). The longest winter Corridor Day Recreation trip takes two hours and 15 minutes. About five percent of these trips occur in the 45-minute-to-one-hour bin, and the one-hour-and-45-minutes-to-two-hour interval.

Chart A-10. 2000 Winter Saturday Corridor Day Recreation Trip-Length Distribution



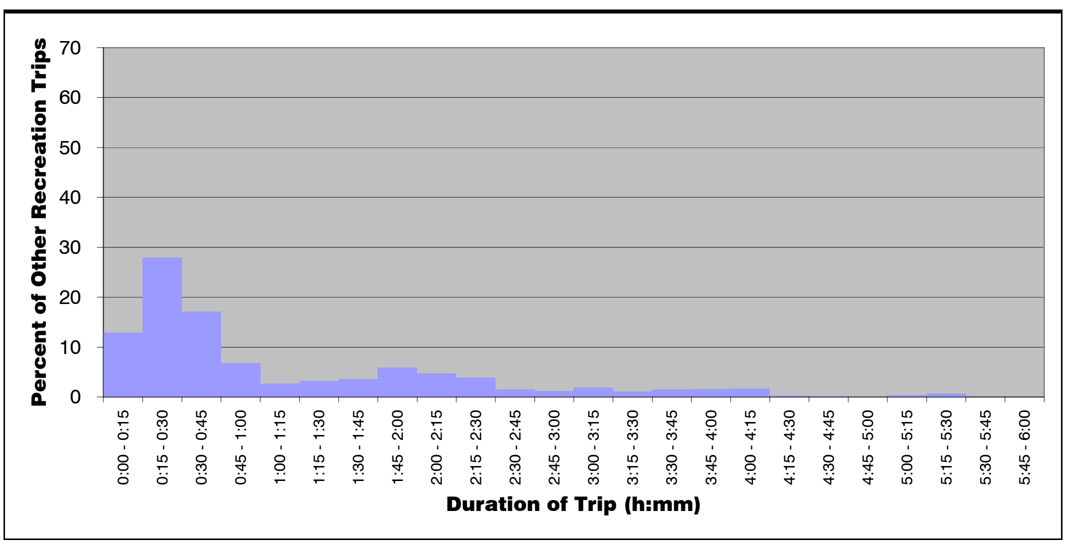
The Other Recreation category includes overnight trips from residents outside the Corridor, and all trips by Corridor residents to the Front Range. The summer 2000 trip-length distribution for these recreational trips is shown in **Chart A-11**. About 70 percent of these trips are completed within an hour, while other trips take up to 5.5 hours. The trip-length distribution has a peak at the 15-to-30-minute interval, with over 30 percent of trips, and a median trip length between 30 and 45 minutes. About 90 percent of summer other recreation trips are completed within three hours.

Chart A-11. 2000 Summer Sunday Other Recreation Trip-Length Distribution



The winter other recreation trip-length distribution shown in **Chart A-12** has a shape similar to the distribution for summer (**Chart A-11**). About 65 percent of winter trips are completed within an hour, and the longest trips take up to 5.5 hours. The winter distribution also peaks with about 30 percent of trips in the 15-to-30-minute interval. The median trip length is also between 30 and 45 minutes. Just over 90 percent of winter other recreation trips take three hours or less. Unlike day recreation trips, which are generally destined to attractions, these other recreation trips end at lodging within the Corridor, which are available year round.

Chart A-12. 2000 Winter Saturday Other Recreation Trip-Length Distribution



Trip Matrix Transformation

Recall that the output of trip distribution is technically a production-attraction matrix. However, to associate trips with a particular transportation facility (roadway) or service (transit line), an origin-destination matrix is required. The output of trip distribution is also in person trips, while vehicle trips are more useful for highway analysis. The conversion is the average vehicle occupancy; that is, the average number of persons per vehicle. Finally, facility capacities are often specified on an hourly basis, while trip distribution (as a result of trip generation) produces a daily trip table. These transformations may be applied at any convenient and appropriate step between trip distribution and assignment.

To understand PA to OD transformation, consider a work trip as an example. Recall that during trip generation, the home end is treated as the production and the work end as the attraction. After distribution, a particular person's commute shows up as two trips in the PA matrix, from home zone to work zone. However, on an origin-destination (or chronologically ordered) basis, this person makes one trip from home to work and one trip from work to home. The OD matrix is therefore the sum of one-half the PA matrix plus one-half the transpose of the PA matrix.

The work trip example above represents an ideal case; the commuter goes to work and returns home before midnight the same day. In this case, the factors on the PA matrix and its transpose are both 0.5, and the work purpose is said to have balanced departing and return trips. Not all trip purposes exhibit this property. For example, consider multi-day recreation trips: more of these trips depart on a Friday than return, while on Sunday more return trips are observed.

TransCAD exploits computational advantages to multiplying matrices by constants, such as time-of-day factors or (reciprocals of) vehicle occupancies at the same time as performing PA to OD transformation.

A.2.7 Mode Choice

After the total trip table is produced in trip distribution, a mode choice model estimates which percentage use which mode, based on the relative travel times and costs plus other factors.

Overview of Utility

Because there are so many different components of travel — for example, the time spent in vehicles, the time to walk to the destination, the cost to park, and ride comfort — the economic concept of utility is used to combine these components into a single measure for comparison. Economic theory asserts that various goods contain different attributes, each of which contribute to the utility of or the satisfaction gained from the final product. For example, a soft drink might have attributes such as volume of the drink, temperature, sweetness, flavor, and degree of carbonation. Travel is generally thought to be a *bad* rather than a good; that is, people prefer to avoid the components of travel, so travel attributes make a negative contribution to utility.

Utility may consist of subjective components as well as objective attributes. For example, a traveler may find a maglev train to be more attractive than one pulled by a diesel locomotive, even if differences in travel times (and other factors) are controlled. These subjective elements are often represented by a random term within the utility. The average of this random term, called a bias constant or an alternative-specific constant, may be thought of as analogous to the intercept term of linear regression.

The utility of travel between two zones may then be written as:

$$V_{in} = \alpha_{in} + \sum_{\text{all attributes } k} \beta_k X_{ink} \quad \text{and} \quad U_{in} = V_{in} + \varepsilon_{in}$$

where V_{in} is the systematic (that is, non-random) utility for mode *i* and person *n*, α_{in} is the mode-specific constant, β_k is a coefficient associated with attribute *k* (often β_k is negative), X_{ink} is the value of attribute *k* for mode *i*, U_{in} is the (total) utility, and ε_{in} is a random term with zero mean.

For a specific type of ε_{in}, the probability that person *n* chooses mode *i*, $P_n(i)$, can be written as:

$$P_n(i) = \frac{\exp(V_{in})}{\sum_{\text{all alternatives } j} \exp(V_{jn})}$$

This relation is known as the logit model. If there are only two alternatives, the model can be called a binary logit model; otherwise, it is called a multinomial logit model. The PEIS uses a binary logit model for all trip purposes except for out-of-state air passengers, who are assumed to make a choice among three alternatives:

- take an automobile from the current airport
- take transit from the current airport
- switch to DIA and take transit from there

Estimation of the Mode Choice Model

The PEIS Mode Choice Model is based on the I-70 Ridership Survey, which asked respondents hypothetical (that is, stated preference) questions regarding their anticipated mode choice for a particular trip in the Corridor. Up to five stated preference questions were asked of each respondent, and the transit mode to be considered was randomly selected each time. Trip attributes such as travel time, fares, and other costs were based on a trip the respondent reported making recently, with random adjustments made to better explore travel tradeoffs. (The random adjustments also help model estimation because the adjustments reduce the correlation between variables like travel time and travel distance.) The Ridership Survey also asked respondents to think about situational constraints involved in their trip, such as the amount of baggage being carried, traveling as a family or other group, and the need for a private vehicle at the destination. Respondents were also asked to consider amenities on board the hypothetical transit system, including food service, ski lockers, bike storage, and checked luggage. When checked luggage service was offered, out-of-state air passengers did not need to claim their luggage at the airport; the transfer is similar to changing airplanes.

Based on travelers' responses, the model estimation software can determine values for the model coefficients (α and β in **Overview of Utility**) using the Maximum Likelihood Estimation procedure. While a discussion of this procedure is beyond the scope of this appendix, a simple explanation is that coefficient values are adjusted so that the probability (or likelihood) of observing the responses in the survey as predicted by the model is as great as possible.

The specification of the utility function underwent considerable revision during development of the model, with input from stakeholders and the peer review panel. Initially, the model used common composite time and composite cost variables for all purposes, with factors and constant terms unique to each purpose. Later models were estimated using all segment-specific coefficients (that is, by trip purpose) for all variables. Because unconstrained estimates produced unrealistically low values of time (the willingness of travelers to pay extra to avoid travel time), the in-vehicle-time coefficients were constrained to produce values of time consistent with Corridor incomes.

Estimation results are shown in **Table A-68**. There is no physical unit to measure utility. Modelers often describe the abstract units of preference as *utils*. Generally, comparing different coefficients is more meaningful than looking at a single value. For example, the value of time is calculated by dividing the in-vehicle-time coefficient (utils per minute) by the First $10 of Fare Cost coefficient (utils per dollar).

Another useful comparison involves values of the mode-specific constants: terms that capture travelers' inherent preferences for a particular mode after normalizing for difference in travel time, cost, and so on. In the I-70 travel demand model, transit utilities are calculated with respect to the automobile alternative. Many of the transit constants in **Table A-68** are negative, meaning that the respondents generally prefer driving to taking transit when all other factors are equal. However, for some trip purposes, the rail and monorail constants are positive, indicating that these travelers prefer these guideway systems to driving.

Further, note that the coefficient on parking cost for the Trips to Hotels purpose is zero. This constraint was assumed during the estimation process because hotels typically provide free parking to their guests (or rather, parking is included in the room rate).

One unusual result was that the bags-checked-to-destination coefficient was negative (and statistically more significant than some other coefficients) for the Airport Trips to Corridor purpose. During development of the Ridership Survey, it was believed that out-of-state air passengers value the convenience of having their bags transferred to an I-70 transit system. However, survey responses suggest that these travelers instead value control over the bags they checked for flight: they want to know their luggage arrived safely, and perhaps access its contents (for instance, to put on clothes more suitable to mountain weather).

Table A-68. Mode Choice Model Coefficients as Estimated

Coefficients	Home-Based Work	Local Non-Work	Front Range Day Recreation	Stay at Hotel, Resort or Forest; Resort to Resort	Corridor to Airport or Front Range	Corridor Day Recreation	Second Homes	Visit Friends and Family	Out-of-State Air	Gaming Trips
Fare ($0–$10)	-0.05801	-0.08170	-0.05060	-0.02511	-0.08730	-0.04036	-0.03116	-0.04506	-0.02526	-0.22621
Fare (>$10)	(a) -0.05801	-0.06141	-0.24114	-0.08494	-0.09053	-0.09966	-0.07304	(a) -0.04506	-0.04528	-0.16039
Automobile fuel cost (at 36.5 cents/mi)	(b) 0.00000	-0.04405	-0.02134	-0.05328	-0.04206	-0.03381	-0.03456	-0.05254	-0.00337	-0.03131
Parking cost	-0.05841	-0.00973	-0.14354	(b) 0.00000	-0.06312	-0.01716	-0.06859	(a) -0.04506	-0.07967	-0.16061
Automobile rental cost	(b) 0.00000	(c) -0.00973	(d) -0.04327	-0.03420	(b) 0.00000	-0.06401	-0.00389	(a) -0.04506	(d) -0.00683	0.03580
Automobile In-vehicle time	(e) -0.00892	(f) -0.00629	(e) -0.00778	(e) -0.00386	(f) -0.00671	(f) -0.00621	(e) -0.00479	(f) -0.00347	(e) -0.00389	(g) -0.00252
Transit In-vehicle time	(e) -0.00892	(f) -0.00629	(e) -0.00778	(e) -0.00386	(f) -0.00671	(f) -0.00621	(e) -0.00479	(f) -0.00347	(e) -0.00389	(g) -0.00252
Transit headway (0-15 minutes)	-0.02159	-0.00800	-0.00722	-0.02741	(h) -0.01007	-0.02782	-0.00227	-0.00520	-0.01440	-0.00378
Transit headway (above 15 minutes)	-0.00554	(i) -0.00800	(i) -0.00722	-0.01363	(h) -0.01007	-0.01174	(i) -0.00227	(i) -0.00520	(i) -0.01440	(i) -0.00378

Mode Constants (j)	Home-Based Work	Local Non-Work	Front Range Day Recreation	Stay at Hotel, Resort or Forest; Resort to Resort	Corridor to Airport or Front Range	Corridor Day Recreation	Second Homes	Visit Friends and Family	Out-of-State Air	Gaming Trips
Van services	-0.42468	-1.17306	-0.73459	-3.13671	-1.05091	-1.92760	-0.72603	-0.76694	-0.65097	0.52041
Tour bus	-0.29400	-0.24844	-0.56743	-1.87764	-0.76769	-0.67091	-0.45282	0.02912	-1.38603	1.59640
Guided bus	-0.23408	-1.04094	-2.32355	-1.25362	-0.38968	-0.90345	-0.62922	0.49248	-0.49122	1.21755
Rail	0.58607	0.29437	0.61280	-0.13282	0.63005	0.08034	0.90849	1.34634	1.31431	3.76948
Monorail/maglev (k)	0.76456	0.42019	0.76849	-0.05555	0.76435	0.20451	1.00437	1.41565	1.39201	3.81987

Transit Seasonal and Day Constants	Home-Based Work	Local Non-Work	Front Range Day Recreation	Stay at Hotel, Resort or Forest; Resort to Resort	Corridor to Airport or Front Range	Corridor Day Recreation	Second Homes	Visit Friends and Family	Out-of-State Air	Gaming Trips
Summer Thursday	-0.108	-0.196	0.305	0.091	-0.206	1.099	-0.375	-0.488	-0.718	-3.002
Summer Saturday	(b) 0.000	-0.141	1.137	0.241	0.154	0.275	-0.360	-0.493	0.088	0.669
Summer Sunday	2.824	-0.005	(b) 0.000	0.103	0.393	-0.480	-0.786	-2.120	-0.144	-0.775
Winter Thursday	(b) 0.000	0.721	0.213	-0.029	-0.424	0.231	-0.343	-1.032	0.018	(b) 0.000

Winter Saturday (l)	(b) 0.000	(b) 0.000	(b) 0.000	(b) 0.000	(b) 0.000	(b) 0.000	(b) 0.000	(b) 0.000	(b) 0.000	(b) 0.000
Winter Sunday	(b) 0.000	0.697	0.290	0.470	0.325	0.741	-0.081	-8.798	0.485	(b) 0.000
Day not specified	0.226	0.522	-0.057	0.104	0.047	0.331	-0.510	-1.133	-0.099	(b) 0.000

Other Utility Adjustments	Home-Based Work	Local Non-Work	Front Range Day Recreation	Stay at Hotel, Resort or Forest; Resort to Resort	Corridor to Airport or Front Range	Corridor Day Recreation	Second Homes	Visit Friends and Family	Out-of-State Air	Gaming Trips
Van services in winter	0.72776	0.11774	-0.48540	1.07587	1.15819	1.11951	-0.44591	1.31243	0.43037	-0.30418
Tour bus in winter	0.23437	-0.86903	0.07031	0.70734	0.51112	0.16237	-0.17047	-0.82804	0.90988	(b) 0.00000
Guided bus in winter	0.50253	0.39485	2.54616	1.12304	0.10500	0.77621	0.57626	-0.43893	0.10373	-2.07581
Rail/monorail/maglev in winter	-0.15757	-0.19058	0.11988	0.65800	0.38099	0.49440	-0.40557	-0.73572	-0.49017	-2.14394
Rail transfer to tour bus	(b) 0.00000	(b) 0.00000	(b) 0.00000	-0.27351	(b) 0.00000	-0.27301	-0.21530	-0.41815	-0.59756	(m) -2.17095
Eagle County transit origin	-0.84520	-0.99549	N/A	0.75288	-0.10843	0.06484	N/A	0.52413	N/A	-5.82799
Food service available on board	(b) 0.00000	0.07946	0.15540	0.40755	0.13800	0.15072	0.11107	0.16950	(b) 0.00000	0.23509
Ski lockers available on board	0.49769	0.74071	0.13310	(b) 0.00000	1.31425	(b) 0.00000	0.27521	1.10808	0.21579	2.02495
Bike storage available on board	(b) 0.00000	1.90014	4.89199	(b) 0.00000	(b) 0.00000	0.73547	(b) 0.00000	(b) 0.00000	(b) 0.00000	(b) 0.00000
Bags checked to destination	(b) 0.00000	(b) 0.00000	(b) 0.00000	(b) 0.00000	(b) 0.00000	-0.00148	0.19351	(b) 0.00000	-0.45240	0.30253

1

Legend:

(a) = Coefficient was constrained to the value of the First $10 of Fare Coefficient.

(b) = Coefficient was constrained to zero.

(c) = Coefficient was constrained to the value of the Parking Cost Coefficient.

(d) = Coefficient was constrained to twice the value of the Fuel Cost Coefficient.

(e) = Travel time coefficient was constrained to produce a $9.23 value of time.

(f) = Travel time coefficient was constrained to produce a $4.62 value of time.

(g) = Travel time coefficient was constrained to produce a $0.67 value of time.

(h) = Coefficient was constrained to 1.5 times the value of the In-Vehicle-Time Coefficient; that is, wait time is three times as onerous as in-vehicle-time.

(i) = Coefficient was constrained to the value of the First 15 Minutes of Headway Coefficient.

(j) = Total Mode Constant is the mode constant above plus the Transit Seasonal and Day Constant.

(k) = Monorail mode constant is the mode constant above plus the Transit Seasonal and Day Constant plus 20 times the monorail in vehicle travel time coefficient.

(l) = Winter Saturday is taken as the base or default day.

(m) = Because hypothetical scenarios were generated during the interview, the Rail-to-Bus Transfer Coefficient is able to be estimated. However, for application, all gaming trips require a rail-to-bus transfer, so this coefficient is added to the Rail (and Monorail/maglev) constant(s).

N/A = Not Applicable

Digits are shown for computation only, and should not be construed to imply a level of statistical significance.

Application of the Mode Choice Model

The travel demand model takes a travel demand matrix developed in the Trip Distribution section and splits this table of 749 by 749 origins and destinations into two matrices. The first defines the person trips that travel by automobile and the second defines the person trips that travel by transit. Also included in the automobile matrix are the automobile trips that access transit stations. The method of splitting each of the 15 demand matrices for the two periods of peak and off-peak for each day is:

- calculate the utility of making each trip interchange by each of the two modes (called a binary choice model)
- take the ratio of the inverse natural log of the transit utility over the inverse natural log of both utilities

This analysis is performed for trips that are transit-eligible. Recreation vehicles, internal-external, the four truck purposes, and through vehicles are assumed to be unlikely to shift to transit.

The model calculates a value called a utility that expresses propensity for taking either a transit trip or an automobile trip. The higher the utility's value relative to the value of the other mode, the greater the chance that the person uses that mode.

Utility calculation is a function of the product of the utility coefficients (**Table A-69**) and attributes. The utility calculation for transit is defined below. Many of these attributes are specific to a particular interchange (for example, the Denver CBD to the end of Bridge Street in Vail where the chairlifts start, or Littleton to the town of Winter Park). This is one reason the study area was subdivided into 749 analysis zones that approximate travel from one area to another. For each interchange, the calculation is made from home to recreation or other destination such as work or shopping.

Automobile Attributes

- Time to walk from front door to personal vehicle
- Time to drive to destination, accounting for congestion delays
- Time to walk from parking space/garage to final destination
- Parking fees paid in proportion to vehicle occupancy
- Fuel cost paid (mileage times 36.5 cents per vehicle mile) in proportion to vehicle occupancy

Travel time and costs are calculated by the minimum time algorithm in the software program and then adjusted for vehicle occupancy.

Transit Attributes

- Time to walk from front door to transit stop or walk to personal vehicle for trip to transit station
- Time to drive to transit station and park
- Time to walk from parked vehicle to transit vehicle platform or stop
- Time to wait for transit vehicle
- Time to travel in vehicle, including other stops (dwell time) and deceleration/acceleration at each stop
- Transfer time (if any) while changing vehicles to complete trip
- Time to walk from last vehicle to final destination
- Fare paid based on the relevant fare structure(s)

The software chooses a set of paths to make a trip from the home to the final destination zone using a procedure called the Pathfinder algorithm. The path is a function of vehicle speed, headways, and fares.

The algorithm offers considerable flexibility concerning the tradeoffs travelers make between different components of their journey. The Pathfinder algorithm also calculates a weighted average of attribute values when there are two or more routes that might be reasonable for a trip. Such routes might serve the same roadway, stop at the desired boarding and alighting location, and travel at roughly the same time. The algorithm is explained in more detail in **Transit Route Choice**.

Industry practice has determined that some of these times are more burdensome than others, and therefore wait, walk, and transfer times are weighted to be three times vehicle time. Also, walking more than half a mile or for 10 minutes is not allowed. **Table A-69** shows the weights applied in the model.

Each of the attribute matrices are then multiplied by the appropriate coefficients as shown in **Table A-69**; mode constants, Transit Seasonal and Day Constants, and Other Utility Adjustments are added. The sum of these values for automobile and transit are the mode utility calculation for each interchange. The natural log of the transit utility is divided into the natural log of the sum of the automobile and transit utilities to arrive at the mode split for that purpose and time.

Many automobile and transit attributes change with time, and some automobiles are operating in queues where the travel time is not a simple calculation based on speed limit and distance. In these cases, averages within the peak hour and off-peak periods are used.

Table A-69. Mode Choice Coefficients as Applied, Project Alternatives

Coefficients	Home-Based Work	Local Non-Work	Front Range Day Recreation	Stay at Hotel, Resort or Forest; Resort to Resort	Corridor to Airport or Front Range	Corridor Day Recreation	Second Homes	Visit Friends and Family	Out-of-State Air	Gaming Trips
Fare ($0–$10)	-0.05801	-0.08170	-0.05060	-0.02511	-0.08730	-0.04036	-0.03116	-0.04506	-0.02526	-0.22621
Fare (>$10)	-0.05801	-0.06141	-0.24114	-0.08494	-0.09053	-0.09966	-0.07304	-0.04506	-0.04528	-0.16039
Automobile fuel cost	0.00000	-0.04405	-0.02134	-0.05328	-0.04206	-0.03381	-0.03456	-0.05254	-0.00337	-0.03131
Parking cost	-0.05841	-0.00973	-0.14354	0.00000	-0.06312	-0.01716	-0.06859	-0.04506	-0.07967	-0.16061
Automobile rental cost	0.00000	-0.00973	-0.04327	-0.03420	0.00000	-0.06401	-0.00389	-0.04506	-0.00683	0.03580
Automobile In-vehicle time	-0.00892	-0.00629	-0.00778	-0.00386	-0.00671	-0.00621	-0.00479	-0.00347	-0.00389	-0.00252
Transit In-vehicle time	-0.00892	-0.00629	-0.00778	-0.00386	-0.00671	-0.00621	-0.00479	-0.00347	-0.00389	-0.00252
Transit headway (0-15 minutes)	-0.02159	-0.00800	-0.00722	-0.02741	-0.01007	-0.02782	-0.00227	-0.00520	-0.01440	-0.00378
Transit headway (above 15 minutes)	-0.00554	-0.00800	-0.00722	-0.01363	-0.01007	-0.01174	-0.00227	-0.00520	-0.01440	-0.00378
Mode Constants (1)	**Home-Based Work**	**Local Non-Work**	**Front Range Day Recreation**	**Stay at Hotel, Resort or Forest; Resort to Resort**	**Corridor to Airport or Front Range**	**Corridor Day Recreation**	**Second Homes**	**Visit Friends and Family**	**Out-of-State Air**	**Gaming Trips**
Van services	-0.42468	-1.37306	-0.73459	-3.13671	-1.05091	-1.92760	-0.72603	-0.76694	-0.65097	-0.88000
Tour bus	-0.29400	-1.30000	-2.59799	-4.06666	-3.05184	-1.37000	-2.54184	-2.21234	-3.05813	0.00000
Guided bus	-0.23408	-1.24094	-2.32355	-1.25362	-0.38968	-0.90345	-0.62922	0.49248	-0.49122	0.00000
Rail	0.58607	0.09437	0.61280	-0.13282	0.63005	0.08034	0.90849	1.34634	1.31431	0.20000
Monorail/maglev (2)	0.76456	0.22019	0.76849	-0.05555	0.76435	0.20451	1.00437	1.41565	1.39201	0.25039
Transit Seasonal and Day Constants	**Home-Based Work**	**Local Non-Work**	**Front Range Day Recreation**	**Stay at Hotel, Resort or Forest; Resort to Resort**	**Corridor to Airport or Front Range**	**Corridor Day Recreation**	**Second Homes**	**Visit Friends and Family**	**Out-of-State Air**	**Gaming Trips**
Summer Thursday	-0.370	-0.950	0.305	0.091	-0.206	0.200	-0.375	-0.488	-0.718	0.100
Summer Saturday	-0.600	-0.730	1.137	0.241	0.154	0.400	-0.360	-0.493	0.088	-0.430
Summer Sunday	-0.047	-0.215	0.000	0.103	0.393	-0.300	-0.786	-2.120	-0.144	-0.070
Winter Thursday	0.000	0.300	0.213	-0.029	-0.424	-0.400	-0.343	-1.032	0.018	0.000
Winter Saturday	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Winter Sunday	0.000	0.750	0.290	0.470	0.325	0.300	-0.081	-3.000	0.485	0.000

Other Utility Adjustments	Home-Based Work	Local Non-Work	Front Range Day Recreation	Stay at Hotel, Resort or Forest; Resort to Resort	Corridor to Airport or Front Range	Corridor Day Recreation	Second Homes	Visit Friends and Family	Out-of-State Air	Gaming Trips
Van services in winter	0.50000	-0.45000	-0.48540	1.07587	1.15819	0.75000	-0.44591	1.31243	0.43037	-0.30418
Tour bus in winter	0.00000	-0.45000	0.07031	0.70734	0.51112	-0.37000	-0.17047	-0.82804	0.90988	0.00000
Guided bus in winter	0.25000	-0.45000	2.54616	1.12304	0.10500	0.41000	0.57626	-0.43893	0.10373	-2.07581
Rail/monorail/maglev in winter	0.10000	0.20000	0.11988	0.65800	0.38099	0.12000	-0.40557	-0.73572	-0.49017	-2.14394
Rail transfer to tour bus	0.00000	0.00000	0.00000	-0.27351	0.00000	-0.27301	-0.21530	-0.41815	-0.59756	0.00000
Eagle County transit origin	-1.00000	-1.48000	0.00000	0.75288	-0.10843	-1.10000	0.00000	0.52413	0.00000	-5.82799

Model of Aspen/Pitkin County Airport and Eagle County Airport passengers shifting to Denver International Airport based upon improved transit service

Factor	Value
Eagle County Airport Constant	3
Aspen/Pitkin County Airport Constant	3
Fare Difference by Using DIA	-$100
Time Difference by Using DIA	-60

Notes:

1. Total Mode Constant is the mode constant above plus the Transit Seasonal and Day Constant.

2. Monorail mode constant is the mode constant above plus the Transit Seasonal and Day Constant plus 20 times the monorail in vehicle travel time coefficient.

Sensitivities of the Mode Choice Model

The Ridership Survey provided more reliable mode choice results than the User Study because (1) respondents were asked about a trip they were in the process of making rather than one made several weeks ago, (2) a wider variety of modes was examined, and (3) respondents were encouraged to more thoroughly visualize the trip by looking at depictions of the various modes and by imagining situational constraints such as carrying luggage or sporting gear, traveling with children, and needing a private vehicle at their destination.

Survey responses were divided into 10 trip purposes, which have particular characteristics. **Table A-70** shows the percentage of survey respondents traveling alone or with others, and the average size of such groups. People traveling alone may be more amenable to traveling by transit, especially compared to someone traveling with a small child or other family member requiring their care. Furthermore, certain automobile costs such as fuel and parking may be shared among group members, while a transit operator likely requires separate fares for each individual. (Some operators offer free or discounted fares for children traveling with their parents.) For groups traveling by automobile, the group size corresponds to the vehicle occupancy. Analysts or commentators may regard higher vehicle occupancies as reflecting a more efficient use of highway capacity.

Table A-70. Ridership Survey Group Sizes

Purpose	Percent of Respondents Traveling Alone	Percent of Respondents Traveling in Groups of Two or More	Average Group Size
Stay at Second Home	6	94	3.25
Stay at Hotel, Resort, or Forest; Resort to Resort	8	92	3.04
Gaming	10	90	2.39
Front Range Day Recreation	12	88	2.81
Corridor Day Recreation	13	87	2.69
Out-of-State Air Passenger	19	81	2.86
Stay Visiting Friends or Family	31	69	2.34
Corridor to Airport or Front Range	32	68	2.24
Local Non-Work	33	67	2.23
Work	86	14	1.21
All Purposes	21	79	2.64

Source: I-70 Ridership Survey.
Notes: Average group size also corresponds to average vehicle occupancy.

As expected, work trips have the highest percent of people traveling alone and the lowest average group size. About a third of the people traveling to stay with friends or relatives or to make shopping or similar trips — either within their city or from the Corridor to Front Range attractions — travel alone. Trips made to second homes are most likely to be made by groups of two or more, presumably other household members or guests of the homeowner.

Table A-71 shows a breakdown of group composition where two or more people travel together. Respondents were asked how many of the other people they were traveling with did not belong to their household. The table shows the percentage of cases where (1) the other group members all belong to the respondent's household, (2) none of the other group members belong to the respondent's household (however, it is possible that two or more other group members belong to the same household; they just do not belong to the respondent's household), and (3) the group is mixed; that is, some of the other group members belong to the respondent's household and some do not.

Table A-71. Ridership Survey Group Composition

Purpose	Percent of Groups of Two or More, Where Other Group Members:		
	All Belong to Respondent's Household	Do Not Belong to Respondent's Household	Are a Mix of Household and Non-Household Members
Front Range Day Recreation	37	37	26
Corridor Day Recreation	52	36	12
Local Non-Work	55	31	14
Stay Visiting Friends or Family	57	24	20
Corridor to Airport or Front Range	60	24	16
Out-of-State Air Passengers	63	19	18
Stay at Second Home	64	18	17
Work	65	29	6
Stay at Hotel, Resort, or Forest; Resort to Resort	65	18	17
Gaming	69	20	12
All Purposes	56	26	18

Source: I-70 Ridership Survey.
Notes: Totals may not add to 100 percent because of rounding. Purposes are sorted in increasing prevalence of all group members being from the same household.

Day Recreation groups are the least likely to be composed of members of a single household (just over one third of such groups come from the same household). In fact, roughly the same number of Day Recreation respondents are traveling in groups where no one else is from their households as are groups traveling solely with members of their households. At the other extreme, people traveling together for gaming are the most likely to come from the same household (just over two-thirds do).

Work travelers are the least likely to be in a group with both household and non-household members. This result is expected, because Work groups tend to be the smallest in the survey. A mixed group requires a minimum of three members: (1) the respondent, (2) another member of the respondent's household, and (3) someone who is not a member of the respondent's household. Only about a third of Work groups consist of three or more people.

The duration of a person's stay in the Corridor is useful information for several reasons. First, this data helps relate the number of activities to the number of trips. For example, Colorado Ski Country USA tracks the number of lift tickets (or skier visits) sold by member resorts, and demographics such as whether a skier is a resident of the Corridor, the Front Range, or another state. Responses to the Ridership Survey (summarized in **Table A-72**) indicate that the average out-of-state resident who flies to Colorado to ski stays an average of 6.7 nights. Assuming that these people also ski for 6.7 days on average (for example, to exclude a move in-move out day), the number of Out-of-State Air Passenger trips can be easily calculated from the number of out-of-state air passenger skier visits.

Table A-72. Trip Duration by Purpose

Purpose	Average Duration (nights)
Out-of-State Air Passengers	6.7
Stay at Hotel, Resort, or Forest; Resort to Resort	4.6
Stay at Second Home	3.7
Stay Visiting Friends or Family	3.5
Corridor Day Recreation	1.8
Gaming	0.9
Corridor to Airport or Front Range	0.7
Local Non-Work	0.7
Work	0.2
Front Range Day Recreation	0.0

Source: I-70 Ridership Survey.
Notes: Purposes are sorted in decreasing trip duration. Average shown for Work trips excludes outlying observations. "Corridor Day Recreation" includes overnight recreation trips made by Corridor residents.

Trip duration may also affect a person's mode choice. If transit travel is slower than automobile, a person traveling and returning the same day (such as for a Front Range Day Recreation trip) might prefer automobile to maximize their activity time. Someone staying for a few days may be more willing to take transit because they may not have such tight time constraints. However, someone spending many nights in the Corridor may be carrying more luggage and therefore may prefer the convenience of a private vehicle's trunk. Trip duration also affects socioeconomic variables, simply because the longer someone stays in the Corridor, the more likely they are to spend more money in the Corridor.

Not surprisingly, Out-of-State Air Passengers — a group that includes so-called Destination Skiers as well as summer recreation seekers — have the greatest average trip duration. These people average 6.7 nights in Colorado, which corresponds closely to the week-long accommodation packages many resorts offer. Front Range residents who stay at resorts average 4.6 nights, while those staying at a private home in the Corridor — theirs or someone else's — average about 3.5 nights per visit.

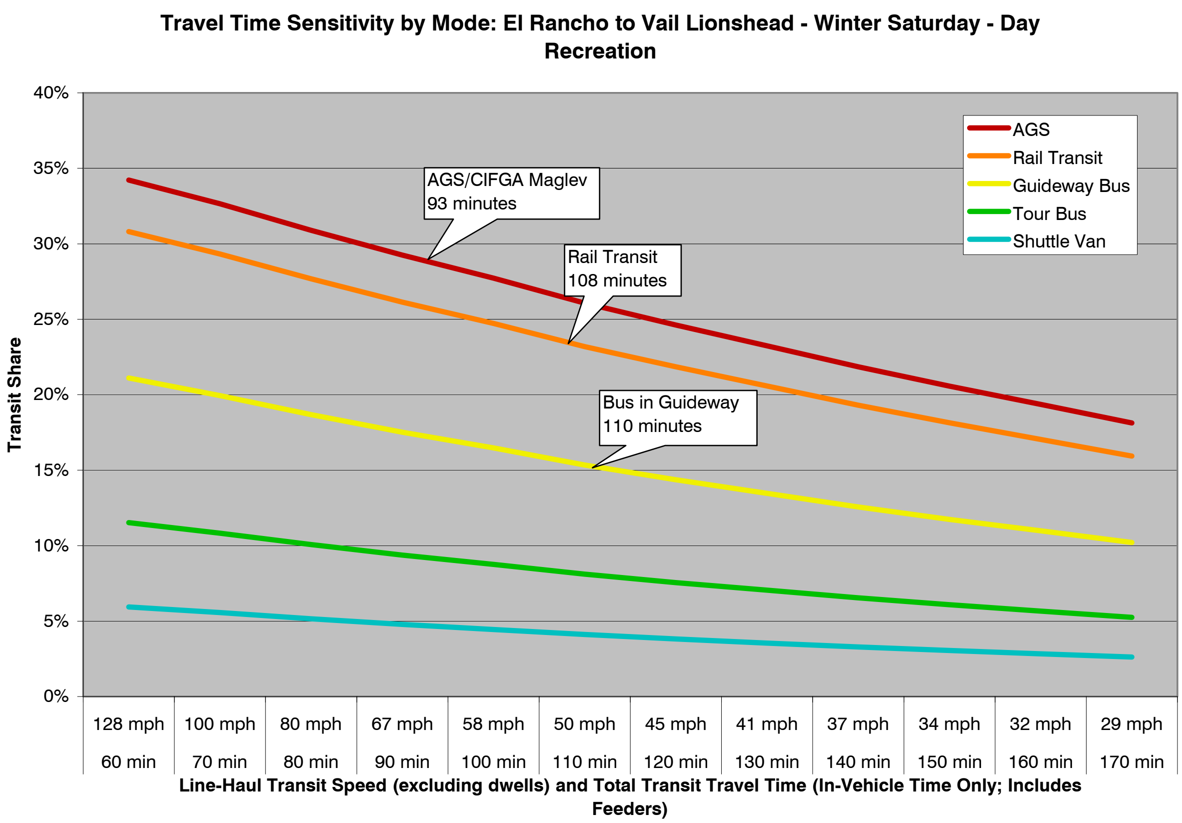
By definition, Front Range Day Recreation travelers do not stay overnight. Work trips have the next lowest average duration — over 90 percent of the survey respondents commute and return home the same day. The overnight Work trips generally represent few-day business meetings or conferences. About three-quarters of all Local Non-Work and Corridor-to-Front-Range trips return the same day.

Responses from the mode choice exercises were analyzed to develop a model used as part of a larger simulation to develop internally consistent traffic results in the Corridor. The mode choice model results reveal important information on the tradeoffs respondents make to reach their decision. The Ridership Survey revealed that respondents are very sensitive to cost levels, followed by factors related to the various mode technologies and requirements to transfer. Surprisingly, little sensitivity to travel time was found. In fact, the value of time (that is, the time-cost tradeoff) had to be constrained based on regional earnings rates to produce a more reasonable model.

Chart A-13 shows the sensitivity of transit ridership to travel time and mode technology for Day Recreation trips on a winter Saturday. El Rancho to Vail Lionshead is chosen as a representative OD pair for this example. This example assumes a 10-cent-per-mile transit fare structure, free parking at Vail, and highway travel times consistent with each alternative. Note that this or most any other OD pair represents less than 1 percent of the trips made in the Corridor. Because of differences in access, geography, and route structure, any other OD pair likely have a different mode choice pattern. Vehicle volumes at any point and transit ridership must be calculated as sums over all OD pairs, so these end results may not be obvious or easily calculated from a single OD pair's response. Therefore, conclusions made about any particular OD pair other than the most general statements should not be applied to the Corridor as a whole without also examining aggregate results.

Chart A-13 shows a natural order of mode preference of transit modes among Corridor travelers. That is, with travel times and all other factors being equal, more people choose to ride an AGS or monorail than choose to ride a Rail Transit system. This result is shown in **Chart A-13**, with the red AGS curve being above the orange Rail Transit curve. The AGS and Rail Transit curves are much closer together than Rail Transit and the next-preferred mode: Bus in Guideway. The interpretation of this observation is that AGS and Rail with IMC are much closer substitutes, and that much more ridership is lost if a Bus in Guideway is selected over Rail Transit, compared to the lost ridership from choosing Rail Transit over AGS. Similarly, Bus in Guideway is preferred to a Tour Bus in mixed traffic, and Tour Bus is preferred to Shuttle Vans, which also operate in mixed traffic.

Chart A-13. Travel Time Sensitivity by Mode



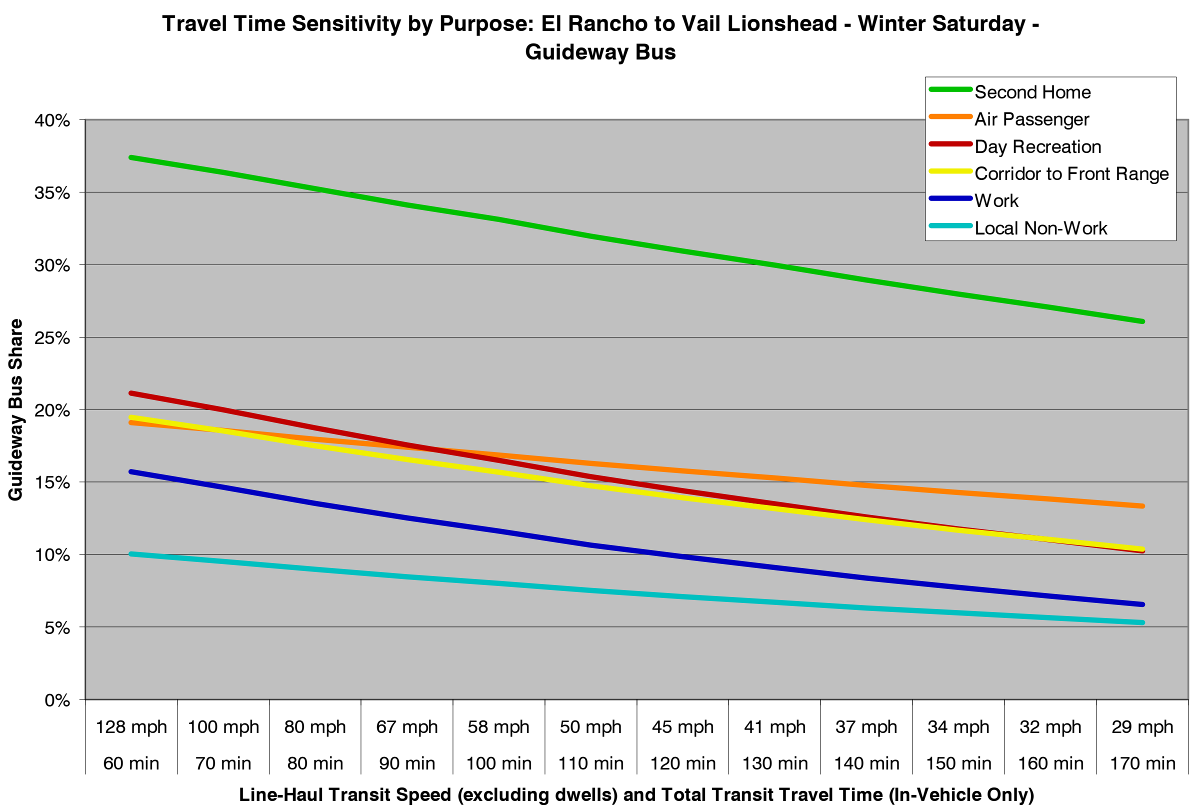
Note that each of the five curves has a relatively gentle slope down to the right. This slope reflects the relative insensitivity that Ridership Survey respondents showed to changes in travel time. A greater sensitivity results in a steeper curve.

For example, an AGS that averages about 63 mph in the Corridor (consistent with the maglev system currently being studied by CIFGA) it has about a 29 percent transit share for this OD pair. Note from

Chart A-13 that a super-high-speed AGS with an average speed of 120 mph only gains about five percentage points in mode share (to about 34 percent) over the CIFGA maglev.

Chart A-14 shows how the sensitivity to travel time varies by purpose for a guided bus on a winter Saturday. (Note that travel times shown on the left half of the graph are not feasible with current technology. They are shown for information purposes only.) Regardless of the average bus speed, trips to second homes show the greatest propensity to use transit. Trips by Out-of-State Air Passengers, Front Range residents making day recreation trips, and Corridor residents visiting attractions in the Front Range show sensitivities that are clustered together. However, notice that the Day Recreation curve has the greatest slope. This indicates that Day Recreation travelers are the most sensitive to travel time, which is understandable given their desire to reach their destination when the lifts start running, to make the most out of their day skiing.

Chart A-14. Travel Time Sensitivity by Purpose



Air travelers have the flattest curve of the three purposes, indicating little willingness to pay for travel time savings. These travelers may be less sensitive to transit speed because their trip in the Corridor is part of a larger trip involving lines to check in and go through security, a flight of several hours, and waiting to claim baggage at their home airport. Any travel time savings in the Corridor seems small in comparison to the total journey.

Work trips show a similar time sensitivity as Corridor-to-Front-Range trips (though a lesser overall propensity to use transit), while Local Non-Work trips have a flatter curve, which is roughly parallel to that of Out-of-State Air Passengers. People making Local Non-Work trips reasonably showed a lesser time sensitivity than for Work or Corridor-to-Front Range, because (1) Work trips have greater economic value (that is, the wages or salary earned) to the trip maker, and (2) Local Non-Work trips are presumably made more often — being shorter and involving less value — than a Corridor-to-Front Range trip. For example, a Local Non-Work trip might involve buying lunch or spending $20 at a pharmacy, while a Corridor-to-Front-Range trip might involve spending a day at a mall or attending one of the professional sports venues in Denver.

The sensitivity to travel time on various types of days is shown on **Chart A-15**. The guideway bus attracts the greatest share on winter Saturdays — not surprising because travelers may wish to avoid driving in inclement weather, and because Winter destinations tend to be less dispersed than Summer attractions. Summer Saturday ridership is about one-third of winter Saturday ridership. Summer Weekday ridership is even lower: about half of summer Saturday. Surprisingly, the summer Sunday transit share curve more closely resembles a Summer Weekday than a summer Saturday. Perhaps survey respondents placed more importance on their return trip, wanting to get home in sufficient time before reporting to work on Monday.

Chart A-15. Travel Time Sensitivity by Day

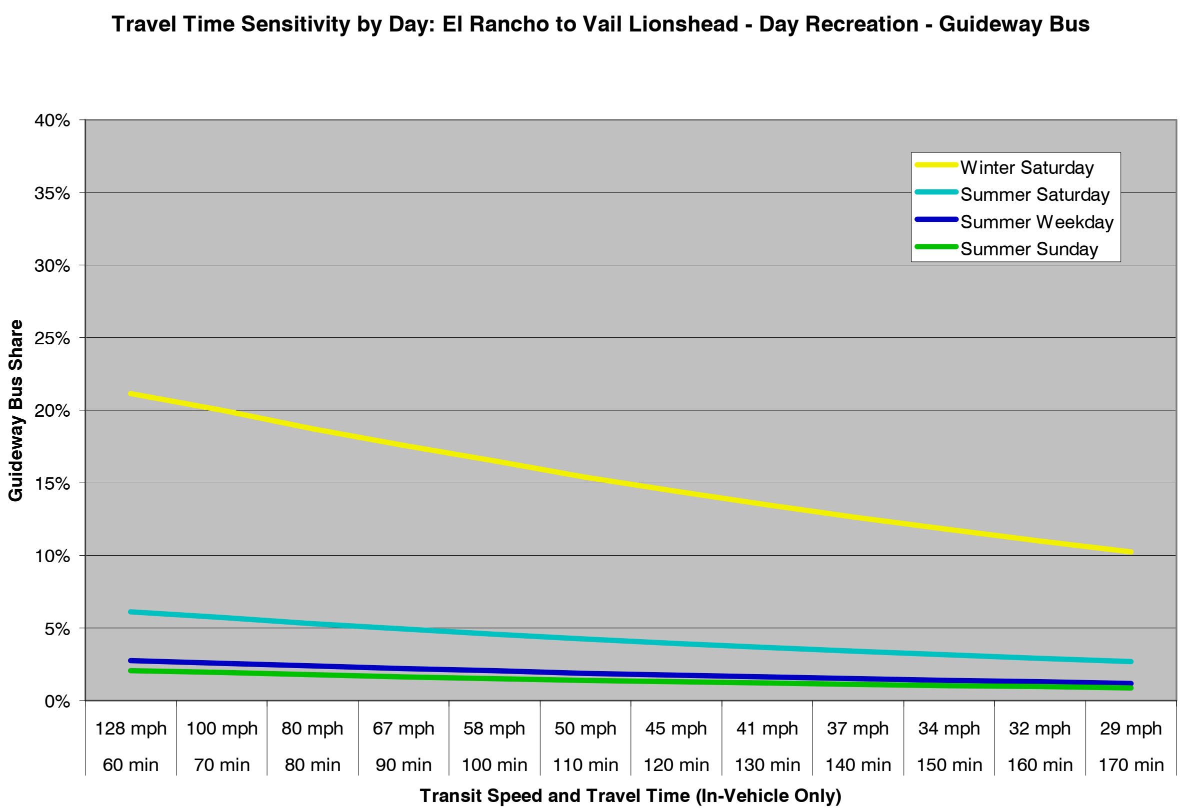
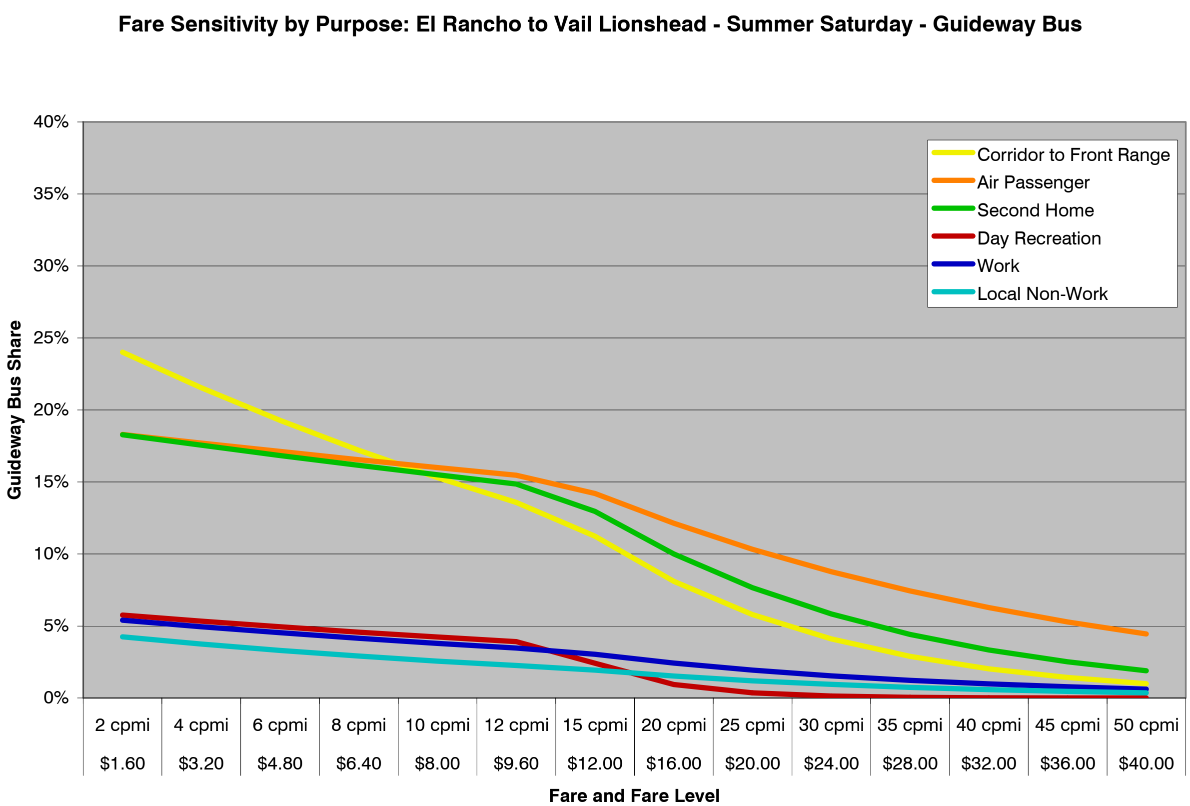


Chart A-16 shows travelers' sensitivity to fares for various purposes, for a 50-mph guideway bus on a summer Saturday. Corridor-to-Front-Range trips have the steepest curve, representing the greatest fare sensitivity. This result seems reasonable, because every dollar not spent on transit fare is an additional dollar available to spend at Front Range attractions. Out-of-State Air Passengers have a relatively flat fare sensitivity compared to Corridor-to-Front-Range and Second Home trips. Recall that Out-of-State Air Passengers are also relatively insensitive to travel time. Therefore, this travel market segment appears to place greater importance on other aspects of their trip such as comfort, amenities, and schedule dependability. Day Recreation, Work, and Local Non-Work trips are generally unlikely to use transit, and therefore show less sensitivity to fares. That is, in instances where transit share is low, the people who do choose to use transit may represent certain extremes in market behavior: for example, an extreme dislike of driving in congestion or an unusually low value of time relative to the average traveler.

Chart A-16. Fare Sensitivity by Purpose



Notice that between the 12-cents-per-mile and the 20-cents-per-mile fare levels, the Day Recreation transit share drops rapidly from slightly greater than that of Work trips to less than that of Local Non-Work trips. Other purposes also show *kinks* at this fare level, and this is only due in part to the change in horizontal scale at this point. This fare level also seems to be a natural price point, above which increased fares are more than offset by decreased ridership. The analysis found that the 10 cents-per-mile fare level offered the best combination of highway congestion reduction and farebox recovery of transit operating costs.

A.2.8 Route Choice

The final step of the four-step process is often called traffic assignment or route choice. At this point, the travel demand model has predicted how many people are traveling, where they are traveling, and what mode they are taking. The question now is what roadway or transportation facility do these people use? In this final step, trips are associated with or assigned to certain facilities based on the behavioral assumption that people take the easiest way possible and on empirical observations of how performance of the facility changes as more people use it. Specifically, automobile drivers are assumed to minimize travel time, but the travel time of a roadway depends on how many people are using it relative to its capacity.

Transit customers face several travel attributes they wish to minimize such as time spent in the vehicle, time spent waiting, time spent accessing or leaving the system, and fare. Network models allow the construction of paths minimizing variables associated with links (for example, in-vehicle time and walking time) and nodes (for example, waiting time, dwell time, and fares paid upon boarding). Factors consistent with the mode choice coefficients weighted by purpose are used in building transit paths.

Highway Route Choice and Congestion

The traffic assignment portion of the travel demand model is performed on the highway network for each of the four periods in the day. The technique, which has been implemented in the TransCAD software, is called User Equilibrium Assignment. The technique attempts to put traffic on each segment in the network such that the travel time from an origin zone to a destination zone is the same for each path chosen between the two points. Depending on the level of congestion in the system, the method requires several iterations to be calculated before the times stabilize between iterations. Further details about this technique can be found in Caliper Corporation’s travel demand modeling with TransCAD 4.5.

The method requires that a path be built between each zone. The travel demand model finds the path with the shortest travel time. The travel time is then adjusted for each segment in the highway network by the following equation, which is named after the Bureau of Public Roads (BPR), the predecessor to today’s US Department of Transportation.

$$TravelTime_{next\_iteration} = TravelTime_{last\_iteration}\left[1+\alpha\left(\frac{Volume}{Capacity}\right)^{\beta}\right]$$

The initial travel time is calculated from the initial free-flow speeds described earlier.

Alpha is a value associated with the functional classification of each highway segment: freeways and expressways (0.66), principal and minor arterials (0.76), and collectors and freeway ramps (0.15). The beta value is also a function of the highway functional classification and is for freeways and expressways (7.2), principal and minor arterials (5.9), and collectors and freeway ramps (4.0). Slightly different values are used for I-70 links to better replicate the HCM volume-speed relationships.

This technique has been applied to many travel demand models throughout the country, and provides a quick adjustment of travel times with a minimum of information. After the travel times have been adjusted for the first iteration, the trip table that contains the volume information from each origin to each destination is rerun, new volumes are determined, and new travel times calculated.

The volume is calculated in the assignment program, and represents the total of the volumes from each of the origin zones to the destination zones where a minimum path has been built using the highway segment.

The capacity is the specified hourly value described earlier in **Capacities** and then factored to reflect the effective highway capacity of the period based on the relative volumes for the peak hour and the total period. The default factors used are AM Period-3, Noon Period-4, PM Period-3.5, and Night Period-5.5. These factors are less than the number of hours in each period to adjust for the peaking that occurs within each period. A peak-spreading module adjusts these factors slightly for I-70 based on total congestion levels, the percentage of trucks in the traffic stream, and the transit share at that location.

Before beginning the next iteration and reloading the vehicle trip table onto the highway network, a weighted average of travel times is calculated. The Method of Successive Averages, which specifies a pre-set series of weights, may be used for any iterative process. However, for User Equilibrium Traffic Assignment, a more efficient process called the Frank-Wolfe Algorithm is used. The Frank-Wolfe Algorithm is a particular implementation of the Method of Convex Combinations.

At each iteration, the differences between link travel times of the current and previous iteration are calculated. Additional iterations of loading the vehicle trip table and recalculating travel times (based on the BPR function) are performed for up to 30 iterations of the assignment routine within TransCAD or until the average percent difference of all of the highway links travel times between iterations is less than 10 percent. (Both thresholds may be changed by the analyst.)

One property of User Equilibrium Assignment, known as Wardrop's first principle, describes the relationship between path flows and travel times:

- Travel times on all alternative paths that are used between a given origin and destination (that is, paths that are assigned flow) are equal
- Travel times on unused paths are greater than those of paths with flow

This principle applies for all the roadways in the model study area, whether local roads accessing I-70, I-70 and the Frontage Road, or an alternative route such as US 50 or US 285 outside the Corridor. However, in the case of alternative routes in other corridors, congestion on I-70 has to be severe to justify going out of the way to reach the other corridor. A more likely result is that these other corridors are not used for trips between origins and destinations in proximity to I-70.

Transit Route Choice

Transit Route Choice influences two modules of the I-70 travel demand model: (1) determining the transit attributes (travel times, costs, and so on) that become input to the Mode Choice model, and 2) assigning or loading the transit person trip table — an output of Mode Choice — to various routes to see where demand is greatest. Compared to Highway Route Choice, Transit Route Choice may appear more complicated because there are more components to transit trips.

Tradeoffs Between Components of Time and Cost, Pathfinder Algorithm

Some of the more important (and more easily understood) options used by TransCAD in determining transit paths are shown in **Table A-73**. Other options are not shown because they involve filenames or data table variables that change from alternative to alternative, or because they are not relevant to the path selection procedure used by the I-70 travel demand model.

Table A-73. Values of Transit Path-Building Parameters

Option Name	Value	Description
SP Method	3	Pathfinder
Skim Method	3	Pathfinder
Assign Method	3	Pathfinder

Table A-73. Values of Transit Path-Building Parameters

Option Name	Value	Description
Value of Time	$0.126	Monetary equivalent of 1 minute in-vehicle time ($7.56 per hour)
Global Wait Weight	3.888	Ratio of how onerous (initial) wait time is, relative to in-vehicle time
Global Xfer Wait	3.888	Default minutes of in-vehicle time that are equivalent to one minute of transfer wait time
Walk Weight	3.0	Minutes of in-vehicle time that are equivalent to one minute of walk time
Interarrival Para	0.5	Fraction of headway that represents the average wait time
Use Mode	Yes	Flag indicating whether a mode table is used
Use Mode Cost	No	Flag indicating whether travel times come primarily from the mode table
Mode Table	modetbl1a.bin	See **Table A-74** below
Mode Used	varies by alternative	Array of flags indicating whether a mode is available for travel
Mode Access, Mode Egress	{0, 0, 0, 0, 0, 0, 0, 0, 1}	Array of flags indicating whether a mode (coded on routes and links) may be used for access or egress; this setting indicates that highway links may be used for access and egress
Mode Fare	null	Variable in mode table indicating default fare
Mode Xfer Fare	null	Variable in mode table indicating default fare when transferring
Mode Free Xfer	null	Variable in mode table indicating the number of free transfers allowed
Mode Disc Xfer	null	Variable in mode table indicating the number of transfers for which Mode Xfer Fare should be applied
Global Fare Type	1	Flat fare structure
Fare System	3	Mixed flat and zone fares
Global Free Xfer	0	Default number of free transfers allowed
Global Disc Xfer	0	Default number of discount transfers allowed
Global Dwell Time	0.5	Default minutes per stop
Dwell On Para, Dwell Off Para	0	Additional time added to dwell time for each passenger boarding or alighting at a stop
Global Min Wait	1.5	Wait time is revised to this amount (minutes) if wait time is calculated to be less; reflects time walking between vehicles, etc.
Global Max Wait	120	Path is unavailable if total wait time exceeds this amount (minutes)
Max Xfer Time	999	Path is unavailable if total transfer time exceeds this amount (minutes)
Max Xfer Number	5	Path is unavailable if total number of transfers exceeds this number
Global Max Access	30	Path is unavailable if access time exceeds this amount (minutes)
Global Max Egress	30	Path is unavailable if egress time exceeds this amount (minutes)
Global Max Imp	999	Path is unavailable if total trip impedance (generalized cost in dollars) exceeds this amount
Max Trip Time	9999	Path is unavailable if total trip time exceeds this amount (minutes)

The first three options specify which of three algorithms supported by TransCAD should be used to identify the best transit path or a reasonable combination of transit paths. The simplest algorithm is a basic Shortest Path implementation, which always outputs a single path. However, a disadvantage of the Shortest Path approach is that there may be certain situations where a passenger might find it beneficial not to follow such a fixed routing, especially when multiple routes serve the same roadway or OD pair.

For example, consider the Summit Stage Silverthorne and Keystone routes. Both routes start at Frisco Station and travel on I-70 to Silverthorne Station. At Silverthorne Station the routes split, with the

Keystone route heading south to serve the Dillon and Keystone Resort areas. During peak hours, both routes have 30-minute headways.

Consider the situation if the Silverthorne route left Frisco Station every hour and half hour, and if the Keystone route departed Frisco Station at 15 and 45 minutes past the hour. Someone traveling from Frisco to Silverthorne Station uses either route, and does not particularly care if the head-sign says Silverthorne or Keystone. From this person's point of view, a Stage bus to Silverthorne comes every 15 minutes.

Other complicated situations can arise with overlapping routes. For example, suppose a different Summit County resident wants to travel from Frisco Station to somewhere served by the Silverthorne route, but not the Keystone route. What is this person's best option be if he or she arrived after the departure of the Silverthorne bus, say at 5 minutes past the hour? Depending on how close the destination is to Silverthorne Station and how willing this person is to walk, it may be advantageous to take the Keystone bus. For example, if the destination is a 10-minute walk from Silverthorne Station, taking the Keystone bus allows this person to complete his or her trip 5 minutes before the next Silverthorne bus gets to Silverthorne Station.

Another complication occurs when the departures of overlapping routes are not evenly spaced. Returning to the above example, Summit Stage actually schedules both the Silverthorne and Keystone routes to depart Frisco Station on the hour and half hour. The effective headway for someone traveling between Frisco and Silverthorne Stations is 30 minutes (the same as if the Keystone route was not in service).

TransCAD offers two other path selection algorithms to address more complicated situations of overlapping routes. The Optimal Strategies method starts with the shortest path and then considers whether adding routes reduces the frequency-weighted path utility. (This procedure is analogous to the first passenger of the above example resolving to "take whichever of the Silverthorne or Keystone routes that arrives first.") While the Optimal Strategies procedure is theoretically attractive, it is also computationally intensive.

The other transit path selection procedure, Pathfinder, was designed specifically for TransCAD, and solves the overlapping route issue by making certain transformations to the computer representation of the transit network. (The Pathfinder algorithm is a generalization of the one used in the UTPS program sponsored by USDOT before microcomputers were as prevalent as they are today. The Pathfinder algorithm reflects the state of the practice, and is also used in the DRCOG Compass regional model.)

Before searching for possible paths, Pathfinder first looks for overlapping routes and turns these segments into trunk links. With the example Summit Stage network, Pathfinder converts the two links representing the Keystone and Silverthorne routes between Frisco Station and Silverthorne Station into a single link with a combined headway of 15 minutes. Then the best transit path is found using the modified network with trunk links.

The Pathfinder algorithm also allows specification of how similar the impedance of two routes must be before they are combined into a trunk link.

Another set of Transit Path Choice options involves the relationships among various aspects of transit travel. These values are established from the I-70 Ridership Survey by averaging the Mode Choice coefficients, weighted by the number of respondents traveling for each of ten trip purposes. The value of time averages to $0.126 per minute, or about $7.56 per hour. On average, a minute of wait time is viewed as about 3.888 times as undesirable as a minute of in-vehicle time. Walking time — one type of access time — was constrained to be three times as onerous as in-vehicle time during model estimation. The interarrival parameter takes a value of 0.5, because a transit system in the Corridor is assumed to be able to maintain a reasonable level of schedule adherence. With the additional assumption of random passenger arrivals (which is generally reasonable with headways of 20 minutes or less), the average waiting time among passengers is one-half the headway.

TransCAD allows considerable flexibility in setting operating and behavioral parameters. Some variables such as headway, dwell time, and fare structure can be set on a route-by-route basis. If route-level data is not specified, data pertaining to individual modes can be used. Global defaults are used as a last resort.

The I-70 travel demand model takes advantage of some mode-specific parameters, which are shown in **Table A-74**. Shuttle vans, local public transit operators, and the proposed Corridor transit system use zone fare structures, while other operators (RTD Light Rail, the ski train, and the proposed Intermountain Connection) use a flat fare structure. Because feeder buses connecting off-Corridor destinations to the Rail and AGS alternatives serve a limited number of stops, these feeders are also assumed to use a flat fare structure. The mode table also specifies which matrix in the fare matrix file (the file structure is similar to an Excel spreadsheet with multiple tabs) should be used for each mode.

Table A-74. Data in Transit Mode Table

Mode #	Mode Name	Fare Type	Fare Matrix Index	Fare Matrix Name	Fare Matrix Description
1	Shuttle Van	Zoned	3	CMEXFARE	Fare for Colorado Mountain Express, Home James, and Resort Express
2	Transit Bus	Zoned	2	BUSFARE	Fare for local public operators, primarily RFTA
3	Guideway Feeder Bus	Flat			
4	Bus in Guideway	Zoned	0	FARE	Corridor fare structure (see Transit Costs)
5	RTD Light Rail	Flat			
6	The Ski Train	Flat			
7	Intermountain Connection	Flat			
8	Rail or AGS Guideway	Zoned	0	FARE	Corridor fare structure

The Fare System option of three means that the combined transit network includes routes with both flat and zone fare structures. If no fare structure is specified for a route or its mode, the Global Fare Type option says to assume a flat fare structure. No free or reduced transfers are assumed; transit systems requiring transfers (such as the Corridor system associated with major build alternatives) have zone fare structures. Thirty seconds is assumed as the default dwell at each stop, regardless of the number of passengers boarding or alighting.

The remaining options help define a reasonable transit path. The Global Min Wait option prevents high-frequency services from resulting in unreasonably short waiting times (generally, some small amount of time is needed when transferring between transit vehicles). Other options involve attribute values at which transit ceases to be an attractive volume. For example, Corridor travelers are assumed to be unwilling to wait more than two hours total when making a transit journey. In such a case, transit is reported as being unavailable for this OD pair, which speeds up the mode choice computations.

A.2.9 Traffic Operations

The traffic origin-destination matrices (a matrix that provides the number of vehicles traveling from an origin, represented by a Parking Lot Number or PLN, to a destination, also represented by a PLN) obtained from TransCAD are used to obtain the input origin-destination matrices for the dynamic VISSIM simulation. The files obtained from TransCAD provide the volumes for each origin-destination pair in the model for each hour of the day, resulting in twenty-four hourly files.

The VISSIM simulations were done for nineteen hours out of the available twenty-four for practical reasons. This was done to reduce the time required for each simulation run, given that the peak travel conditions were within the analysis period of 6 AM – Midnight (though volumes were fed starting 5 AM, the first hour was considered as seeding time for the network).

The TransCAD model, along I-70, has been calibrated based on ATR counts at specific cut locations on the mainline and therefore might not necessarily have the expected ramp/turning-movement counts at each interchange. It was therefore necessary to analyze the volumes at various cut lines along the interstate and at interchanges. The ramp volumes were modified at some interchanges if necessary to obtain logical traffic volumes. Some of the modifications that were done included:

- Adjusting the Downieville on- and off-ramp volumes to more accurately represent the truck traffic due to the weigh station.
- Modifying the Loveland Pass interchange eastbound on-ramp, Georgetown on- and off-ramp, and East Idaho Springs eastbound on-ramp volumes to reflect the available tube counts at these locations. This was done by redistributing the traffic going to Denver such that it did not have a significant effect on the volumes at the cut-line (ATR count) locations.
- Adjusting the Dowd Junction WB off-ramp volume in some runs by redistributing the off-ramp volume between Dowd Junction, Eagle-Vail, Post Boulevard, and Avon based on the TransCAD TAZ characteristics.

VISSIM allows different methods to specify volumes by vehicle type. Separate trip tables may be used for each vehicle type, or a single trip table may be used with constant percentages for each vehicle type. The second method is chosen since the multi-class user equilibrium assignment method that is used to generate separate trip tables for the first method does not have a unique solution. Proportions of volumes by vehicle type are shown in **Table A-75** for the eastern part of the Corridor and in **Table A-76** for the western part of the Corridor.

Table A-75. Proportions of Volume Between Silverthorne and C-470 by Vehicle Type and Model Day

Model Day	Winter Weekend	Summer Weekend	Summer Weekday
Direction	WB/EB	WB/EB	WB/EB
Automobile	93.0%	93.0%	91.0%
Semis	1.8%	2.0%	4.0%
Single-Unit Trucks	1.2%	2.0%	2.0%
Low Performance RVs	0.7%	1.5%	2.0%
High Performance RVs	3.3%	1.5%	1.0%

Table A-76. Proportion of Volume Between Glenwood Springs and Eisenhower-Johnson Memorial Tunnels by Vehicle Type and Model Day

Model Day	Winter Weekend	Summer Weekend		Summer Weekday	
Direction	WB/EB	WB	EB	WB	EB
Automobile	93.0%	91.0%	93.5%	91.0%	93.0%
Semis	1.8%	2.0%	1.5%	4.0%	2.0%
Single-Unit Trucks	1.2%	2.0%	2.0%	2.0%	2.0%

Model Day	Winter Weekend	Summer Weekend		Summer Weekday	
Direction	WB/EB	WB	EB	WB	EB
Low Performance RVs	0.7%	1.7%	1.0%	2.0%	1.5%
High Performance RVs	3.3%	3.3%	2.0%	1.0%	1.5%

A.2.10 Airborne Emissions

The Mobile 6 model was used to determine the emission factors for ***Carbon Monoxide*** (CO). This computer program calculates emission factors for twenty-eight individual vehicle types in low and high altitudes of the US based on factors such as ambient temperature, speeds, operating modes, fuel volatility, and mileage accrual rates.

The vehicle categories were summarized under Automobiles, Light Trucks, Heavy Trucks, Shuttles, and Buses. The corresponding emission factors were weighted averages of the various Mobile 6 vehicle types under each of the five categories. The Light Trucks emissions category corresponds to the Single-Unit Truck and Single-Unit Truck Internal-External and Through trip purposes. The Heavy Trucks category corresponds to the Combination-Unit Truck and Combination-Unit Truck Internal-External and Through trip purposes. VMT for shuttle vans and buses was calculated from the operating plan of the appropriate year and alternative.

These emission factors quantify the pollutants in grams of emission per mile based on speed. Mobile 6 generates different factors for each increase of 5 mph, from 0 to 65 mph. The emission factors used for CO emission calculations are shown in **Table A-77**. (Note that RVs and shuttle vans have the same emission rates as automobiles.)

Table A-77. Carbon Monoxide Emission Factors (grams per vehicle mile)

	Vehicle Type				
Speed (mph)	Automobiles	Light Trucks	Heavy Trucks	Shuttle Vans	Buses
0 - 5	16.33	56.52	3.53	16.33	3.57
> 5 - 10	9.45	37.62	2.44	9.45	2.46
> 10 - 15	7.43	26.46	1.76	7.43	1.77
> 15 - 20	7.06	19.65	1.33	7.06	1.34
> 20 - 25	6.84	15.42	1.05	6.84	1.06
> 25 - 30	6.68	12.79	0.87	6.68	0.88
> 30 - 35	6.74	11.20	0.75	6.74	0.76
> 35 - 40	7.19	10.36	0.68	7.19	0.69
> 40 - 45	7.13	10.12	0.65	7.13	0.65
> 45 - 50	8.12	10.45	0.64	8.12	0.65
> 50 - 55	8.58	11.40	0.66	8.58	0.67
> 55 - 60	9.14	13.13	0.72	9.14	0.73
> 60 - 65	9.69	15.99	0.82	9.69	0.83
>65	9.69	15.99	0.00	9.69	0.83

Source: Colorado Department of Public Health and Environment (CDPHE)

The factors multiplied by VMT (Vehicle Miles of Travel) for a particular day give the total emission for that day. The factor to be used with VMT is dependent upon the average speed in the section of I-70 in question.

VMT (number of vehicles multiplied by sections length) was calculated from the TransCAD outputs for through sections between all interchanges from Glenwood Springs to C-470 (in each direction) and the frontage roads. The speeds for these sections were derived from VISSIM simulations and TransCAD runs. A lookup table was generated to determine the appropriate CO emission factor based on the speed, and multiplied that by VMT to obtain total emission.

Nitrogen Oxide and ***Sulfur Dioxide*** emissions were based on a procedure similar to that of CO, but the factors used were the same for all speeds and across all vehicle categories. Hence, the emissions were calculated by multiplying the appropriate factors directly to the VMT (for all vehicle types).

Mobile 6.2 was used to provide the factors that are used based on the fleet mix for the I-70 corridor for the month of January (since the analysis period is Winter Weekend). The factors applied are:

NO_x: **2.540 g per mile** (for year 2000) and **0.432 g per mile** (for year 2025)

SO_2: **0.0962 g per mile** (for year 2000) and **0.0090 g per mile** (for year 2025)

To determine the ***Particulate Matter*** (PM) emissions, a factor was determined using Mobile 6.2 for the fleet mix for the corridor. As for NO_x and SO_2, a single factor was used for PM for all speeds and across all vehicle categories. The PM emissions correspond to exhaust PM (Gas PM, Elemental Carbon, Organic Carbon and SO_4) along with PM due to brakes and tires.

The factors used were **0.0437 g per mile** (for year 2000) and **0.1290 g per mile** (for year 2025).

Nitrogen content of emissions was based on NO and NH_3 emission factors. These emission factors were multiplied by the Nitrogen content of the corresponding compound (content based on the fraction of the Nitrogen atomic weight to the molecular weight; 46.7 percent for NO and 82.4 percent for NH_3). The resulting factors for elemental Nitrogen were then summed and multiplied to the total VMT (as described earlier) to obtain the Nitrogen content of vehicle emissions.

The resultant factors obtained are **1.2616 g per mile** (for year 2000) and **0.2807 g per mile** (for the year 2025).

The ***Re-entrained Dust*** pollution was calculated based on the assumption that on the Winter Saturday in question, sanding had been performed on the highway. Multiplying this factor to the total VMT gave the re-entrained dust from highway sanding for the Corridor. The factor used for all vehicle types to estimate this pollutant is **0.02 lb per mile**.

A.3 Model Calibration

Calibration is the process of adjusting model parameters — input values with certain physical or behavioral interpretation — so that the model is able to correctly predict existing conditions. This section describes the traffic data used to verify that the model can properly reflect present conditions, which model parameters were adjusted, and methods for adjusting model parameters. The final part of this section compares calibration data to model outputs.

Model calibration is an iterative process to adjust model parameters — input values with certain physical or behavioral interpretation and algorithms — the process to link the input data together into an overall process that provides traffic and transit demand volumes and other data. This section first describes traffic data used to show how well the model can duplicate existing conditions and then provides the comparison for 2000.

A.3.1 Calibration Data

Calibration data is available from a wide variety of sources. CDOT uses Automatic Traffic Recorders (ATRs) at several locations to record daily traffic for the year by hour on and near I-70 (Genesee, Twin Tunnels, SH 119 north of US 6, Eisenhower-Johnson Memorial Tunnels, SH 9 south of Breckenridge, west of Copper Mountain, west of Vail West Entrance, east of Wolcott, No Name, Castle Creek Bridge on SH 82, and Snowmass Canyon on SH 82). These counts provide a wide range of volumes that allow the analyst to infer what trip purposes are in each count for each day. Comparisons of traffic variation by day can be used to suggest how much long distance traffic from Denver and how much local traffic exist with a single count.

All of the 40 I-70 interchange sets of ramps were counted in 2000 for the winter and the summer. These values can be used to show the ons and offs of I-70 and can be used to identify relative activity locations.

Field studies have been conducted at various times throughout the course of this study. Files that provide data on vehicle composition, free flow speeds, and direct observation of capacity have been referenced earlier in this appendix. Additional files documenting speed/travel time studies are referenced later in this section.

Transit operators maintain boarding totals to track revenues and (in the case of public agencies) to satisfy federal reporting requirements. Special-purpose data collection may be undertaken as part of a specific corridor or project study.

ATR Counts

Table A-84 through **Table A-103** show the ATR values that were used as a control in developing the travel demand model. The goal was that the model matches these values within 10 percent for each day and within 20 percent for each of the four periods of the day. The CDOT website is the source of these data.

Travel Time Expectations for 2000

Other Studies

A Travel Time study on the I-70 Corridor by the University of Colorado at Denver (UCD) was conducted in 2000. Sarosh Khan, a professor at UCD, oversaw this effort. To collect travel time data for the study, Global Positioning System (GPS) units were placed on vans operated in the Corridor by a commercial shuttle operator, Vans to Vail. Raw data files from July and August 2000 were provided to the PEIS study team in October 2000. The raw data contained x/y coordinates for the vans along with the time, to the nearest second, as they moved through the Corridor. A brief summary of the results showing combined eastbound and westbound travel times between the Hogback/Morrison Interchange (milepost 259) and the East Vail Interchange (milepost 180) is as follows:

- Weekdays: 27 data results, average travel time = 81.1 minutes, average speed = 58 mph
- Saturdays: 17 data results, average travel time = 81.2 minutes, average speed = 58 mph
- Sundays: 11 data results, average travel time = 87.7 minutes, average speed = 54 mph

There were a few travel time runs with some appreciable delay, up to about 40 minutes. Upon closer observation, these travel times did not correlate well with periods and directions when non-incident-related delay might be expected. As an example, the longest travel time was 121.7 minutes. This occurred, however, on a Sunday evening from 5:35 to 7:35 PM in the westbound direction. Traffic volumes are rather light in the westbound direction on a Sunday evening, so it can be reasonably concluded that this delay was not due to non-incident-related delay. If this outlier were removed, then the average travel time on Sundays is 84.3 minutes. The processed data is available upon request.

An explanation for why the weekend travel times were essentially the same as the weekday travel times is as follows: The commercial vans were operated by professional drivers who are very familiar with travel patterns in the Corridor. They had some flexibility in when they traveled, so they consciously avoided periods they expected to be congested. It was concluded that the data was not representative of the congested travel conditions that are known to occur in the Corridor. A copy of the final report was never obtained.

PEIS Study Team Data

A number of field visits were conducted during the years 2001 through 2004 to get some congested travel time data and to better understand travel conditions in the corridor. Locations, directions and days for these field visits are listed below. Conditions during those visits are documented in files that are available upon request.

Summer

- Eastbound in Clear Creek County, Sunday, August 26, 2001
- Eastbound in Clear Creek County, Monday, September 3, 2001
- Denver to Vail (westbound) and Vail to Denver (eastbound), Sunday, August 4 2002
- Westbound from C-470 to Silverthorne, Friday, July 4, 2003
- Eastbound from Copper Mountain to C-470, Sunday, July 6, 2003
- Eastbound from Silverthorne to C-470, Sunday, July 27, 2003
- Eastbound from Silverthorne to C-470, Sunday, July 5, 2004

Winter

- Westbound from Denver to Frisco, Sunday, March 4
- Westbound in the West Evergreen to Hidden Valley Area (including Floyd Hill), February 23, 2002
- Westbound from Floyd Hill to Copper Mountain, Saturday, January 25, 2003

2000 Model Day Expectations

Through observation of the collected data, the following travel expectations were defined for the 2000 model days.

Table A-78. 2000 Travel Expectations

Model Day	Direction	Peak Hour		Travel Description (including expected queue lengths)
		Delay (minutes)	Total Travel Time (minutes)	
Summer Saturday	WB	15	70	Sluggish up Mt. Vernon Canyon. Minor queue (0-1 mile) at Floyd Hill Lane drop. Sluggish up western approach to EJMT.
Summer Sunday	EB	45	100	2-3 mile queue west of EJMT. Approx. 10-mile queue west of Empire Jct. Sluggish next 10 miles up to E. Idaho Springs with probable queuing.
Winter Saturday	WB	30	85	Sluggish up Mt. Vernon Canyon. Approximately 4-mile queue at Floyd Hill Lane drop. Sluggish up to Empire Junction.

Notes: Times shown are calculated for a trip from Silverthorne to C-470, for a distance of 55 miles. The Free-Flow Travel Time for this portion of I-70 is 55 minutes, with no provision of time to stop for gas, food, and so on.

Transit Ridership Counts

Different methods were used to estimate daily ridership for various transit services in the Corridor. Monthly ridership totals were readily available from public operators (ECO, Summit, RFTA), so a set of factors was developed to convert weekly ridership totals to daily counts. The Gaming Area Access EIS team examined casino-sponsored bus travel extensively, and developed relationships to vehicular volumes approaching the Gaming Area. The I-70 User Study estimated the number of passengers on various private transit services for a typical winter and summer Saturday. Passenger counts for other model days were developed by factoring.

Public Operator Ridership

Monthly ridership (boardings or unlinked trips) totals for selected months in 2000 are shown in **Table A-79** for three of the largest public operators in the Corridor: ECO Transit, Summit Stage, and RFTA. The off-season or mud season ridership is assumed to be the average of the May and October totals. In cases where ridership from the month corresponding to a model day was not available, ridership from a similar month was used or ridership was estimated based on relationships established in previous years.

Table A-79. Monthly Ridership on Public Corridor Transit Agencies

Operator	February 2000 Ridership	May 2000 Ridership	August 2000 Ridership	October 2000 Ridership	Average of May and October Ridership
ECO Transit	87,609	34,318	48,422	37,652	35,985
Summit Stage	(a) 243,173	77,084	(b) 106,223	92,976	85,030
RFTA Valley Routes	185,156	N/A	154,288	N/A	(c) 81,469
RFTA Other Services	171,861	N/A	73,922	N/A	(d) 2,458
RFTA Valley and Other Total	357,017	N/A	228,210	N/A	83,926

Source: Ridership statistics provided by respective operators.

Legend:

N/A = Not available.
(a) = Figure shown is for December 2000.
(b) = Figure shown is for July 2000.
(c) = Figure developed by applying the relation that in 1994 and 1995 the average of May and October ridership was typically 44 percent of February ridership.
(d) = Figure developed by applying the relation that during 1993 to 1995 the average of May and October ridership was typically two percent of the average of February and August ridership.

Note that during peak months, RFTA carries more riders than Summit Stage and ECO combined. However, during the off-season, Summit Stage has slightly more patrons than RFTA. As expected, all three operators see their greatest ridership during the winter. For Summit Stage and ECO, summer monthly ridership is about half that of winter, and off-season ridership is about three-quarters that of summer. RFTA summer ridership is just under two-thirds its winter ridership, and off-season ridership is about one-third of summer.

Table A-80 shows daily boardings and average boardings for a week for ECO and RFTA during various seasons. This information was used to calculate the ratio of a given day's boardings to the weekly average boardings. These ratios were then used to calculate daily boardings for the PEIS model days by multiplying by the average boardings in the corresponding month (that is, total monthly boardings divided by the number of days in the month).

Table A-80. Comparison of Daily and Weekly Average Boardings for Public Operators

Operator	Date and Season		Thursday	Friday	Saturday	Sunday	Weekly Average
RFTA Valley Routes	5-11 March 1995 (Winter)	Boardings	3,861	3,995	3,435	3,311	3,934
		Percent of Weekly Average	98	102	87	84	(100)
	9-15 July 1995 (Summer)	Boardings	3,603	3,326	3,216	2,431	3,396
		Percent of Weekly Average	106	98	95	72	(100)
	9-15 October 1995 (Mud)	Boardings	2,597	2,459	1,935	1,550	2,282
		Percent of Weekly Average	114	108	85	68	(100)
ECO Transit	October 2001 (Mud)	Boardings	1,430	1,496	1,270	910	1,300
		Percent of Weekly Average	110	115	98	70	(100)

Note: Boardings presented for ECO Transit are averages for the whole month of October 2001.

Sources: Transit Development Plan for the Roaring Fork Valley (1996).ECO Transit.

For the mud season, an average of the RFTA and ECO ratios was used to determine Summit Stage boardings by weekday. The resulting model day boardings are presented in **Table A-81**. Detailed ridership statistics were not available for Town of Vail routes. However, annual boardings are similar for both RFTA and the Town of Vail, so assuming daily boardings are also similar seems reasonable.

Table A-81. Public Operator Boardings for Model Days

Season	Operator	Thursday	Friday	Saturday	Sunday
Winter	ECO Transit	3,071	3,178	2,732	2,634
	RFTA	12,515	12,950	11,134	10,733
	Summit Stage	7,700	7,967	6,850	6,603
Summer	ECO Transit	1,657	1,530	1,479	1,118
	RFTA	7,811	7,211	6,972	5,270
	Summit Stage	4,342	4,008	3,876	2,930
Mud	ECO Transit	1,414	1,479	1,256	900
	RFTA	3,411	3,229	2,541	2,036
	Summit Stage	3,069	3,056	2,503	1,892

Sources: ECO Transit. RFTA. Summit Stage.

Casino Bus Ridership

Analysis from the Gaming Area Access EIS suggested that ridership on casino-sponsored private buses are calculated using the following relationships: (1) About two percent of all vehicles bound for the Gaming Area are buses. (2) Each bus carries an average of 30 people.

If the average occupancy of all other vehicles bound for the Gaming Area is 2.5 persons, then these relationships imply that about 20 percent of all people traveling to Black Hawk and Central City do so by transit, as expected.

Casino bus ridership can thus be estimated from the vehicle counts collected at the ATR on SH 119 north of US 6. The results of this calculation are shown in **Table A-82**. Note that Saturday is consistently the most popular day for gaming. Also, compared to ridership on public operators in the Corridor, casino bus ridership shows less change by season. The summertime is the peak gaming season, and during the mud season travel to the Gaming Area is about 80 to 90 percent of its summer level.

Table A-82. Vehicle Volumes and Casino Bus Boardings for Model Days

Season	Vehicle	Thursday	Friday	Saturday	Sunday
Winter	Vehicles on SH 119	14,125	17,200	23,815	21,914
	Buses on SH 119	282	344	476	438
	Bus Passengers	8,475	10,320	14,289	13,148
Summer	Vehicles on SH 119	16,784	20,205	25,043	23,792
	Buses on SH 119	336	404	501	476
	Bus Passengers	10,070	12,123	15,026	14,275
Mud	Vehicles on SH 119	14,647	18,172	21,590	20,830
	Buses on SH 119	293	363	432	417
	Bus Passengers	8,788	10,903	12,954	12,498

Sources: CDOT. J.F. Sato and Associates.

Private Operator Ridership

The I-70 User Study estimated the number of passengers on different types of transit in the Corridor for a typical winter and summer Saturday in 2000 based on annual and seasonal ridership data collected by TranSystems. These estimates are summarized in **Table A-83**.

Table A-83. Summary of Daily Private Carrier Ridership by Season

Description of Service	Typical Winter Saturday Ridership	Typical Summer Saturday Ridership
Private Common Carriers (shuttle vans)	4,800	650
Ski Train	1,500	750
Greyhound	200	200
Amtrak and Others	50	1,100
Total Intercity Providers	1,750	2,050

Source: I-70 User Study.

Shuttle van riders were allocated to different companies and routes in proportion to the number of scheduled runs provided each day.

After typical Saturday ridership was established from the User Study, ridership for other days was estimated using day-of-week factors. A previous version of the calibrated travel demand model suggested that Thursday day recreational automobile trip-making is 13 percent of that of Saturday, and Sunday's level is 90 percent of Saturday. These factors were assumed to also apply to transit passengers traveling for other recreation purposes. A Thursday-to-Friday factor based on RFTA boardings (see **Table A-80**) was used to estimate summer Friday shuttle van ridership.

A.3.2 Calibration Process

Travel Demand Model

Many parameters of a travel demand model are not readily observable. For example, observing a household's propensity to make work trips on a Saturday or an out-of-state visitor's value of time is far more complicated than measuring the number of vehicles traversing the Twin Tunnels or measuring the speed of a particular truck.

The process of selecting values for travel demand models to yield reasonable results is called calibration. Generally this process involves using the model to forecast some known situation in a given base year; in this case, 4 periods of the day for one winter Saturday and four days in the summer: Thursday, Friday, Saturday, and Sunday.

Although not rigorously applied as in a least squares statistical regression, the general concept is to choose a set of model parameters that reduces the difference between the traffic counts for the various periods, locations, and days and the travel demand model results as much as possible. Unfortunately, there may be many sets of parameters that accomplish this to the same degree, and some may have compensating errors so that two wrong parameters may make the traffic-count-to-model result look good. Over the period of the calibration (with so many different days and with other calibration data such as enplanement information, second home data, census data, ski resort annual visitor estimates, and general discussions with tourist bureaus), a reasonable profile of who traveled in the Corridor in 2000 has been extracted. This review continues during the publication of the PEIS and, based on the comments received, may result in further modifications to the travel demand model.

Development of the Model Structure

The travel demand model structure refers to how the components of the model were put together. Although the model is based on the 4-step process of the DRCOG and Roaring Fork Valley models, additional purposes and procedures were added to address the recreation aspects of the Corridor, particularly from the Denver region. Periodically the structure was changed to better simulate traffic in the Corridor. For example, early in the model development process, a single speed table was used for input, while later model versions incorporated different speeds for different days and thus specified the model more explicitly than before.

What Model Parameters May Be Changed?

The original model parameters were taken from the DRCOG model for urban purposes: home-based work, home-based other, non-home-based, and truck trips.

The following parameters were modified.

Travel Times on the 2000 Networks for Transit and Highway Use

First the model was developed using the speeds in the speed table noted earlier (**Table A-17**). After getting the model results to be close, the speeds developed from the speed survey were introduced in the model. This reduced demand for the trip purposes that were more sensitive to speed: work, home-based other, and non-home-based trips. With this reduction, less time-sensitive demand was increased; particularly day recreation trips were added to make up the difference consistent with the marketing surveys that provide a constraint on activity.

Travel times were modified to incorporate the queuing expected in the system on summer Saturday, summer Sunday, and winter Saturday. This time reflected the average travel time over the entire period. As the travel time between C-470 and Silverthorne was reduced to account for queues, the time-sensitive purposes were automatically reduced and additional time-insensitive purposes were increased, particularly day recreation.

Trip Generation Rates

The trip generation rates for urban purposes were left the same as the DRCOG model after being modified to account for four income classes rather than three as in the DRCOG model. Later in the process the notion of a Corridor Day Recreation trip purpose was introduced. This purpose is based on the concept that resorts provide anchors to trip-making in the Corridor, and that both permanent residents and visitors travel to these anchors for the purpose of day recreation, specialty shopping (ski apparel rather than groceries), dining and drinking, and music festivals and special shows. For example, a second homeowner in Edwards might travel to Vail for day skiing and return to the family's second home, and then go to Vail again in the evening for dinner. These are all be considered Corridor Day Recreation trips.

Population and Employment by Zone

Although population by town from the 2000 Census is used, the population in February and August (the calibration periods) may be higher or differently distributed. Employment by zone was factored by land use from estimates by town, controlled to estimates from the state demographer by county.

Locations of Second Home, Hotel, Day Recreation, Sightseeing Trips

The model forecasts trips to second homes, hotels, day recreation sites, and sightseeing and out of state bed locations. The physical locations of the buildings where people stay overnight are not required by the forecasting process. Note that a second homeowner whose home is located outside of the anchor resort is more likely to rent their home to a permanent resident. This makes the forecast of the building location more problematic for these purposes.

Friction Factors by Purpose

DRCOG friction factors were listed in a database and then converted to a gamma function for the urban purposes. On Thursday, work trips are expected to represent 10 to 40 percent of the traffic flow, home-based other should be 30 to 50 percent, non-home-based should be about 20 to 35 percent, and trucks should be 5 to 15 percent. Keeping the trip generation constant, the three parameters of the gamma function were adjusted to provide trip percentages within the range noted above while providing for a reasonable estimate of recreation trips. The distribution of the trips by time increment was plotted to confirm reasonableness. Both a high component of very short trips and some very long trips are expected.

The long-distance recreation trips are forecast directly for each recreational destination. Based on discussions with a marketing consultant, trips to resorts are less sensitive to travel time if the travel time is less than several hours. That is, not much substitution is expected among resorts, as people make their decision to go to a particular resort based upon the activities at the resort, the skiing or summer recreation experiences, or the dining or other amenities offered.

Utility Coefficients

After the general structure of the mode choice model was decided by stakeholders and the peer review panel (assumed values of time, and relationships between the monorail constant and other mode-specific constants), calibration and validation of the mode choice model involved adjusting other model parameters to match observed ridership counts.

Because winter Saturday is used as a base day in the mode choice model, it was calibrated first. The shuttle van and tour bus constants and the constants for taking either of these modes in winter were adjusted to match existing counts. Then year 2000 forecasts for other model days were made and compared to counts to identify patterns. Day-specific constants adjusted to increase or decrease ridership on all transit services. Mode constants are also adjusted to affect ridership on that mode for all model days.

Ridership by purpose summaries were useful during the calibration process for determining coefficients of which trip purposes to adjust. For example, if the travel demand model predicted that Summit Stage has more riders making local non-work trips than RFTA, and if the model is overestimating Summit Stage ridership while underestimating RFTA passengers, then the tour bus constant for local non-work trips are lowered, while the same constant for other purposes might be raised.

ECO Transit ridership proved challenging to match, so an Eagle County production term was added to the Mode Choice model. This term gave another option for adjusting model results.

Time of Day Factors

Time of Day Factors were one of the last groups of factors to be adjusted. A close approximation of daily volumes was desired before making adjustments to make the directional volumes by period.

Ramp Profile Factors

Ramp profile factors distribute the trips from a directional period volume to an hourly volume for a specific on-ramp for I-70. During the weekends for traffic westbound on I-70 through Jefferson and Clear Creek counties, the dominant ramps are those at the eastern cordon of the VISSIM model. The ramp profiles were derived from the ramp traffic counts that were done over the course of several months for both the winter and summer. Traffic eastbound was first adjusted for the ramps at Frisco and Silverthorne. Adjustments kept the assumption that the ramp percents had to sum to 100 percent within each period.

Traffic Simulation Model

To calibrate the 2000 VISSIM models, the following general issues needed to be addressed:

- **Static checks on capacity:** Just upstream of a given highway section, feed a greater volume of traffic than the capacity of that section. This traffic is fed in by static assignment, as opposed to through OD matrices, which constitute dynamic assignment. Output files indicate how many vehicles got through. If this achieved volume is more than 50 vph above or below the expected capacity, adjust parameters until the achieved flow substantially matches the expected capacity.
- **Dynamic tests of travel time, speed, and queuing:** Run 19-hour Traffic Simulation Model runs. Obtain travel times and queuing information. Compare to expectations. Adjust the distribution of the demand or model parameters until the results substantially agree.

A.3.3 Calibration Statistics and Model Comparison

Travel Demand Model Highway Volume Estimates at ATR Locations

Matching traffic counts is a useful but insufficient criteria for determining whether the travel demand model is calibrated, particularly in the Corridor where the traffic counts are not as stable as in an urban environment. Weather, snow conditions, accidents that block traffic, special festivals, and other special events all potentially modify the expected characteristics of the traffic counts shown in the following tables. And trips estimated for the travel demand model need to correspond to trips estimated through independent processes such as ski market survey data. Nevertheless, they represent an important measure that provides information concerning the potential bias present in the calibrated model.

The travel demand model calibration process does not use k-factors during trip distribution (factors that force travel from one zone to another) to correct obvious over- or under-simulation (the difference between model demand and traffic counts). The justification for this approach is to avoid masking incorrect assumptions that are manifested by the difference between the counts and the model. Also, the model does not use specific county travel factors. Corridor Day Recreation factors, such as time of day factors, are the same throughout the model.

This analysis notes where the travel demand model and the counts differ by more than 2,000 vehicle trips by direction during one of the three periods, or 6,000 during the day. This value is thought to represent normal model variation, and is generally less than 20 percent of capacity. Daily differences greater than 6,000 vehicles per day suggest that there may be a systemic problem that needs adjustment in the model.

Table A-84 through **Table A-87** compare the travel demand model results to counts for summer Thursday, first daily and then through the three daylight periods. Little recreation traffic is expected during this day. The greatest model to count difference is in the area between Summit and Eagle counties using Vail Pass. Analysts should add trips to the area between Breckenridge and Vail (daily 6,000). There may be more Corridor Day Recreation and Work trips between Summit and Eagle counties throughout the day and in both directions than the model is estimating.

Table A-84. Summary of 2000 Summer Thursday 24-Hour Calibration

I-70 Locations			
Name	Assigned Volume	ATR Count	Percent Difference
No Name Tunnels	19,010	20,884	-8.97%
Eagle to Wolcott	28,240	24,695	14.36%
West entrance of Vail	39,911	43,449	-8.14%
Vail Pass to Copper Mountain	19,853	25,925	-23.42%
EJMT	33,403	34,498	-3.17%
Twin Tunnels	49,927	49,832	0.19%
East of Genesee	63,986	69,427	-7.84%
Other Locations			
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 82 South of Glenwood Springs	25,302	26,614	-4.93%
SH 82 Northwest of Old Snowmass	14,339	20,656	-30.58%
SH 9 South of Tiger Road (Breckenridge)	18,021	22,901	-21.31%
SH 9 North of Silverthorne	438	8,749	-94.99%
US 40 Berthoud Pass	9,881	5,894	67.65%
SH 119 North of US 6	18,408	16,784	9.68%

Source: J.F. Sato and Associates.

Table A-85. Summary of 2000 Summer Thursday AM Peak Period Calibration

I-70 Locations	Eastbound			Westbound		
Name	Assigned Volume	ATR Count	Percent Difference	Assigned Volume	ATR Count	Percent Difference
No Name Tunnels	1,622	2,039	-20.43%	1,673	1,444	15.86%
Eagle to Wolcott	2,486	1,778	39.86%	2,648	2,333	13.50%
West entrance of Vail	3,695	4,466	-17.26%	3,419	3,694	-7.43%
Vail Pass to Copper Mountain	1,457	1,877	-22.36%	1,699	2,249	-24.46%
EJMT	2,500	2,374	5.33%	3,624	3,249	11.56%
Twin Tunnels	3,907	3,688	5.94%	5,542	4,051	36.81%
East of Genesee	5,160	6,996	-26.24%	6,731	7,071	-4.81%
Other Location	**Northbound (to Gaming Area)**			**Southbound (from Gaming Area)**		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 119 North of US 6	1,362	1,559	-12.61%	1,018	552	84.42%

Source: J.F. Sato and Associates.

Table A-86. Summary of 2000 Summer Thursday Midday Period Calibration

I-70 Locations	Eastbound			Westbound		
Name	Assigned Volume	ATR Count	Percent Difference	Assigned Volume	ATR Count	Percent Difference
No Name Tunnels	3,442	3,530	-2.48%	3,628	3,485	4.10%
Eagle to Wolcott	5,051	4,181	20.82%	5,432	4,378	24.09%
West entrance of Vail	7,276	7,155	1.70%	6,768	7,145	-5.28%
Vail Pass to Copper Mountain	3,254	4,494	-27.58%	3,507	4,616	-24.02%
EJMT	5,154	5,591	-7.81%	5,906	6,523	-9.46%
Twin Tunnels	7,504	7,671	-2.17%	8,731	9,558	-8.65%
East of Genesee	9,563	10,063	-4.97%	11,507	11,321	1.65%
Other Location	**Northbound (to Gaming Area)**			**Southbound (from Gaming Area)**		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 119 North of US 6	2,984	2,782	7.28%	1,947	1,621	20.11%

Source: J.F. Sato and Associates.

Table A-87. Summary of 2000 Summer Thursday PM Peak Period Calibration

I-70 Locations	Eastbound			Westbound		
Name	Assigned Volume	ATR Count	Percent Difference	Assigned Volume	ATR Count	Percent Difference
No Name Tunnels	3,015	2,838	6.24%	3,006	3,295	-8.77%
Eagle to Wolcott	4,475	3,556	25.84%	4,473	3,523	26.97%
West entrance of Vail	5,993	6,164	-2.77%	6,141	6,732	-8.78%
Vail Pass to Copper Mountain	2,984	3,663	-18.53%	2,909	3,867	-24.77%
EJMT	5,406	4,875	10.89%	4,590	5,014	-8.46%
Twin Tunnels	8,018	7,632	5.06%	6,844	7,612	-10.08%
East of Genesee	10,034	9,881	1.55%	9,595	10,610	-9.57%
Other Location	**Northbound (to Gaming Area)**			**Southbound (from Gaming Area)**		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 119 North of US 6	2,954	2,505	17.92%	2,539	2,422	4.83%

Source: J.F. Sato and Associates.

Table A-88 through **Table A-91** compare the results to counts for Summer Friday, first daily and then through the three daylight periods. The expectation is that travel on Summer Thursday and Friday are similar except for the addition of overnight trips, particularly in the afternoon and evening on Friday heading west from the Denver region and, to a much lesser extent (about one third), from the mountains to Denver. The travel demand model is underestimating these trips from Denver to Vail in both directions. An additional 8,000 vehicle trips from Denver might be expected to travel to Frisco, Leadville, and Vail over the volumes predicted in the model, and 2,500 in the reverse direction.

Table A-88. Summary of 2000 Summer Friday 24-Hour Calibration

I-70 Locations			
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**
No Name Tunnels	21,263	24,477	-13.13%
Eagle to Wolcott	25,580	29,455	-13.16%
West entrance of Vail	44,239	47,917	-7.68%
Vail Pass to Copper Mountain	25,710	31,661	-18.80%
EJMT	36,708	45,745	-19.75%
Twin Tunnels	53,628	62,907	-14.75%
East of Genesee	67,840	83,103	-18.37%
Other Locations			
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 82 South of Glenwood Springs	27,577	27,526	0.19%
SH 82 Northwest of Old Snowmass	16,226	20,812	-22.04%
SH 9 South of Tiger Road (Breckenridge)	23,843	24,475	-2.58%
SH 9 North of Silverthorne	546	10,388	-94.74%
US 40 Berthoud Pass	10,760	8,518	26.32%
SH 119 North of US 6	20,067	20,205	-0.68%

Source: J.F. Sato and Associates

Table A-89. Summary of 2000 Summer Friday AM Peak Period Calibration

I-70 Locations	Eastbound			Westbound		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
No Name Tunnels	1,556	2,112	-26.31%	1,922	1,468	30.97%
Eagle to Wolcott	1,797	1,904	-5.62%	2,323	2,350	-1.13%
West entrance of Vail	3,788	4,433	-14.54%	3,898	3,736	4.34%
Vail Pass to Copper Mountain	1,684	2,044	-17.61%	2,271	2,501	-9.20%
EJMT	1,873	2,592	-27.73%	3,173	3,637	-12.76%
Twin Tunnels	3,152	3,865	-18.44%	5,156	5,119	0.73%
East of Genesee	4,489	7,108	-36.84%	6,511	7,453	-12.64%
Other Location	**Northbound (to Gaming Area)**			**Southbound (from Gaming Area)**		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 119 North of US 6	1,324	1,620	-18.27%	1,005	564	78.19%

Source: J.F. Sato and Associates.

Table A-90. Summary of 2000 Summer Friday Midday Period Calibration

I-70 Locations	Eastbound			Westbound		
Name	Assigned Volume	ATR Count	Percent Difference	Assigned Volume	ATR Count	Percent Difference
No Name Tunnels	3,942	4,227	-6.74%	4,439	4,154	6.87%
Eagle to Wolcott	4,558	4,979	-8.45%	5,159	5,095	1.26%
West entrance of Vail	7,809	8,119	-3.82%	7,996	7,800	2.51%
Vail Pass to Copper Mountain	4,392	5,306	-17.23%	5,002	5,721	-12.57%
EJMT	5,646	6,823	-17.24%	6,558	8,787	-25.37%
Twin Tunnels	8,052	9,629	-16.37%	9,472	11,739	-19.31%
East of Genesee	9,985	11,194	-10.80%	12,232	14,338	-14.69%
Other Location	**Northbound (to Gaming Area)**			**Southbound (from Gaming Area)**		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 119 North of US 6	3,178	3,082	3.11%	2,041	1,806	13.01%

Source: J.F. Sato and Associates.

Table A-91. Summary of 2000 Summer Friday PM Peak Period Calibration

I-70 Locations	Eastbound			Westbound		
Name	Assigned Volume	ATR Count	Percent Difference	Assigned Volume	ATR Count	Percent Difference
No Name Tunnels	2,879	3,210	-10.30%	3,204	3,951	-18.91%
Eagle to Wolcott	3,458	4,233	-18.30%	3,801	4,656	-18.36%
West entrance of Vail	6,142	6,872	-10.62%	6,973	7,137	-2.30%
Vail Pass to Copper Mountain	3,325	4,295	-22.58%	3,966	5,066	-21.71%
EJMT	4,260	5,778	-26.27%	6,465	8,271	-21.83%
Twin Tunnels	6,838	9,088	-24.75%	8,795	10,608	-17.09%
East of Genesee	9,091	10,798	-15.80%	11,301	14,773	-23.50%
Other Location	**Northbound (to Gaming Area)**			**Southbound (from Gaming Area)**		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 119 North of US 6	3,272	3,326	-1.62%	2,662	2,493	6.78%

Source: J.F. Sato and Associates.

Table A-92 through **Table A-95** compare the results to counts for summer Saturday, first daily and then through the three daylight periods. The expectation is that travel on summer Saturday is dominated by travel from the Denver region for recreation to the Denver and Jefferson County Parks in Jefferson County, and overnight trips to the mountains. Because of the static nature of the traffic assignment routine within the travel demand model, it may be that some of the over-assignment shown at the Eisenhower-Johnson Memorial Tunnels is because trips are leaving in the AM and actually crossing the Eisenhower-Johnson Memorial Tunnels in the midday period. This problem can be addressed in the simulation model, which simulates when a vehicle enters I-70 and calculates when it reaches other points in the Corridor. Some additional traffic may be on tours through Clear Creek County (2,000 vehicles) using Loveland Pass and SH 103. These trips are added to the Traffic Simulation Model.

1 **Table A-92. Summary of 2000 Summer Saturday 24-Hour Calibration**

I-70 Locations			
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**
No Name Tunnels	22,879	22,500	1.68%
Eagle to Wolcott	28,290	29,535	-4.22%
West entrance of Vail	38,247	42,746	-10.52%
Vail Pass to Copper Mountain	28,488	25,295	12.63%
EJMT	44,680	44,921	-0.54%
Twin Tunnels	61,804	66,966	-7.71%
East of Genesee	84,810	84,106	0.84%
Other Locations			
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 82 South of Glenwood Springs	22,354	21,151	5.69%
SH 82 Northwest of Old Snowmass	16,257	12,594	29.09%
SH 9 South of Tiger Road (Breckenridge)	19,696	19,706	-0.05%
SH 9 North of Silverthorne	193	9,136	-97.89%
US 40 Berthoud Pass	16,565	9,986	65.88%
SH 119 North of US 6	25,125	25,043	0.33%

Source: J.F. Sato and Associates.

2 **Table A-93. Summary of 2000 Summer Saturday AM Peak Period Calibration**

I-70 Locations	Eastbound			Westbound		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
No Name Tunnels	1,716	1,807	-5.04%	2,766	1,508	83.42%
Eagle to Wolcott	2,226	2,042	9.01%	3,320	2,345	41.56%
West entrance of Vail	2,962	3,463	-14.47%	4,288	3,285	30.53%
Vail Pass to Copper Mountain	1,864	1,791	4.10%	3,479	2,229	56.08%
EJMT	2,397	2,829	-15.26%	5,940	4,654	27.63%
Twin Tunnels	3,151	3,707	-15.00%	8,238	8,301	-0.75%
East of Genesee	4,109	4,468	-8.03%	11,407	9,864	15.65%
Other Location	**Northbound (to Gaming Area)**			**Southbound (from Gaming Area)**		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 119 North of US 6	2,010	1,658	21.27%	558	543	2.86%

Source: J.F. Sato and Associates

1 **Table A-94. Summary of 2000 Summer Saturday Midday Period Calibration**

I-70 Locations	Eastbound			Westbound		
Name	Assigned Volume	ATR Count	Percent Difference	Assigned Volume	ATR Count	Percent Difference
No Name Tunnels	4,096	4,089	0.17%	4,629	4,568	1.34%
Eagle to Wolcott	4,922	5,086	-3.23%	5,550	5,153	7.70%
West entrance of Vail	6,518	7,775	-16.16%	6,785	7,804	-13.05%
Vail Pass to Copper Mountain	4,812	4,645	3.61%	5,807	5,181	12.09%
EJMT	7,276	7,395	-1.60%	9,363	9,994	-6.31%
Twin Tunnels	9,963	12,502	-20.31%	12,717	13,529	-6.00%
East of Genesee	13,824	13,462	2.69%	16,534	17,454	-5.27%
Other Location	**Northbound (to Gaming Area)**			**Southbound (from Gaming Area)**		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 119 North of US 6	3391	4,297	-21.08%	2,925	1,975	48.10%

Source: J.F. Sato and Associates.

2 **Table A-95. Summary of 2000 Summer Saturday PM Peak Period Calibration**

I-70 Locations	Eastbound			Westbound		
Name	Assigned Volume	ATR Count	Percent Difference	Assigned Volume	ATR Count	Percent Difference
No Name Tunnels	3,150	3,073	2.52%	3,012	3,013	-0.02%
Eagle to Wolcott	3,940	4,352	-9.46%	3,796	4,544	-16.46%
West entrance of Vail	5,058	5,583	-9.40%	5,246	5,818	-9.83%
Vail Pass to Copper Mountain	3,769	3,275	15.08%	3,541	3,311	6.96%
EJMT	5,974	6,396	-6.60%	5,141	5,456	-5.77%
Twin Tunnels	8,291	9,622	-13.83%	6,871	6,786	1.25%
East of Genesee	11,715	12,382	-5.38%	9,931	9,792	1.42%
Other Location	**Northbound (to Gaming Area)**			**Southbound (from Gaming Area)**		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 119 North of US 6	3,043	3,830	-20.55%	3,224	3,194	0.94%

Source: J.F. Sato and Associates.

Table A-96 through **Table A-99** compare the results to counts for summer Sunday, first daily and then through the three daylight periods. The expectation is that travel on summer Sunday is dominated by overnight recreation trips returning to the Denver region. The AM traffic is consistently being slightly under-simulated both eastbound and westbound. Overnight trips to Grand County should be reduced (6,000), and trips to Summit County should be increased (6,000). Gaming trips westbound should be reduced by 2,000 in the PM and increased 2,000 in the midday period.

Table A-96. Summary of 2000 Summer Sunday 24-Hour Calibration

Name	Assigned Volume	ATR Count	Percent Difference
No Name Tunnels	24,055	24,308	-1.04%
Eagle to Wolcott	27,111	29,272	-7.38%
West entrance of Vail	36,097	40,474	-10.81%
Vail Pass to Copper Mountain	31,088	27,365	13.61%
EJMT	45,377	49,090	-7.56%
Twin Tunnels	65,740	67,713	-2.91%
East of Genesee	82,414	83,065	-0.78%
Other Locations			
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 82 South of Glenwood Springs	21,169	18,455	14.71%
SH 82 Northwest of Old Snowmass	16,552	12,594	31.43%
SH 9 South of Tiger Road (Breckenridge)	17,953	19,706	-8.90%
SH 9 North of Silverthorne	86	9,136	-99.06%
US 40 Berthoud Pass	18,256	9,986	82.82%
SH 119 North of US 6	22,487	23,792	-5.49%

Source: J.F. Sato and Associates.

Table A-97. Summary of 2000 Summer Sunday AM Peak Period Calibration

I-70 Locations	Eastbound			Westbound		
Name	Assigned Volume	ATR Count	Percent Difference	Assigned Volume	ATR Count	Percent Difference
No Name Tunnels	1,188	1,617	-26.53%	1,387	1,140	21.67%
Eagle to Wolcott	1,361	1,820	-25.20%	1,525	1,666	-8.44%
West entrance of Vail	1,997	2,878	-30.60%	2,094	2,337	-10.40%
Vail Pass to Copper Mountain	1,413	1,628	-13.18%	1,694	1,517	11.67%
EJMT	2,066	2,772	-25.47%	2,563	2,864	-10.49%
Twin Tunnels	2,770	3,831	-27.70%	3,649	4,496	-18.83%
East of Genesee	3,271	3,862	-15.29%	4,769	5,831	-18.21%
Other Location	**Northbound (to Gaming Area)**			**Southbound (from Gaming Area)**		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 119 North of US 6	1,411	1,864	-24.28%	448	413	8.61%

Source: J.F. Sato and Associates.

Table A-98. Summary of 2000 Summer Sunday Midday Period Calibration

I-70 Locations	Eastbound			Westbound		
Name	Assigned Volume	ATR Count	Percent Difference	Assigned Volume	ATR Count	Percent Difference
No Name Tunnels	5,575	5,006	11.37%	3,847	4,235	-9.16%
Eagle to Wolcott	6,164	6,705	-8.07%	4,285	4,958	-13.57%
West entrance of Vail	8,136	8,335	-2.38%	5,206	6,747	-22.83%
Vail Pass to Copper Mountain	7,466	6,274	19.01%	4,963	4,558	8.89%
EJMT	9,321	12,059	-22.70%	7,543	7,744	-2.60%
Twin Tunnels	15,607	15,182	2.80%	10,527	10,978	-4.10%
East of Genesee	17,758	16,257	9.24%	13,697	15,084	-9.20%
Other Location	**Northbound (to Gaming Area)**			**Southbound (from Gaming Area)**		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 119 North of US 6	3,423	4,636	-26.16%	1,531	2,381	-35.69%

Source: J.F. Sato and Associates.

Table A-99. Summary of 2000 Summer Sunday PM Peak Period Calibration

I-70 Locations	Eastbound			Westbound		
Name	Assigned Volume	ATR Count	Percent Difference	Assigned Volume	ATR Count	Percent Difference
No Name Tunnels	4,195	3,796	10.53%	3,310	3,481	-4.90%
Eagle to Wolcott	4,696	4,660	0.77%	3,701	3,735	-0.91%
West entrance of Vail	5,980	5,751	3.98%	5,117	5,983	-14.47%
Vail Pass to Copper Mountain	5,500	4,522	21.64%	3,999	3,483	14.81%
EJMT	8,564	8,450	1.35%	5,818	5,237	11.09%
Twin Tunnels	11,963	12,209	-2.01%	7,975	6,443	23.79%
East of Genesee	16,154	16,160	-0.04%	10,761	8,608	25.01%
Other Location	**Northbound (to Gaming Area)**			**Southbound (from Gaming Area)**		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 119 North of US 6	3,246	2,923	11.05%	3,042	3,573	-14.85%

Source: J.F. Sato and Associates.

Table A-100 through **Table A-103** compare the results to counts for winter Saturday, first daily and then through the three daylight periods. Travel on winter Saturday is expected to include a large day skier demand from the Denver region that accesses the eight major resorts in the Corridor. There may be too much local traffic headed westbound through Vail from Summit County (about 2,000 vehicles), and overnight traffic from Denver to Vail should be reduced by 2,000 vehicles.

Table A-100. Summary of 2000 Winter Saturday 24-Hour Calibration

I-70 Locations			
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**
No Name Tunnels	14,444	11,659	23.89%
Eagle to Wolcott	17,216	20,498	-16.01%
West entrance of Vail	36,292	36,740	-1.22%
Vail Pass to Copper Mountain	22,957	17,942	27.95%
EJMT	39,930	36,206	10.29%
Twin Tunnels	58,885	57,027	3.26%
East of Genesee	66,834	62,345	7.20%
Other Locations			
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 82 South of Glenwood Springs	17,630	17,632	-0.01%
SH 82 Northwest of Old Snowmass	13,541	13,583	-0.31%
SH 9 South of Tiger Road (Breckenridge)	22,578	22,609	-0.13%
SH 9 North of Silverthorne	210	4,032	-94.79%
US 40 Berthoud Pass	13,279	9,814	35.31%
SH 119 North of US 6	23,766	23,815	-0.20%

Source: J.F. Sato and Associates.

Table A-101. Summary of 2000 Winter Saturday AM Peak Period Calibration

I-70 Locations	Eastbound			Westbound		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
No Name Tunnels	1,730	1,097	57.77%	2,519	763	230.36%
Eagle to Wolcott	2,292	1,491	53.72%	2,708	2,853	-5.09%
West entrance of Vail	3,960	3,809	3.96%	5,248	3,449	52.16%
Vail Pass to Copper Mountain	1,906	1,395	36.63%	4,263	2,147	98.56%
EJMT	2,150	2,002	7.39%	8,318	6,797	22.38%
Twin Tunnels	2,839	2,793	1.67%	12,304	12,420	-0.93%
East of Genesee	3,290	3,263	0.84%	12,856	10,446	23.07%
Other Location	**Northbound (to Gaming Area)**			**Southbound (from Gaming Area)**		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 119 North of US 6	2,034	1,803	12.81%	783	444	76.35%

Source: J.F. Sato and Associates.

Table A-102. Summary of 2000 Winter Saturday Midday Period Calibration

I-70 Locations	Eastbound			Westbound		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
No Name Tunnels	1,865	2,070	-9.88%	2,088	2,502	-16.55%
Eagle to Wolcott	2,182	3,638	-40.03%	2,462	3,659	-32.71%
West entrance of Vail	5,516	5,740	-3.89%	5,589	5,485	1.91%
Vail Pass to Copper Mountain	3,488	3,005	16.09%	3,643	3,326	9.53%
EJMT	6,494	5,287	22.83%	5,958	6,159	-3.26%
Twin Tunnels	9,773	7,677	27.31%	8,976	9,408	-4.59%
East of Genesee	10,071	8,978	12.17%	11,665	10,422	11.93%
Other Location	**Northbound (to Gaming Area)**			**Southbound (from Gaming Area)**		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 119 North of US 6	4,184	4,162	0.54%	2,249	1,789	25.71%

Source: J.F. Sato and Associates.

Table A-103. Summary of 2000 Winter Saturday PM Peak Period Calibration

I-70 Locations	Eastbound			Westbound		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
No Name Tunnels	2,401	1,499	60.23%	1,885	1,690	11.57%
Eagle to Wolcott	2,765	3,016	-8.31%	2,422	2,576	-5.96%
West entrance of Vail	5,405	4,327	24.93%	4,826	5,726	-15.71%
Vail Pass to Copper Mountain	3,638	2,674	36.08%	2,367	2,600	-8.94%
EJMT	7,351	7,189	2.26%	3,322	3,903	-14.89%
Twin Tunnels	10,703	11,342	-5.63%	4,737	5,318	-10.93%
East of Genesee	12,314	11,400	8.02%	6,390	7,002	-8.74%
Other Location	**Northbound (to Gaming Area)**			**Southbound (from Gaming Area)**		
Name	**Assigned Volume**	**ATR Count**	**Percent Difference**	**Assigned Volume**	**ATR Count**	**Percent Difference**
SH 119 North of US 6	3,242	3,662	-11.46%	3,193	3,113	2.57%

Source: J.F. Sato and Associates.

Areas of calibration and future model improvement have been identified. The differences are generally less than one-half lane of capacity of I-70. For this reason, because the main purpose of this model during the preparation of the PEIS is comparison of alternatives, the peer review team recommended using the model, with its identified differences, for this purpose. In 2005 and 2006, the Team performed a post-model calibration review. The post model review found that the 2004 model is within an acceptable range of the post-model calibration findings. The uncertainties and the assumptions made during the modeling process are within the reasonable range for a typical travel demand model as established by FHWA. In addition, the Team also presented the calibration process to a peer review panel consisting of members from CDOT-DTD, CDOT Region 1 and DRCOG, to verify the procedures and the results of the calibration. The peer review panel agreed with findings made by the Team. Therefore, the Team did not make any modification to the PEIS models.

2000 Model Day Traffic Simulation Model Calibration Results

The results of the 2000 calibration runs are contained in **Table A-104**.

Table A-104. 2000 Travel Results from VISSIM

Critical Day	Direction	Expected Peak Hour Travel Time (minutes)	Achieved Peak Hour Travel Time (minutes)	Difference in Peak Hour Travel Time (minutes)
Summer Saturday	WB	70	63	7
Summer Sunday	EB	100	84	16
Winter Saturday	WB	85	75	10

Notes: Times shown are calculated for a trip from Silverthorne to C-470, for a distance of 55 miles. The Free-Flow Travel Time for this portion of I-70 is 55 minutes, with no provision of time to stop for gas, food, etc.

The achieved results all have less delay than expected. That is because the expectations are for the worst non-holiday travel times during the summer and winter seasons, whereas the 2000 Traffic Simulation runs used the model day volumes, which are based on a much stricter definition (in terms of particular calendar days).

Transit Volumes by System

Table A-105 through **Table A-107** indicate the present state of transit calibration as a comparison between model daily system boardings and estimates prepared by JFSA staff based on information from each operator. Generally, all of the private operators consider their numbers proprietary, and estimates for these systems were based on operator schedules rather than counts, as described previously.

Additional casino bus calibration is done based on meeting the 20 percent mode choice for gaming patrons and the 30 percent mode choice for casino employees as identified in the Black Hawk Transportation Study.

Mode choice for existing private operators is difficult to calibrate, given the very small number of transit operator trips (sometimes less than 100) out of millions of trips contained in the travel demand model. For 2000, the criteria for calibration should be within 500 boardings if the count is below 1,000. If the count is more than 1,000 boardings, a model value within 30 percent of the estimated count is the recommended calibration criterion.

The ski train trips are constrained by the capacity of the ski train, which is often sold out during the winter.

The dominant trips in the future do not show up in 2000; in particular, day recreation trips that originate from the Denver region and air-based overnight trips that might choose transit because of the low price. Calibration of these purposes has been through estimation of the stated preference survey as reported in **section A.2.7**.

Table A-105. Transit Calibration Summary for Summer Thursday and Friday

	Summer Thursday			Summer Friday		
Operator	Count	Model	Model as Percent of Count	Count	Model	Model as Percent of Count
Casino Shuttles	10,070	8,294	82%	12,132	11,549	95%
ECO Transit	1,657	1,688	102%	1,530	4,387	290%
Total of Private Corridor Operators	140	647	460%	129	1,375	1100%

Operator	Summer Thursday			Summer Friday		
	Count	Model	Model as Percent of Count	Count	Model	Model as Percent of Count
RFTA	7,811	6,327	81%	7,211	15,679	217%
Summit Stage	4,342	2,769	64%	4,008	11,503	290%
Town of Vail	7,800	455	6%	7,200	1,379	19%
Total	**31,820**	**20,181**	**63%**	**32,209**	**45,872**	**142%**
Total, Excluding Town of Vail & Private Corridor Operators	23,880	19,078	80%	24,881	43,119	173%

Source: J.F. Sato and Associates.

Table A-106. Transit Calibration Summary for Summer Saturday and Sunday

Operator	Summer Saturday			Summer Sunday		
	Count	Model	Model as Percent of Count	Count	Model	Model as Percent of Count
Casino Shuttles	15,026	13,658	91%	14,275	17,591	123%
ECO Transit	1,479	1,041	70%	1,118	778	70%
Total of Private Corridor Operators	1,075	6,147	570%	967	3,691	380%
RFTA	6,972	3,648	52%	5,270	2,741	52%
Summit Stage	3,876	3,574	92%	2,930	2,385	81%
Town of Vail	7,000	431	6%	5,300	369	7%
Total	**35,428**	**28,499**	**80%**	**29,860**	**27,556**	**92%**
Total, Excluding Town of Vail & Private Corridor Operators	27,353	21,921	80%	23,593	23,496	100%

Source: J.F. Sato and Associates.

Table A-107. Transit Calibration Summary for Winter Saturday

Operator	Winter Saturday		
	Count	Model	Model as Percent of Count
Casino Shuttles	14,289	21,207	148%
ECO Transit	2,732	2,102	77%
Total of Private Corridor Operators	4,150	2,844	69%
RFTA	11,134	8,075	73%
Summit Stage	6,850	5,181	76%
Town of Vail	11,100	535	5%
Total	**50,255**	**39,949**	**79%**
Total, Excluding Town of Vail & Private Corridor Operators	35,005	36,571	104%

Source: J.F. Sato and Associates.

Appendix B
I-70 Ridership Survey

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Appendix B. I-70 Ridership Survey

J.F. Sato and Associates has created a transportation model focusing on I-70 from Glenwood Springs to C-470 in Denver, to predict the potential impacts of various transportation improvements in the Corridor. Of particular interest is the potential introduction of a high-quality transit system in the Corridor —either rail or bus—where no such system exists at the present time. The main basis for the Corridor travel demand model is two existing models: the Denver Regional Council of Governments (DRCOG) model of the Denver region and a similar, smaller model for the Roaring Fork Valley at the western end of the Corridor. For this study, however, these existing models do not cover the following important areas:

- Longer distance travel to and from the Corridor is not treated in any detail.
- Recreational travel such as skiing and hiking is not treated as a separate segment.
- Visitors from out of the region are not included in the models.
- The transit modes in the models are local urban transit and do not reflect the choice of transit for longer distances.

For these reasons, it was necessary to design and estimate additional travel models to represent the specific types of trips that are most prevalent in the Corridor. The *I-70 User Study* was conducted in 1999 and 2000 to provide details on a representative cross section of trips in the Corridor. While that survey was useful for calibrating models of trip generation and distribution, it did not sufficiently address the issue of mode choice between auto and transit. Because there is currently no transit system in the Corridor (and there is no similar system anywhere else in North America from which to transfer results), it is necessary to use the Stated Preference (SP) method based on hypothetical mode choice scenarios. The initial *I-70 User Study* contained a few hypothetical questions along these lines, but they were simplistic and far below the state-of-the-art for asking such questions. Also, they did not cover the full range of mode choice alternatives and attributes that are required for the model.

In both the winter and summer of 2001, a second survey approach was carried out, focusing primarily on the SP mode choice questions. The survey contained several state-of-the-art features to maximize response rates and realism:

- The surveys were administered at intercept sites using laptop computers, making it easy to capture respondents and keep their interest.
- The questions and mode choice scenarios in the surveys were customized extensively to respondents' actual trips, making the choices more realistic to the respondents and more relevant for modeling purposes.
- The surveys used databases of access and egress times and station-to-station line-haul distances, ensuring that the transit options that were generated are realistic and compatible with those that eventually are modeled.

Following a discussion of the SP approach to provide some additional context, the remainder of this document provides extensive detail on the survey instrument and data.

B.1 The SP Approach

Ideally, data could be collected on existing travel that allows observed behavior to be extrapolated to any future scenario of interest. In the Corridor, however, the possible future scenarios include Transit alternatives that are not reflected by anything that exists there at present. Nor are there any comparable transit systems operating anywhere in North America. The closest thing may be the train that runs from Vancouver up to Whistler in British Columbia. That system, however, runs very slowly and only once per day in each direction. It is more of a scenic tourist attraction than an efficient, high-capacity transit system. (In this regard, the train to Whistler is more like to the ski train between Denver Union Station and Winter Park Resort.) Given this lack of existing data, the best option is to mimic data on actual choices by carefully creating hypothetical choice scenarios and presenting them to respondents.

The SP approach is often subject to criticism because there is no guarantee that the respondents would actually behave as they say they would in the hypothetical choice situations. While this issue cannot be denied, it can be dealt with to a large extent by making the choice situations as detailed and realistic as possible. So, instead of simply asking respondents: "Suppose you could also take a train for your trip. Would you use it?" a detailed picture of what a trip by the new alternative mode involves is created and compared to the existing trip. These details include relative travel times, in total and of various types, access and egress modes and transfers, and travel costs for the entire travel party. Respondents are also reminded of any constraints that might discourage them from using transit; that is, the need to use the car at the destination, carrying large baggage, and visiting multiple destinations. So, by the time that respondents make their choices, it is clear to them what the tradeoffs are and what they are gaining and losing by switching to a new mode. Respondents are also shown a picture of the new mode, similar to what they might see in a brochure or newspaper article, if the new service were actually introduced.

Because the SP data is collected to mimic Revealed Preference (RP) (observed) choice data, the usage of the new mode cannot be predicted simply by tabulating the choice responses. As with RP data, a number of analysis steps are required first:

1. Estimate mode choice models for all market segments, with the choice as a function of all of the attributes varied in the SP experimental design (such as fare, in-vehicle time, frequency, and egress time).
2. Apply the mode choice models to travel segments of the correct size, with the correct origin-destination (OD) trip patterns, and the full representative road and transit networks between those pairs. This means applying them in the full transportation model system, after the networks have been defined to reflect the policy scenario of interest, and after the trip generation and distribution models have been applied to give the predicted OD patterns under that scenario.

This means that simply looking at the raw choice shares from the survey is not very meaningful because those choices are based on thousands of hypothetical scenarios, all with different times, and costs. Also, the survey sample is only meant to be comprehensive in terms of containing all types of travelers, and not representative in terms of containing the right proportion of each type. (For model estimation, it is not necessary that the sample be proportionally representative as long as all key segmentation variables that affect both response rates and choice behavior are included in the model specification.)

The only way to find out what the SP data say about a specific regional scenario is to estimate mode choice model coefficients from the data, including time and cost coefficients and mode-specific constants, and to apply those coefficients for the appropriate market segments in the full travel demand model. This ensures that the models are applied to the appropriate mix of trips in terms of the market segments (trip purposes/traveler characteristics) and spatial patterns (OD pairs).

B.2 SP Versus RP

SP surveys based on choices in hypothetical contexts have become the standard method for predicting choice behavior in cases where RP data on actual choices are not available. Both types of data have their relative strengths and weaknesses.

The main strengths of RP data are:

- **Empirical validity.** The data are from choices that have actually been made.
- **Ease of asking the questions.** Questions about past choices are typically straightforward.

The main potential weaknesses of RP data are:

- **Lack of a controlled situation.** The analyst must infer what external variables have influenced the choices that are observed and collect data to measure those influences. In some cases, this data can be difficult and expensive to measure, as is the case with highway speeds and travel times.
- **Poor statistical properties.** Often, in real choices situations, there is not enough variability in the key variables to reliably estimate their influence on behavior. In many cases, the key variables (for example, travel time and cost) are highly correlated with each other so that their separate influences cannot be estimated.
- **Sensitivity to model specification.** The two weaknesses above lead to a situation where assumptions made by the analyst in model estimation can lead to very different analysis results, and thus the results are very sensitive to analyst error and judgment.
- **Tied to the current reality.** One cannot collect data on choices that do not yet exist.

Conversely, the main strengths of SP data are:

- **Not tied to the current reality.** One can study choice options that do not yet exist.
- **Use of a controlled choice context.** A controlled experimental design ensures good statistical properties in the data and predefines, to a large extent, the analysis that can be done on the data, leaving less to the judgment of the analyst.
- **Efficiency.** Several choice observations can be obtained from each respondent, reducing the total sample size required.

The main potential weaknesses of SP data are:

- **Complexity in survey design.** The surveys require specific expertise to design and are sometimes complicated for respondents to complete.
- **Importance of survey design.** The critical influence of the experimental design on the responses and on the analysis that can eventually be done leaves room for poor survey design to affect the results to a great extent.
- **Empirical uncertainty.** There is no guarantee that respondents would actually behave as they say they would, particularly in the case of new, unfamiliar choice options.

Although the use of SP methods in transportation research has grown steadily over the last 15 years, there is still no consensus on this final issue: the empirical uncertainty. Isolated studies have indicated poor correspondence between stated and actual behavior, but the SP surveys tested in those studies have generally been poor examples. Other studies have shown very close correspondence to models estimated on SP data and models estimated on RP data in analogous choice contexts. Further background on the SP approach and analysis techniques is provided in **Section B.7** of this Appendix.

B.3 Description of the Survey

The full listing of the survey questionnaire is given in **Section B.4** of this Appendix. Visual aids for the interviews included photographs of the outside and inside of each mode (**Figure B-1**) and route maps (**Figure B-2** and **Figure B-3**). Those few instances where the summer questionnaire was different from the winter one are indicated in the list. The differences between the winter and summer versions were:

- Some different intercept sites were used.
- The “ski” purpose definition was changed to “resort-based recreation.”
- Some national forest areas were added as destination names for the summer.

- The question about carrying skis as luggage was changed to ask about bikes.
- The service attribute for offering ski lockers at stations was changed to offering bicycle storage on-board.
- Questions and scenario information about poor weather conditions were dropped for the summer survey.

Otherwise, the questionnaires for the two seasons were kept identical to maximize the comparability of results.

The main sections of the questionnaire are:

1. Introduction and verification of in-scope trip
2. Details of the journey by the existing mode
3. A hypothetical question about paying for a toll lane
4. Introduction of the concept of a new transit mode
5. Questions about probable access and egress stations and times for the new mode.
6. A series of 5 hypothetical choices between the existing mode and the new mode.
7. Questions about possible new trips induced by the new mode.
8. Socioeconomic questions about the respondent and household.

The key section, and the one that is probably most difficult to understand in reading **Section B.4**, is number 6, where the 5 hypothetical mode choice scenarios are designed and administered. The attributes that were varied in creating the scenarios were varied according to an experimental design that has 512 rows or “treatments”. Each row has 29 columns, each of which can take a value from 1 through 8. For each respondent, each of the 5 choices, one of the 512 rows was selected at random. Across the entire sample, the entire 512-row experimental design is represented adequately.

Figure B-1. Visual Representation of Ridership Survey Modes

Shuttle

Bus/ Fixed Guideway Bus

Light Rail Transit

Train

Monorail

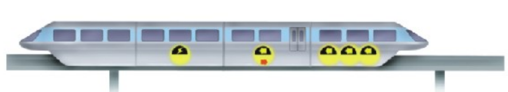


Figure B-2. Transit Routes: Eagle County Airport to Denver International Airport

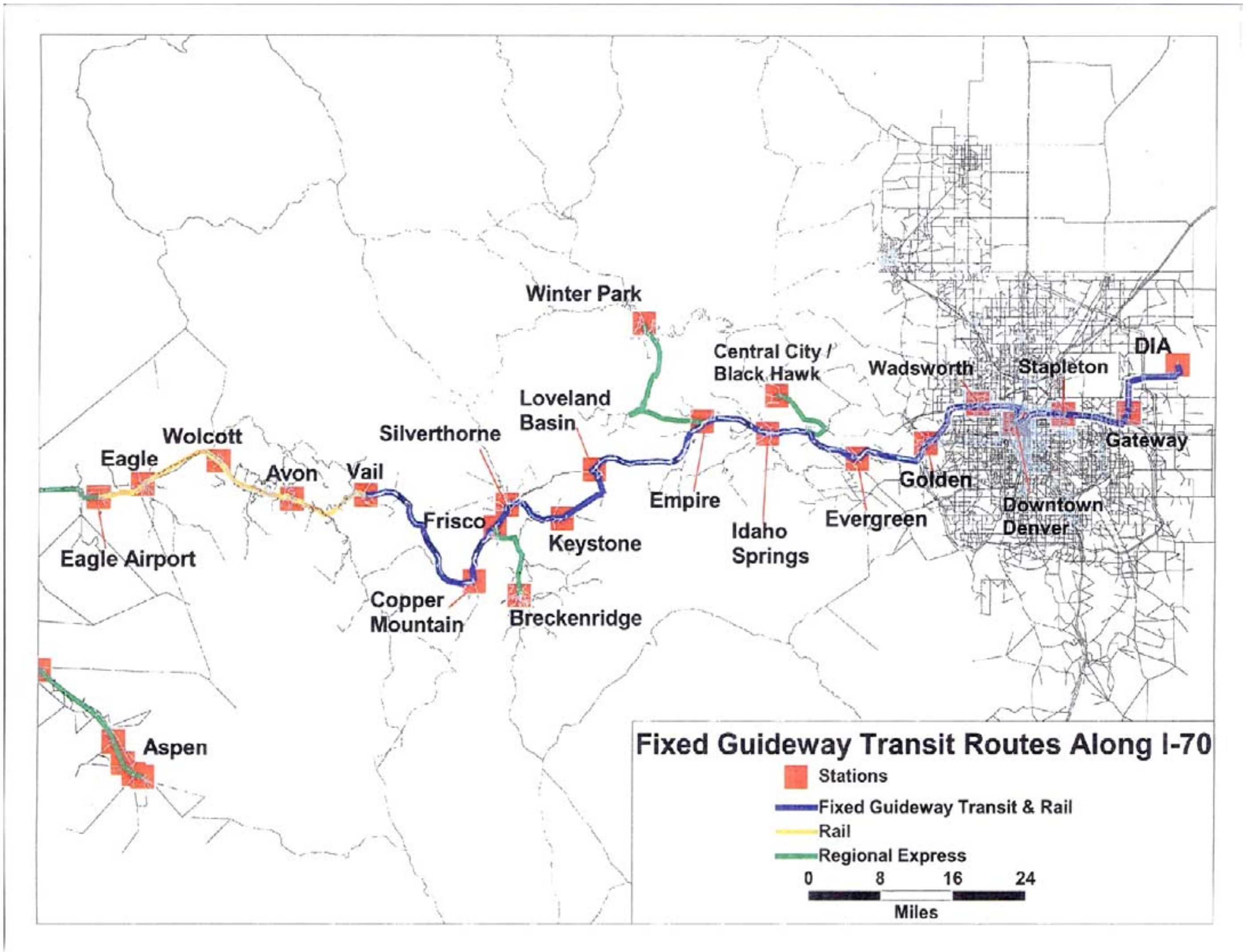


Figure B-3. Transit Routes: West of Eagle

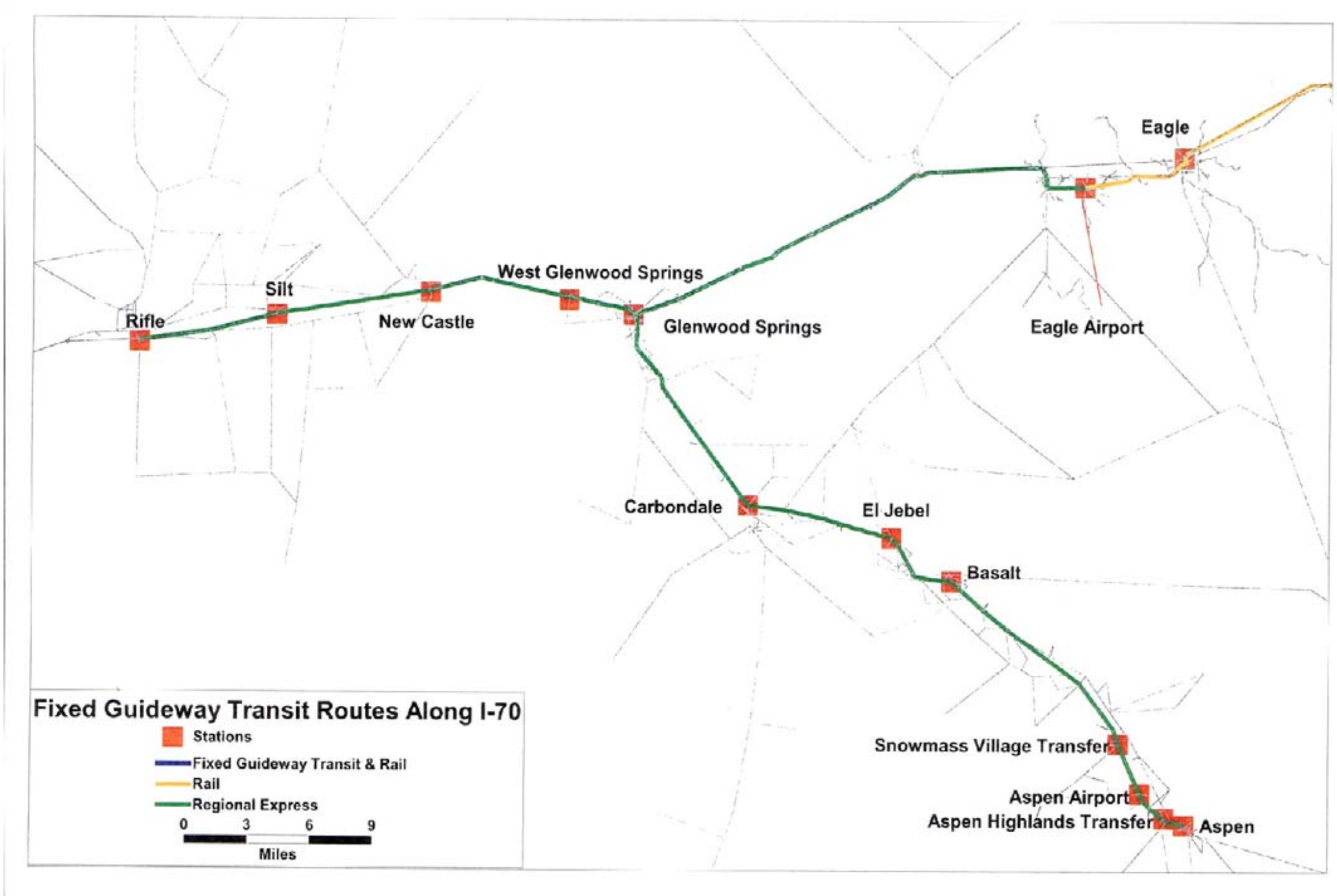


Table B-1 shows how an experimental design row was used to create a mode choice scenario. This table is a summary overview of the many calculations used to create the scenario levels on pages **B-28** to **B-34**. For instance, the table shows that eight possible values were used to specify the mode according to 1 = shuttle van, 2 = tour bus, 3 or 4 = guideway bus, 5 or 6 = train, 7 or 8 = monorail, thus producing the fractions shown in the % of Scenarios column, where all modes appear in 25 percent of the scenarios, except for shuttle van and tour bus, which appear only 12.5 percent of the time (1 out of 8).

Table B-1. Stated Preference Scenario Attributes

Attribute	Attribute Level	% of Scenarios
Transit line-haul mode	Shuttle van Tour bus Guideway bus Train Monorail	12.5 12.5 25 25 25
Transit boarding and alighting stations	Selected by respondent from map	
Transit access mode and time	Levels estimated by respondent	
Transit line-haul frequency	Peak period 3 min 5 min 10 min 15 min 20 min Off-peak period 5 min 10 min 15 min 20 min 30 min 40 min 60 min	 12.5 12.5 25 25 25 12.5 12.5 12.5 12.5 25 12.5 12.5
Food and drink service	No food or drink sold on board Snacks, drinks sold on board Snacks, drinks, meals sold on board	37.5 37.5 25
Extra luggage service	None Seasonal ski lockers to rent at resort stations (WINTER, if carrying skis) Free bicycle storage provided on board (SUMMER, if carrying bikes) Baggage checked through to resort hotels (if staying at a resort/hotel)	62.5 37.5 37.5 37.5
Air travel time saved going from Denver International Airport (DIA) instead (for Eagle County Airport or Pitkin County Airport interviews only)	If actually changed planes at DIA 90 min 120 min Otherwise 5 min 10 min 15 min 20 min 25 min 30 min	 50 50 12.5 25 12.5 25 12.5 12.5
Airfare time saved going from DIA instead (for Eagle County Airport or Pitkin County Airport interviews only)	$50 $100 $150 $200	25 25 25 25
Transit line-haul vehicle travel speed (% of base speed for mode)	70% 80% 90% 100% 110% 120% 130%	12.5 12.5 12.5 25 12.5 12.5 12.5
Transit egress mode (A= staying at a ski resort, B= staying at a hotel, C= other)	 Walk Walk or take a shuttle Transfer to a shuttle Transfer to a bus and a shuttle	A / B / C 50 / 37.5 / 0 50 / 25 / 25 0 / 37.5 / 50 0 / 0 / 25
Transit egress time	If egress mode is walk or walk/shuttle 2 min	 25

Attribute	Attribute Level	% of Scenarios
	5 min 10 min If egress mode is transfer to a shuttle 0 + respondent's estimated time 5 + respondent's estimated time 10 + respondent's estimated time 15 + respondent's estimated time 20 + respondent's estimated time If egress mode is transfer to a bus and shuttle 5 + respondent's estimated time 10 + respondent's estimated time 15 + respondent's estimated time 20 + respondent's estimated time 30 + respondent's estimated time 40 + respondent's estimated time	50 25 25 25 25 12.5 12.5 12.5 12.5 12.5 25 25 12.5
Transit line-haul adult fare (as % of base fare per mile)	40% 65% 85% 100% 125% 150% 200%	12.5 12.5 12.5 25 12.5 12.5 12.5
Transit line-haul adult fare roundtrip add-on (to reduce correlation with travel time)	minus $15 minus $10 minus $5 none plus $5 plus $10 plus $15	12.5 12.5 12.5 25 12.5 12.5 12.5
Transit children's fare, as % of adult fare	25% 50% 75% 100%	12.5 50 25 12.5
EXISTING MODE		
Car parking cost, as % of actual reported parking cost	0% 50% 100% 150% 200%	12.5 12.5 50 12.5 12.5
Car fuel cost, as % of actual reported fuel cost	100% 150% 200%	75 12.5 12.5
Shuttle fare cost, as % of actual reported fare cost (only for actual shuttle users)	60% 80% 100% 120% 150%	12.5 12.5 50 12.5 12.5
Weather conditions (used in winter survey only)	clear low visibility icy roads low visibility and icy roads actual reported	12.5 12.5 12.5 12.5 50

Attribute	Attribute Level	% of Scenarios
Traffic congestion level	actual reported moderate fairly heavy extremely heavy	37.5 12.5 25 25
Car in-vehicle travel time Change in reported travel time based on change in weather conditions and/or traffic congestion level in the scenario	X% time increase for each level increase in traffic congestion compared to reported, Y% = for each level deterioration in weather conditions compare to reported, X and Y = 5% 10% 15% 20% If weather and traffic conditions improve compared to reported, then the travel time is reduced proportionally toward free flow time	25 25 25 25

Table B-2 shows the base speeds and fares per mile for each transit mode alternative, as well as the possible ranges in those variables once the variations from the experimental design have been applied (up to plus or minus 30 percent for speeds and from minus 60 percent up to plus 100 percent for fares. Note that an extra amount in the range of minus $15 to plus $15 was also added to the fare to reduce the correlation with travel time, because fare and time are based directly on line-haul distance. With this extra amount, the Transit alternatives could actually be free in a small percent of cases.

Table B-2. Speed and Fare Ranges for Alternative Transit Modes

Alternative Mode	Percent of scenarios	Speed range (miles per hour)	Fare range (cents per mile)	Fare of an existing comparable service in the region
Shuttle van	12.5	37–69 mph	0–55 cpm	Colorado Mountain Express = 55 cpm
Tour bus	12.5	42–78 mph	0–35 cpm	Greyhound = 15 cpm
Guideway bus	25	42–78 mph	0–45 cpm	None exists
Train	25	42–78 mph	0–45 cpm	Amtrak = 25 cpm
Monorail	25	49–91 mph	0–45 cpm	None exists

Figure B-4 through **Figure B-12** show pictures of screens and responses from an actual, randomly selected interview. In this case, the person lived in Breckenridge and was traveling into Denver to attend a Colorado Rockies' game. This demonstrates that the survey is flexible enough to not only capture recreation trips from the Front Range to the Corridor, but also to apply to Corridor residents traveling to the Front Range or within the Corridor. Some things to note in the example scenarios and responses include:

- In this case, the person would not pay a toll of $3 to save about 5 minutes on the road—the 5 minutes being the time the person thought he had lost due to traffic congestion (**Figure B-4**).
- In this case, the person said that he would board the transit service at Breckenridge (**Figure B-5**) and get off in Downtown Denver.
- In this case, guideway bus is the alternative mode in two of the five choices (**Figure B-7** and **Figure B-11**) and monorail does not appear. This is "the luck of the draw"; the odds were just as good that monorail would appear twice and guideway bus not at all.

- The person chose the transit mode in three of the five options (**Figure B-8**, **Figure B-9**, and **Figure B-11**) and private vehicle in the other two (**Figure B-7** and **Figure B-10**). The transit fare appears to have an influence on the choices, although in two cases (**Figure B-9** and **Figure B-11**) the respondent chose transit even though it was more expensive than driving.
- This person does not think that having the guideway bus service available as shown (from Choice Scenario 5, shown in **Figure B-11**) would induce him to make any additional trips in the Corridor (**Figure B-12**).

Note: These are example choices from only one respondent from among thousands. No policy implications should be read into these few responses.

Figure B-4. Screen Shot, Toll Lane Question

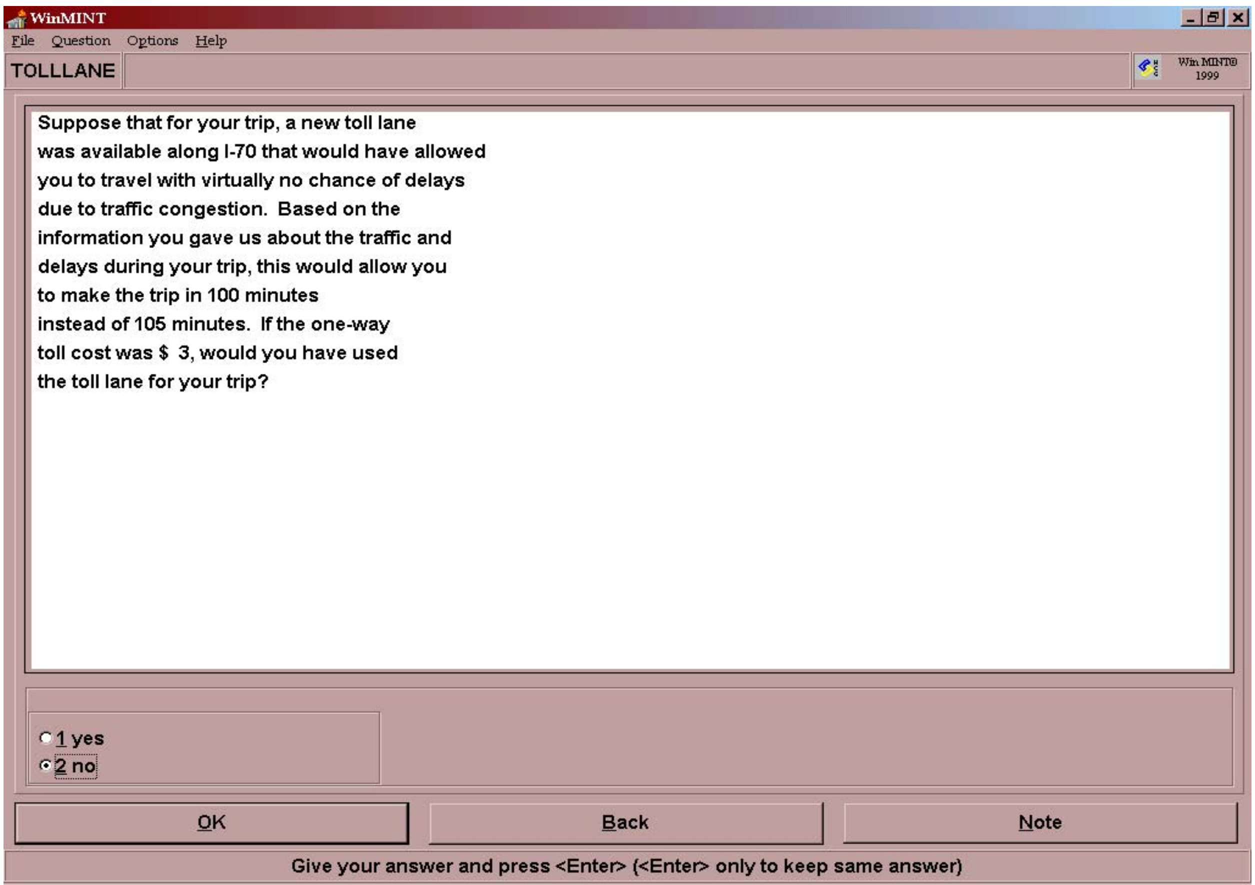


Figure B-5. Screen Shot, Access Station Question

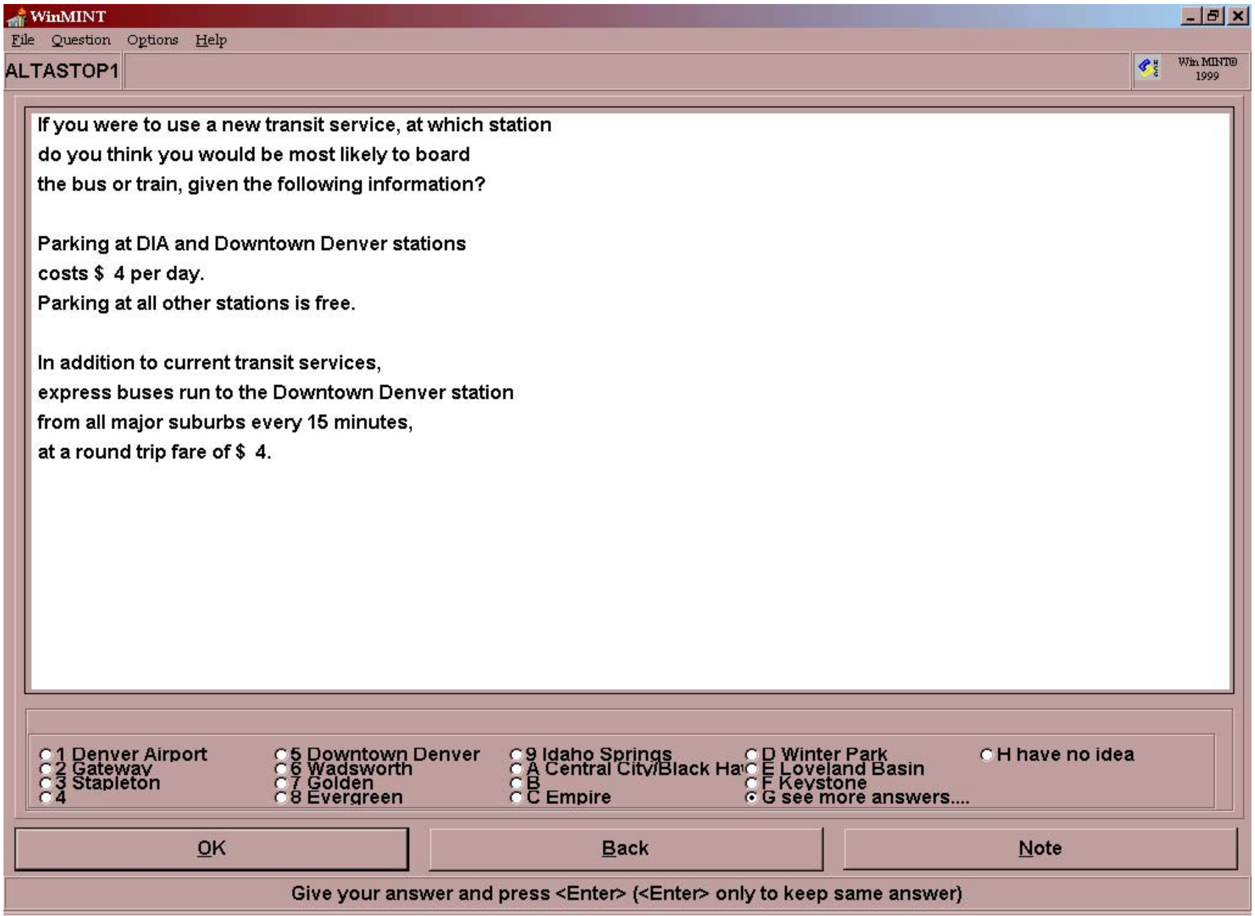


Figure B-6. Screen Shot, Introduction to Mode Choice Questions

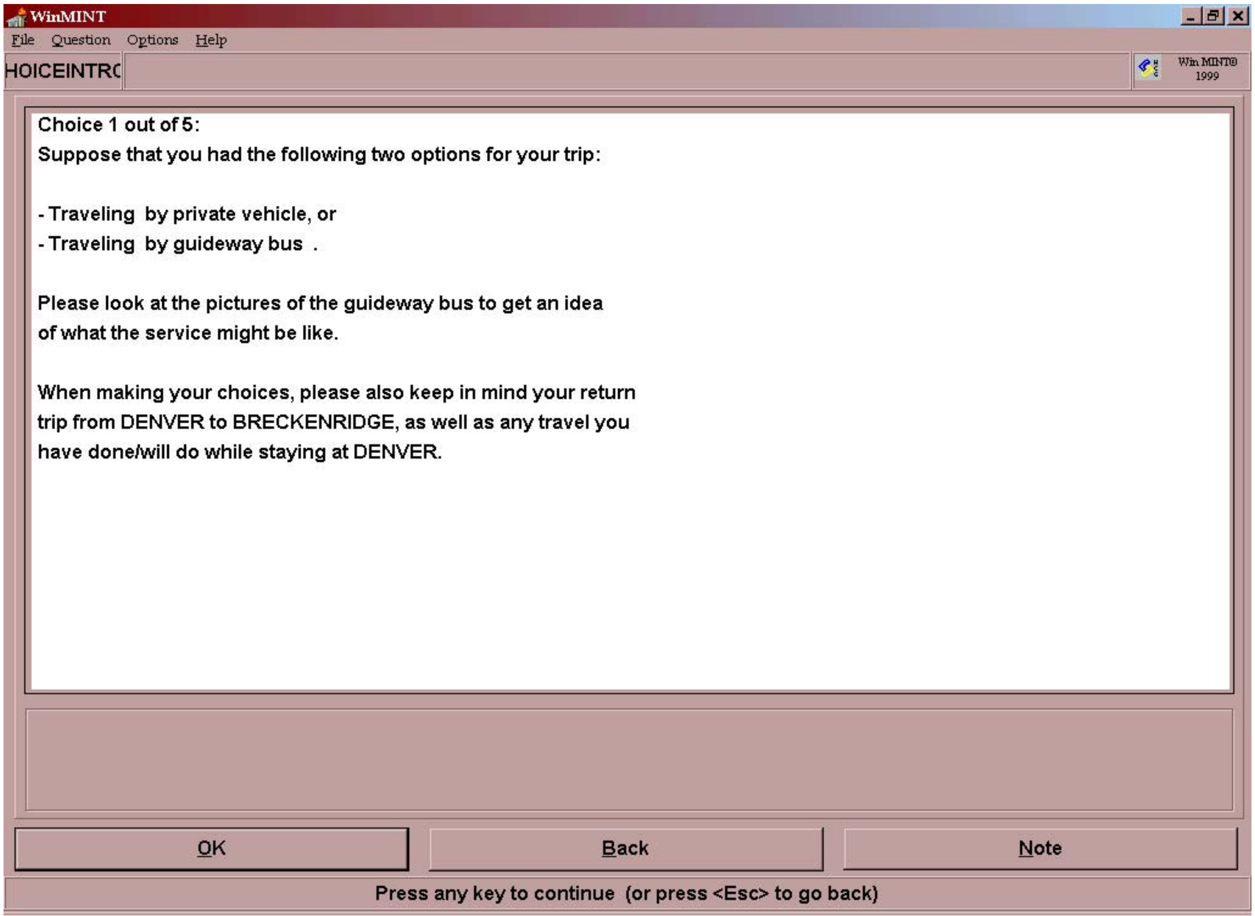


Figure B-7. Screen Shot, First Mode Choice Question

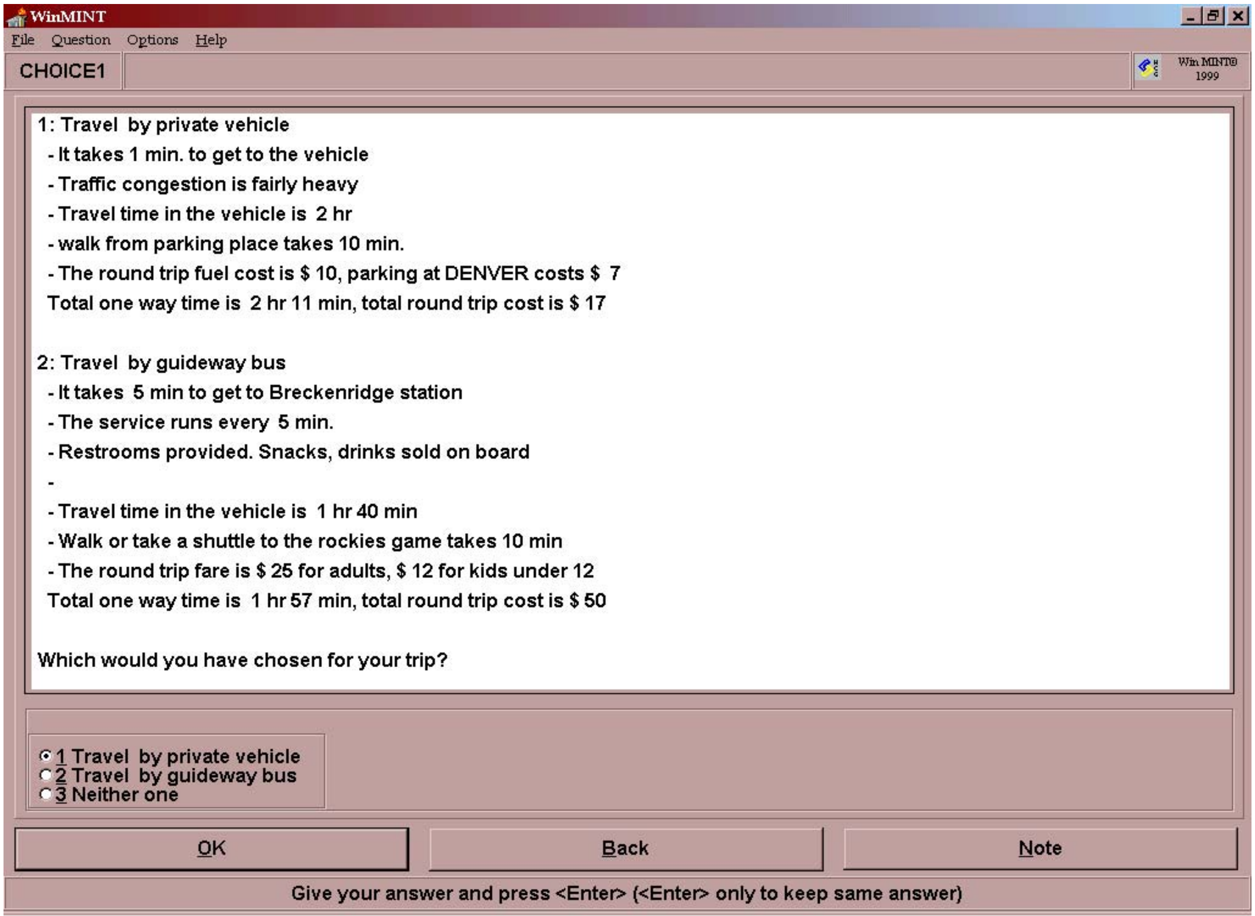


Figure B-8. Screen Shot, Second Mode Choice Question

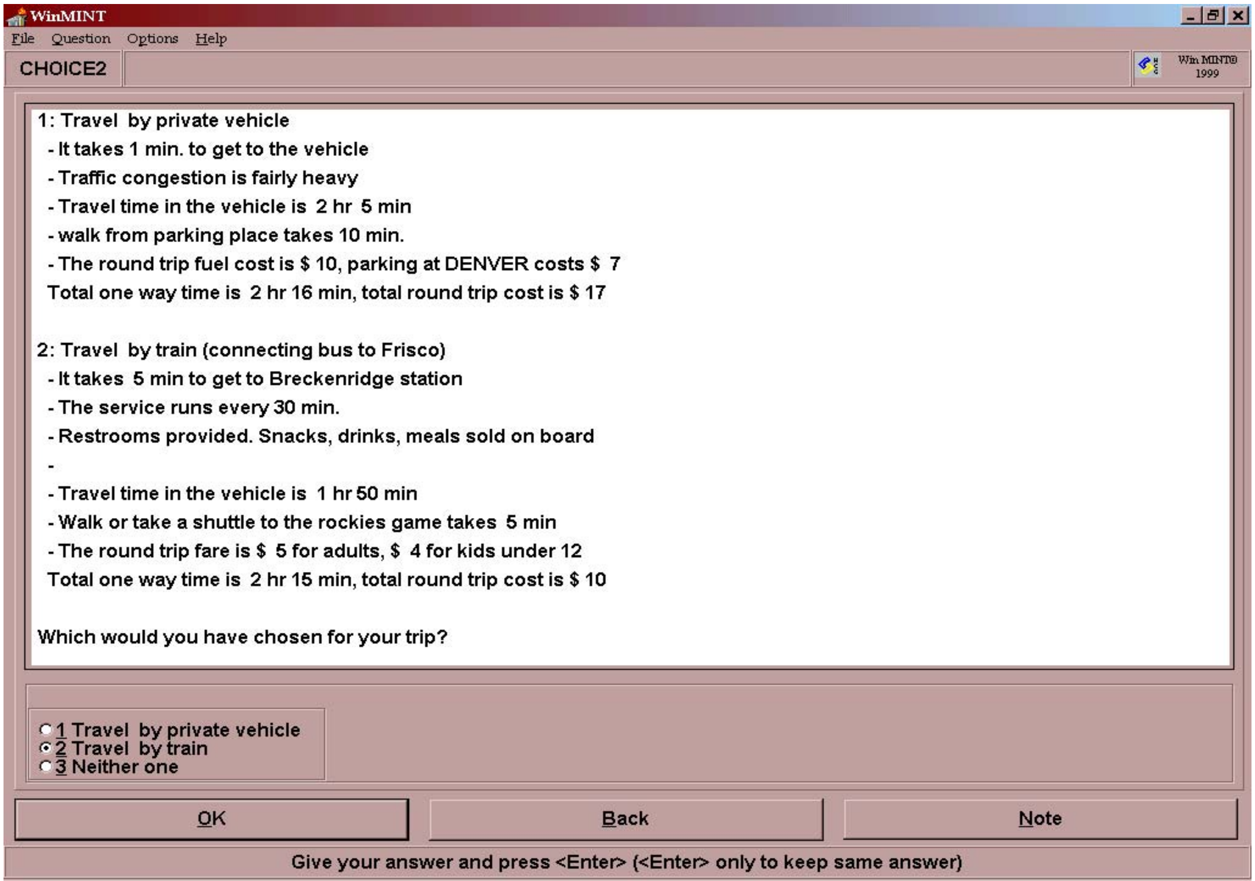


Figure B-9. Screen Shot, Third Mode Choice Question

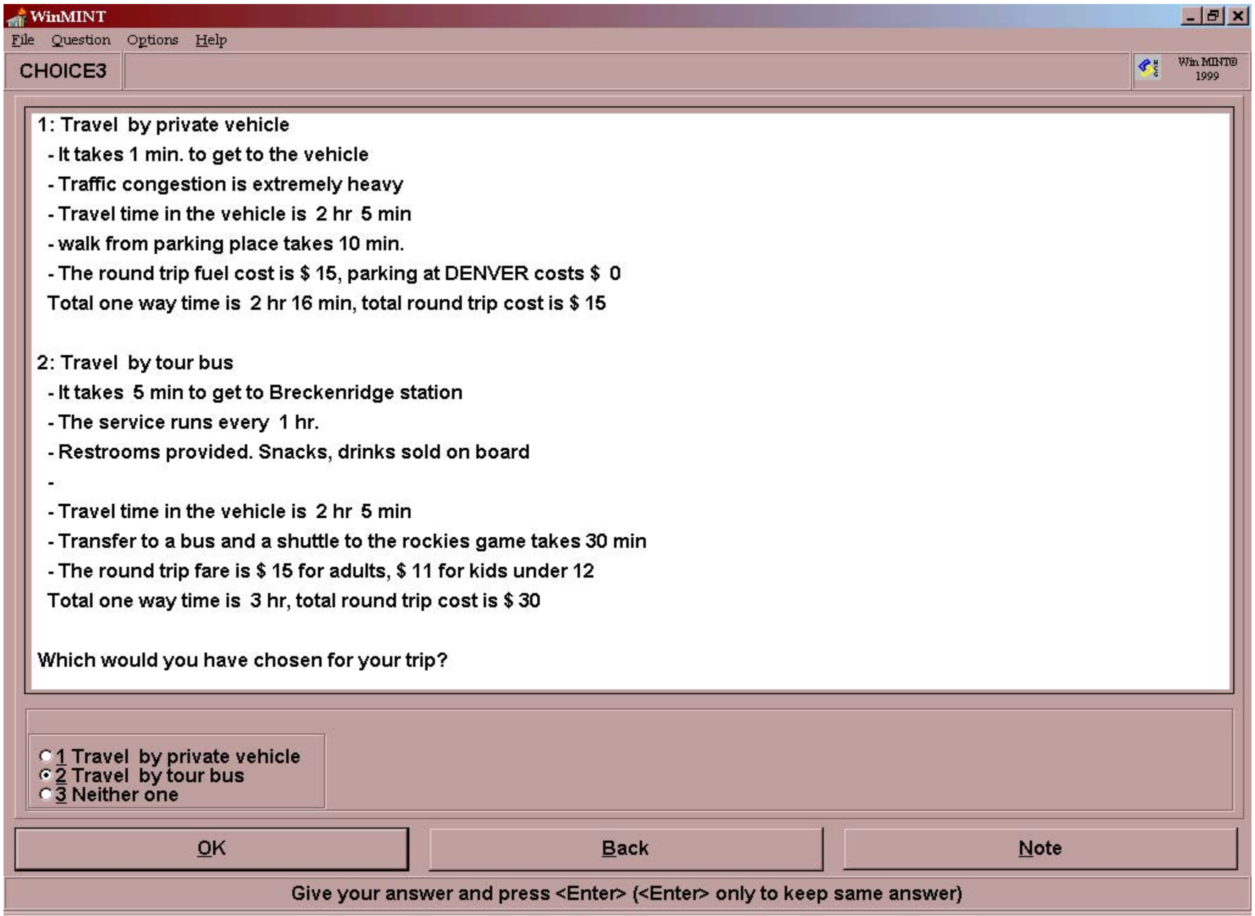


Figure B-10. Screen Shot, Fourth Mode Choice Question

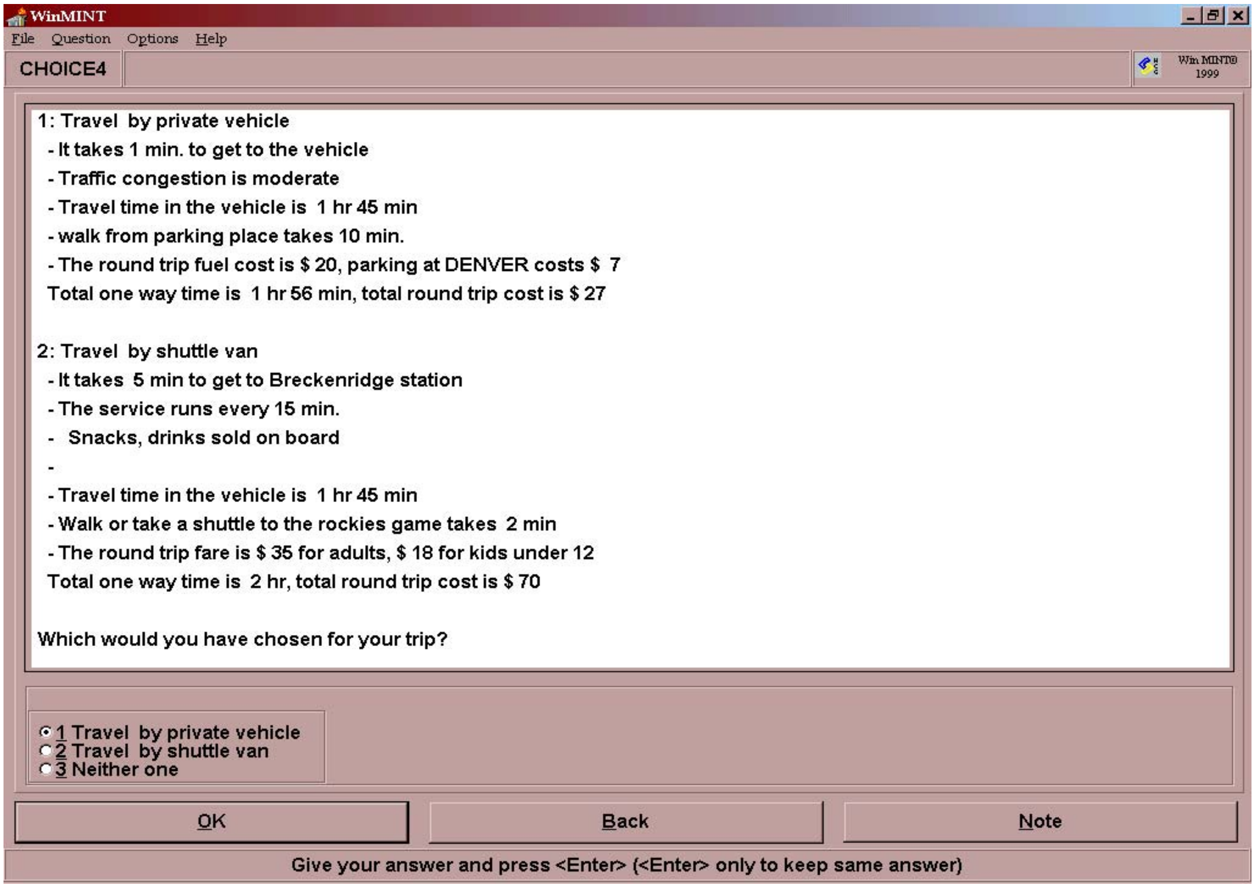


Figure B-11. Screen Shot, Fifth Mode Choice Question

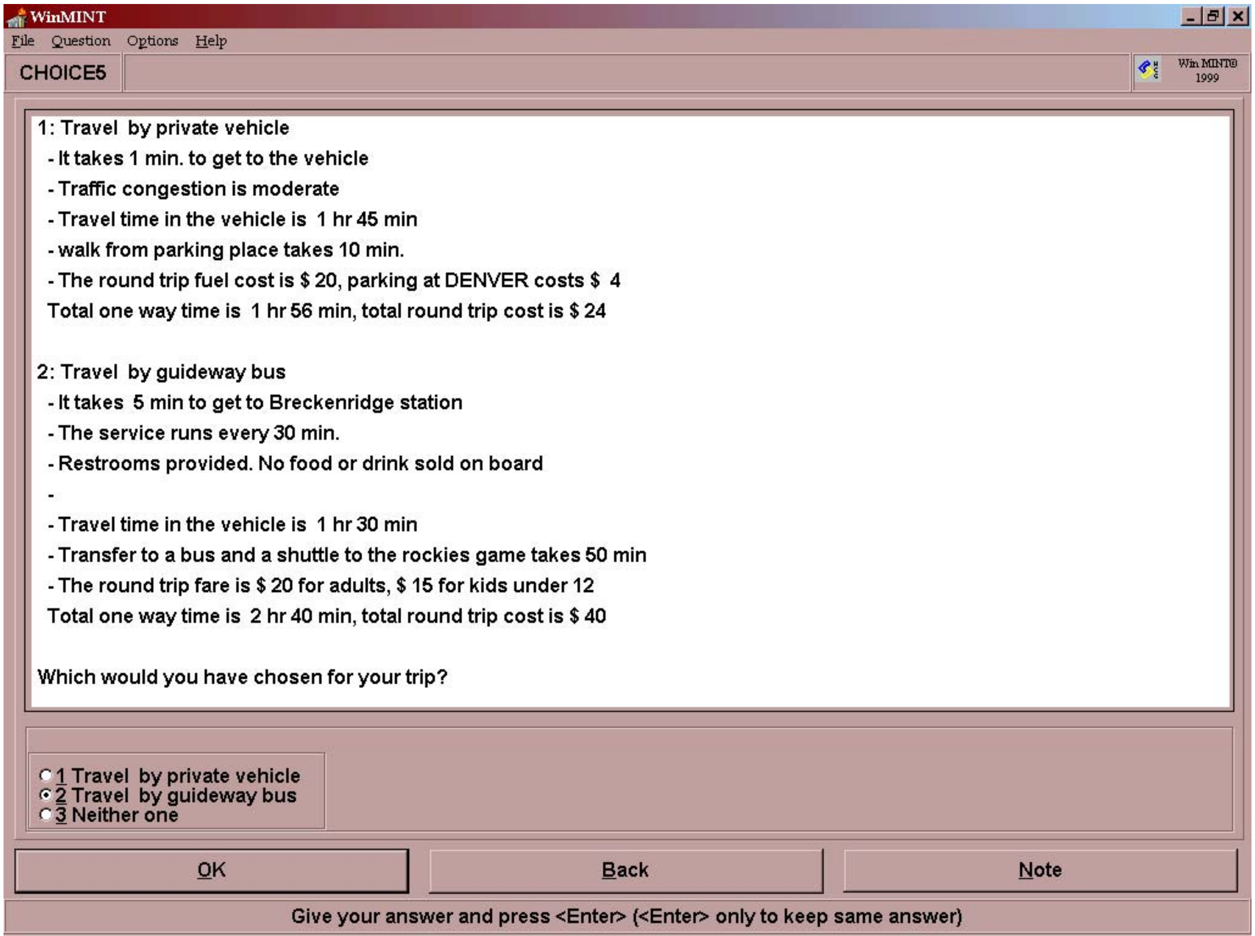
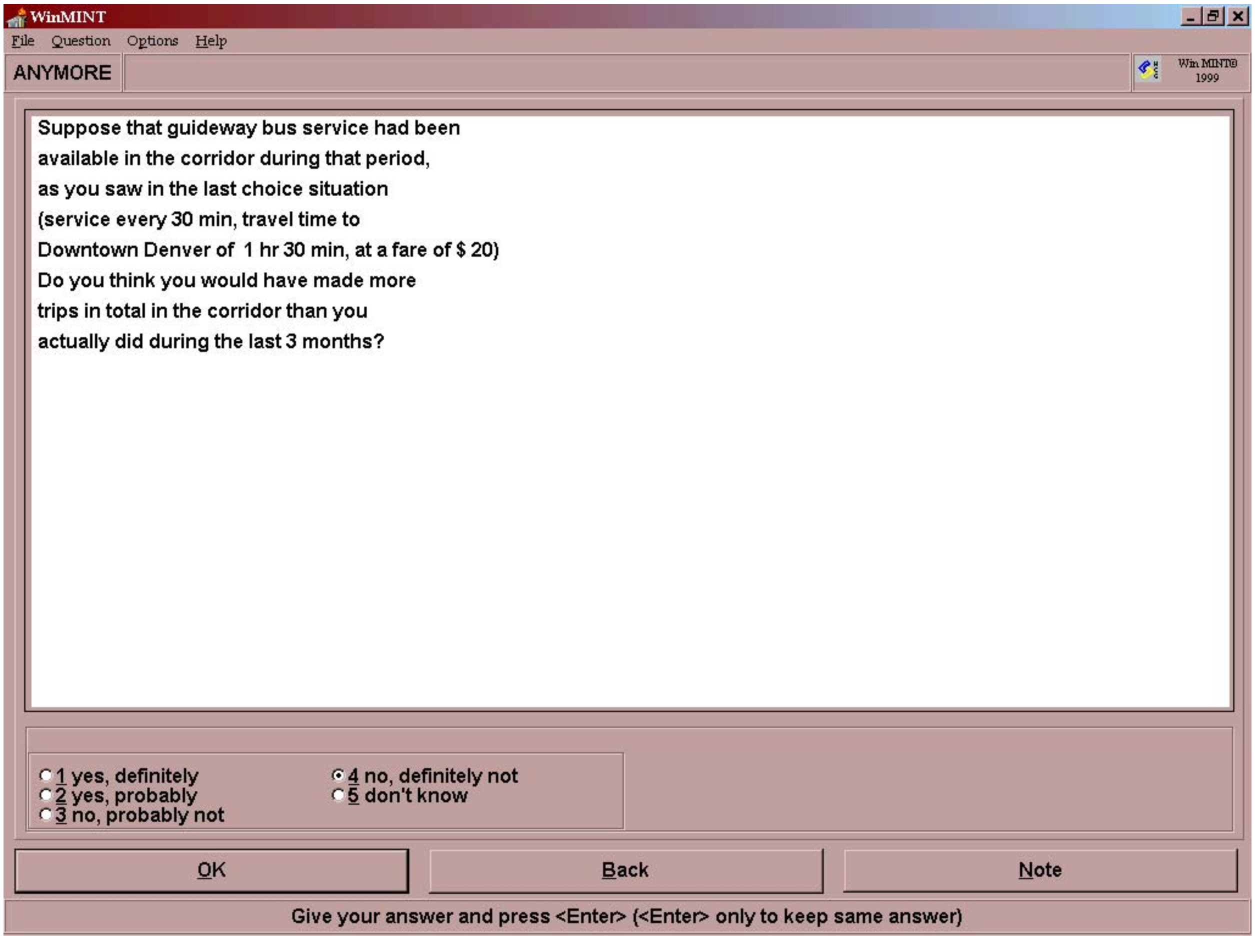


Figure B-12. Screen Shot, Induced Travel Question



B.4 The Survey Questionnaire

The following section is translated from the language used in WinMINT computer-assisted personal interview (CAPI) software. Text that respondents actually see on the screen is shown in **Bold**, with question answers and calculated values substituted where question names appear.

All other text in CAPS is for logic and calculation. Text shown in *Italics* is a comment.

>>>> Section 1. Introduction and verification of in-scope trip <<<<

VERSION
THE QUESTIONNAIRE VERSION INDICATOR:
1 = PILOT
2 = INITIAL WINTER
3 = FINAL WINTER
4 = SUMMER

PRACTICE
INTERVIEWER: IS THIS INTERVIEW FOR PRACTICE, FOR THE PILOT OR FOR THE FINAL SURVEY?

1. **practice**
2. **pilot**
3. **final**

Appendix B. I-70 Ridership Survey

SITE
INTERVIEWER: ENTER SURVEY SITE

WINTER SITES

1. **Denver International Airport**
2. **Eagle County Airport**
3. **Pitkin County Airport**
4. **Breckenridge**
5. **Vail**
6. **Winter Park**
7. **Copper Mountain**
8. **Keystone**
9. **Loveland**
10. **Idaho Springs**
11. **Frisco Safeway**
12. **West Vail Safeway**
13. **Denver Sporting Goods**
14. **Total Gas Station**
15. **Leadville Safeway**
16. **Other Retail Stores**
17. **New Castle/Rifle Grocery**
18. **King Soopers-Littleton**
19. **Denver Region Shopping Mall**

SUMMER SITES

1. **Denver International Airport**
2. **Eagle County Airport**
3. **Pitkin County Airport**
4. **Breckenridge**
5. **Vail**
6. **Winter Park**
7. **Copper Mountain**
8. **Keystone**
9. **Georgetown**
10. **Idaho Springs**
11. **Blackhawk/Central City**
12. **Frisco**
13. **Silverthorne**
14. **Avon**
15. **Edwards**
16. **Shrine Pass**
17. **Gypsum**
18. **New Castle**
19. **Glenwood**
20. **Dillon/Marina**
21. **Herman Gulch**
22. **Empire/Campgrounds**
23. **Eagle (non-airport)**
24. **Aspen (non-airport)**

IF SITE>3 *(non-Airport interview)* SKIP TO DAYSBACK

ASK ONLY IF SITE=3 *(Pitkin County Airport)*
PITTRIP
Did you recently make a trip flying in to this airport to visit a destination in the Aspen area?

1. **yes**
2. **no**

IF SITE=3 AND PITTRIP=2 SKIP TO END
IF SITE=3 AND PITTRIP=1 SKIP TO DAYSBACK1

APTTRIP
Are you returning from a trip to a destination on or near the intermountain portion of Interstate 70, that section from C-470 to Rifle, west of Denver?

1. **yes**
2. **no**

IF SITE<3 AND APTTRIP=2 SKIP TO END

APTROUND
Please think back to when you traveled TO your destination on or near the I-70 corridor, that section from C-470 to Rifle. Did you travel there from this same airport?

1. **yes**
2. **no**

IF SITE<3 AND APTROUND=2 SKIP TO END

DAYSBACK1
How long ago was that trip from this airport to your destination?

1. **today**
2. **yesterday**
3. **within the last week**
4. **within the last two weeks**
5. **more than two weeks ago**

IF SITE<4 *(airport interview)* SKIP TO DAYOFWEEK

DAYSBACK
Please think back to the most recent trip you made of 20 miles or longer to a destination in the intermountain corridor of I-70 (between C-470 and Rifle). (If that trip was to return home, please think back to the trip before that when you left home.)

How long ago was that trip?

1. **today**
2. **yesterday**
3. **within the last week**
4. **within the last two weeks**
5. **more than two weeks ago**
6. **more than 1 month ago**
7. **more than 4 months ago / never**

IF DAYSBACK=7 SKIP TO END

>>>> Section 2. Details of the journey by the existing mode <<<<

DAYOFWEEK
What day of the week was that?

1. **Saturday**
2. **Sunday**
3. **Monday**
4. **Tuesday**
5. **Wednesday**
6. **Thursday**
7. **Friday**

ASK ONLY IF SITE=2 OR SITE=3 (Eagle or Pitkin Airport interview)
XFERDENV
Did you change planes at Denver International Airport on that flight to SITE?

1. **yes**
2. **no**

PURPOSE
What was your main reason for making that trip?

1. **ski, alpine/cross country or boarding *(WINTER)***
   resort-based recreation *(SUMMER)*
2. **for other sport or recreation**
3. **for sightseeing**
4. **to visit friends or family**
5. **to go to work**
6. **to go to school**
7. **for a business appointment**
8. **to shop or run errands**
9. **to pick up/drop off others**
10. **other (specify)**

IF SITE<4 *(airport interview)* SET ORIGTYP=12 AND SKIP TO DESTTYPE
ORIGTYP
From what type of place did you begin that trip?

1. **primary home**
2. **second home**
3. **hotel/motel**
4. **campground**
5. **RV park**
6. **ski resort**
7. **trailhead**
8. **work**
9. **school**
10. **store**
11. **other (specify)**
12. **airport**

ORIG
What is the name of the town or place where that is located?

1. **ARAPAHOE BASIN SKI AREA**
2. **ARAPAHO NATIONAL FOREST**
3. **ARVADA**
4. **ASPEN**
5. **ASPEN HIGHLANDS**
6. **AURORA**
7. **AVON**
8. **BAKERSVILLE**
9. **BASALT**
10. **BEAVER CREEK**
11. **BELLVUE**
12. **BERTHOUD**
13. **BLACK HAWK**
14. **BOULDER**
15. **BRECKENRIDGE**
16. **BRIGHTON**
17. **BROOMFIELD**
18. **CARBONDALE**
19. **CASCADE**
20. **CASTLE ROCK**
21. **CENTRAL CITY**
22. **CHERRY HILLS VILLAGE**
23. **COLORADO SPRINGS**
24. **COPPER MOUNTAIN RESORT**
25. **DENVER**
26. **DENVER INT. AIRPORT**
27. **DILLON**
28. **DOWNIEVILLE**
29. **DUMONT**
30. **EAGLE**
31. **EAGLE COUNTY AIRPORT**
32. **EDWARDS**

33. EL JEBEL
34. EMPIRE
35. ENGLEWOOD
36. ESTES PARK
37. EVERGREEN
38. FAIRPLAY
39. FLATOPS WILDERNESS
40. FORT COLLINS
41. FOUNTAIN
42. FRASER
43. FRISCO
44. GENESSE
45. GEORGETOWN
46. GLENWOOD SPRINGS
47. GOLDEN
48. GRANBY
49. GRAND JUNCTION
50. GRAND LAKE
51. GREELEY
52. GYPSUM
53. HOT SULPHUR SPRINGS
54. HUNTER/FRY PAN WILDERNESS
55. INDIAN HILLS
56. IDAHO SPRINGS
57. JEFFERSON CTY-UNINCORP.
58. JEFFERSON CTY OPEN SPACE
59. KEYSTONE
60. KREMMLING
61. LAKEWOOD
62. LAKE DILLON
63. LEADVILLE
64. LITTLETON
65. LONGMONT
66. LOOKOUT MOUNTAIN
67. LOVELAND (city)
68. LOVELAND (resort)
69. LYONS
70. MARBLE
71. MAROON BELLS/SNOW WILD.
72. MINTURN
73. MOUNT EVANS
74. MORRISON
75. NEDERLAND
76. NEW CASTLE
77. NORTHGLENN
78. PARK MEADOWS
79. PARKER
80. PITKIN COUNTY AIRPORT
81. PUEBLO
82. RED CLIFF
83. REDSTONE
84. RIFLE
85. ROLLINSVILLE
86. ROOSEVELT NATIONAL FOREST
87. SEDALIA
88. SILT
89. SILVERTHORNE
90. SILVER PLUME
91. SNOWMASS VILLAGE
92. STEAMBOAT SPRINGS
93. STRASBURG
94. SUMMIT COUNTY

95. VAIL
96. VAIL PASS
97. WESTMINSTER
98. WEST GLENWOOD SPRINGS
99. WHEAT RIDGE
100. WHITE RIVER NF-EAGLE CTY
101. WHITE RIVER NF-GRAND CTY
102. WHITE RIVER NF-PITKIN CTY
103. WINTER PARK
104. WOLCOTT
105. other (specify)

DESTTYPE
What type place was your destination for that trip?

1. primary home
2. second home
3. hotel/motel
4. campground
5. RV park
6. ski area
7. trailhead
8. work
9. school
10. store
11. other (specify)

DEST
What is the name of the town or place where that is located?

REPEAT LIST FROM ORIG

OVERNIGHT
Did you/will you stay at that destination overnight?

1. yes
2. no
3. not certain

ASK ONLY IF OVERNIGHT = 1
NIGHTS
How many nights did you/will you stay there?

____ **Give a number in the range 1 to 999**

MODE
What was your main means of transportation to get from ORIG to DEST?

1. private vehicle
2. rental vehicle
3. taxi
4. limousine
5. shuttle van
6. charter bus
7. local bus
8. Greyhound bus
9. train
10. RV/camper
11. other (specify)

IF MODE>8 SKIP TO END

GROUPSIZE
How many people made the trip with you in your party, not including yourself?

____**Give a number in the range 0 to 20**

ASK ONLY IF GROUPSIZE>0
GROUPKIDS
Of those, how many were children under age 12?

____**Give a number in the range 0 to GROUPSIZE**

ASK ONLY IF GROUPSIZE>0
GROUPNONHH
And how many were not members of your household?

____**Give a number in the range 0 to GROUPSIZE**

LUGGAGE1
(WINTER)
Were you carrying skis, snowboards and/or snowshoes with you?
(SUMMER)
Were you carrying bicycles with you?

1. **yes**
2. **no**

LUGGAGE2
Were you carrying any other gear much larger than a suitcase? This might include camping or sporting equipment.

1. **yes**
2. **no**

DEPARTTIME
What time of day did you leave ORIG to travel to DEST?

1. **midnight - 6 AM**
2. **6:00 - 6:59 AM**
3. **7:00 - 7:59 AM**
4. **8:00 - 8:59 AM**
5. **9:00 - 9:59 AM**
6. **10:00 - 11:59 AM**
7. **12:00 - 2:59 PM**
8. **3:00 - 6:59 PM**
9. **7:00 - 8:59 PM**
10. **9:00 PM - midnight**

ASK ONLY IF SITE>3 (non-airport interview)
ACCESSMODE
How did you first get to the MODE that you traveled in to DEST?

1. **walked to where it was parked**
2. **rode with someone else**
3. **drove to a park and ride lot**
4. **took public transit from stop**
5. **picked up at door/taxi/limo/van**
6. **other (specify)**

ACCESSTIME
How many minutes did it take you to get from the ORIGTYPE to the vehicle you traveled in?

____**Give a number in the range 0 to 120**

ASKED ONLY IN WINTER – IN SUMMER WEATHER SET TO 1 (clear)
WEATHER
Which of the following best describes the road conditions due to weather along

the highway during your trip to DEST?

- clear (good roads and visibility)
- low visibility (but roads not slippery)
- icy roads (but visibility OK)
- low visibility and icy roads

1. **clear**
2. **low visibility**
3. **icy roads**
4. **low visibility and icy roads**

CONGLEVEL
And which of the following best describes the level of traffic congestion along the highway in the mountains during your trip to DEST?

- very light (no slowdown due to traffic)
- moderate (some slowdown due to traffic)
- fairly heavy (some very slow driving to traffic)
- extremely heavy (some stop and go stretches)

1. **very light**
2. **moderate**
3. **fairly heavy**
4. **extremely heavy**

INVEHTIME
How many minutes did the trip in the vehicle take you, from the time you left ORIG until the time you arrived at DEST?
Do not include any stops you made on the way for gas, food or other purposes.

____Give a number in the range 0 to 120

ASK IF CONGLEVEL1>1
FREEFLOWTIMEX1
About how many minutes do you think that the trip in the vehicle would have taken you if there had been very little traffic on the roads?
[You said the trip actually took you INVEHTIME minutes and that the road conditions were WEATHER]

_____ Give a number in the range 0 to INVEHTIME

FREEFLOWTIME1
IF CONGLEVEL = 1, SET TO INVEHTIME - 5
OTHERWISE SET TO FREEFLOWTIMEX1
IF THE RESULT IS LESS THAN INVEHTIME / 2, SET TO INVEHTIME / 2

ASK IF WEATHER>1
FREEFLOWTIMEX2
About how many minutes do you think that the trip in the vehicle would have taken you if there had been very little traffic on the roads
AND the weather and the roads were clear?
[You said the trip actually took you INVEHTIME minutes]

_____ Give a number in the range 0 to INVEHTIME

FREEFLOWTIME2
IF WEATHER = 1, SET TO FREEFLOWTIME1
OTHERWISE SET TO FREEFLOWTIMEX2
IF THE RESULT IS LESS THAN INVEHTIME / 2, SET TO INVEHTIME / 2

EGRESSMODE
How did you get from where you left the vehicle to your final destination?

1. **walk from parking place**
2. **dropped off at the door**
3. **ride in a shuttle/bus**
4. **ride with someone else**
5. **other (specify)**

EGRESSTIME
And how many minutes did that take (including any time waiting to get picked up)?

____**Give a number in the range 0 to 999**

ASK IF MODE<3
FUELCOST
About how many dollars would you estimate that it cost you to buy fuel for the trip from ORIG to DEST and back again?
[Round trip estimate, to the nearest dollar]

____**Give a number in the range 0 to 999**

ASK IF MODE=2
RENTALCOST
About how many dollars did/will the rental vehicle cost you for your trip to DEST, not including fuel?

____**Give a number in the range 0 to 999**

ASK IF MODE<3
PARKCOST
And about how many dollars would you estimate that it cost you to park at your destination in DEST for the entire time you stayed/ will stay there?

____**Give a number in the range 0 to 999**

ASK IF MODE<3 AND OVERNIGHT=1
CARUSE
How often did you/will you use your MODE while staying at DEST?

1. **not at all, left it parked**
2. **once or twice**
3. **3 or 4 times**
4. **5 times or more**

ASK IF MODE>2
FARECOST
About how many dollars did it/will it cost in fares to travel from ORIG to DEST and back again by MODE?
SET TEMP1 = GROUPSIZE + 1
[Round trip estimate, for TEMP1 person(s)]

____**Give a number in the range 0 to 999**

ASK IF MODE>2 AND OVERNIGHT=1
GETAROUND
How did you/will you get around the area while staying at DEST?
[If more than one applies, give the one used most often]

1. **not go anywhere else**
2. **rent a vehicle**
3. **take a hotel shuttle**
4. **take a local bus**
5. **ride with someone else**
6. **take a taxi/limo**
7. **other (specify)**

>>>> Section 3. A hypothetical question about paying for a toll lane <<<<

SET TOLLCOST RANDOMLY TO $1, $2, $3, $4 or $5

ASK IF MODE<3 (car trip)
TOLLLANE
Suppose that for your trip, a new toll lane was available along I-70 that would have allowed you to travel with virtually no chance of delays due to traffic congestion. Based on the information you gave us about the traffic and weather during your trip, this would allow you to make the trip in FREEFLOWTIME1 minutes instead of INVEHTIME minutes. If the one-way toll cost was TOLLCOST, would you have used the toll lane for your trip?

1. **yes**
2. **no**

>>>> Section 4. Questions about probable access and egress stations and times for the new mode <<<

CHOICEINTRO
FOR ALL SITES EXCEPT EAGLE AIRPORT AND PITKIN AIRPORT
For the next series of questions, we would like you to imagine that there is a new bus or rail service running along the Interstate 70 corridor.

The questions relate to the trip you have just described for us between ORIG and DEST.
First, we ask a couple of questions about where you would get on and off the bus or train.
Then, you will be shown 5 different situations where you will be asked to choose between going by MODE or else using a new transit service.

FOR SITES EAGLE AIRPORT AND PITKIN AIRPORT
For the next series of questions, we would like you to imagine that there is a new bus or rail service running along the Interstate 70 corridor from Denver International Airport. Instead of flying to SITE, you could save on airfare by flying to Denver and taking the new bus or rail service to your destination.

The questions relate to the trip you have just described for us to DEST.
First, we ask a couple of questions about where you would get off the bus or train.
Then, you will be shown 5 different situations where you will be asked to choose between going by MODE from SITE or else using a new transit service from Denver Airport.

SET SPARKCOST RANDOMLY TO $4, $6, $8, $10 or $12

SET SBUSFREQ RANDOMLY TO 15, 30 or 60

SET SBUSFARE RANDOMLY TO $2, $4 or $6

IF SITE<4 *(airport interview)* SKIP TO ALTESTOP1
ALTASTOP1
If you were to use a new transit service, at which station do you think you would be most likely to board the bus or train, given the following information?

Parking at DIA and Downtown Denver stations costs SPARKCOST per day.
Parking at all other stations is free.

In addition to current transit services, express buses run to the Downtown Denver station from all major suburbs every SBUSFREQ, at a round trip fare of SBUSFARE.

1. **Denver Airport**
2. **Gateway**
3. **Stapleton**
4. **Downing**
5. **Downtown Denver**
6. **Wadsworth**
7. **Golden**
8. **Evergreen**
9. **Idaho Springs**
10. **Central City/Black Hawk**
11. **Empire**
12. **Winter Park**
13. **Loveland Basin**
14. **Keystone**
15. **Silverthorne**
16. **Frisco**
17. **Breckenridge**
18. **Copper Mountain**
19. **Vail**
20. **Avon**
21. **Wolcott**
22. **Eagle**
23. **Eagle Airport**
24. **Glenwood Springs**
25. **West Glenwood Springs**
26. **Carbondale**
27. **El Jebel**
28. **Basalt**
29. **Snowmass Village Trfr**
30. **Pitkin County Airport**
31. **Aspen Highlands Trfr**
32. **Aspen**
33. **New Castle**
34. **Silt**
35. **Rifle**
36. **have no idea**

ASK ONLY IF ALTASTOP1<36
ALTAMODE
How would you be most likely to get to that stop from where you begin your trip at ORIG?

1. **drive and park at station**
2. **get dropped off at station**
3. **take express bus service**
4. **take existing bus/light rail**

5. **walk all the way**
6. **other (specify)**

ASK ONLY IF ALTASTOP1<36
ALTATIME1
And about how many minutes do you think that would take you, from ORIGTYPE to the station?
(Use 999 if you have no idea)

____**Give a number in the range 0 to 999**

ALTESTOP1
At which station do you think you would be most likely to GET OFF the bus or train to get to your destination at DEST?

REPEAT LIST FROM ALTASTOP1

ASK ONLY IF DESTTYPE<>6 AND ALTESTOP1<36
ALTETIME1
Suppose for the moment that connecting bus service were available to take you right to your destination (the DESTTYPE). About how many minutes do you think that would take from the station if there were no stops in-between?

(Use 999 if you have no idea. Use walk time if that would be quicker.)

____**Give a number in the range 0 to 999**

* SET UP SOME VALUES FOR USE IN THE 5 CHOICES

FROM FILE ACCESS1.DAT, LOOK UP RECORD FOR PLACE ORIG *(using text string)*
AND READ:
TEMP5=DEFAULT ACCESS STATION NUMBER (1-35)
TEMP6=DEFAULT ACCESS TRAVEL TIME FROM ORIG

ALTASTOP
IF ALTASTOP1<36 SET TO ALTASTOP1
IF SITE<4 *(airport survey)* SET TO 1 *(Denver Airport)*
OTHERWISE SET TO TEMP5

ALTATIME
IF ALTATIME1>0 AND ALTATIME1<999 SET TO ALTATIME1
OTHERWISE SET TO TEMP6

FROM FILE ACCESS1.DAT, LOOK UP RECORD FOR PLACE DEST *(using text string)*
AND READ:
TEMP5=DEFAULT EGRESS STATION NUMBER (1-35)
TEMP6=DEFAULT EGRESS TRAVEL TIME FROM ORIG

ALTESTOP
IF ALTESTOP1<36 SET TO ALTESTOP1
OTHERWISE SET TO TEMP5

ALTETIME
IF ALTETIME1>0 AND ALTETIME1<999 SET TO ALTETIME1
OTHERWISE SET TO TEMP6

FROM FILE TDIST1.DAT, LOOK UP RECORD FOR STATIONS ALTASTOP (1-35) AND ALTESTOP (1-35)
AND READ:
TEMP6=STATION-TO-STATION DISTANCE, IN MILES

FFLAB
IF MODE<3 SET TO ‘fuel cost’

OTHERWISE SET TO 'fare'

ECVAL1
IF MODE=2 SET TO RENTALCOST
OTHERWISE SET TO 0

ECVAL2
IF ALTAMODE=1 AND ALTASTOP=1 SET TO SPARKCOST*max(NIGHTS,0)
IF ALTAMODE=1 AND ALTASTOP=5 SET TO SPARKCOST*max(NIGHTS,0)
IF ALTAMODE=3 AND ALTASTOP=5 SET TO SBUSFARE
OTHERWISE SET TO 0

ECLAB1
IF MODE=2 SET TO '(incl.ECVAL1 for car rental)'
OTHERWISE SET TO ''

2 ECLAB2
ECLAB2 C
IF ALTAMODE=1 AND ALTASTOP=1 SET TO 'incl.ECVAL2 parking at station)'
IF ALTAMODE=1 AND ALTASTOP=5 SET TO '(incl.ECVAL2 parking at station)'
IF ALTAMODE=3 AND ALTASTOP=5 SET TO '(incl.ECVAL2 bus fare to station)'

SET NPAIRS = 5

>>>> Section 5. A series of five hypothetical choices between the existing mode and the new mode <<<<

start loop on # here – # goes from 1 up to NPAIRS

SET TEMP1 = 512 / NPAIRS
SET DREC = RANDOM NUMBER BETWEEN (# - 1)*TEMP1 AND #*TEMP1
(first pair between 1 and 102, second between 103 and 204, etc.)

GET RECORD DREC FROM DES512.DAT
READ 29 EXPERIMENTAL DESIGN LEVELS (1-8) INTO L1, L2, L3, ……., L29

* SET LEVELS FOR CHOICE SCREEN

WEATH#
WINTER: SET BASED ON L2 (1- 8): WEATHER WEATHER WEATHER WEATHER 1 2 3 4
SUMMER: SET TO 1

1. clear
2. low visibility
3. icy roads
4. low visibility and icy roads

CONGL#
SET BASED ON L1 (1-8): CONGLEVEL CONGLEVEL CONGLEVEL 2 3 3 4 4

1. very light
2. moderate
3. fairly heavy
4. extremely heavy

IVTIMEA#
SET TEMP1 = 100

*congestion worse than actual

SET TEMP2 BASED ON L3 (1- 8): 5 5 10 10 15 15 20 20
SET TEMP3 = CONGL# - CONGLEVEL
IF TEMP3>0 SET TEMP1 = TEMP1 + (TEMP2*TEMP3)

*weather worse than actual

SET TEMP2 BASED ON L4 (1-8): 5 5 10 10 15 15 20 20
SET TEMP3 = WEATH# - WEATHER
IF TEMP3>0 SET TEMP1 = TEMP1 + (TEMP2*TEMP3)

* adjust actual time for worse conditions

SET TEMP5 = TEMP1% OF INVEHTIME

*congestion better than actual
SET TEMP2 = INVEHTIME - FREEFLOWTIME1
SET TEMP3 = CONGLEVEL – CONGL#
SET TEMP4 = CONGLEVEL - 1
IF TEMP3>0 SET TEMP5 = TEMP5 + TEMP2 * (TEMP3 / TEMP4)

*weather better than actual
SET TEMP2 = FREEFLOWTIME1 - FREEFLOWTIME2
SET TEMP3 = WEATHER – WEATH#
SET TEMP4 = WEATHER - 1
IF TEMP3>0 SET TEMP5 = TEMP5 + TEMP2 * (TEMP3 / TEMP4)
SET TO TEMP5, ROUNDED TO THE NEAREST 5 MINUTES

TOTIMEA#
SET TO ACCESSTIME + IVTIMEA# + EGRESSTIME

FCOSTA#
SET X BASED ON L5 (1-8): 100 100 100 100 100 100 150 200
SET Y BASED ON L6 (1-8): 60 80 100 100 100 100 120 150
IF FUELCOST>0 SET TO X% OF FUELCOST,
IF FARECOST>0 SET TO Y% OF FARECOST

PCOSTA#
SET X BASED ON L7 (1- 8): 0 50 100 100 100 100 150 200
IF PARKCOST>0 SET TO X% OF PARKCOST
OTHERWISE SET TO 0

PCLAB#
IF PARKCOST>0 SET TO ‘parking at DEST costs PCOSTA#’
OTHEWISE SET TO ‘’

TOCOSTA#
SET TO FCOSTA# + PCOSTA# + ECVAL1
1 TEMP1

ALTMODE#
SET TEMP1 BASED ON L9 (1- 8): 1 2 3 3 4 4 5 5
IF MODE=5 AND TEMP1=1 SET TEMP1=5
IF MODE>5 AND TEMP1<3 SET TEMP1=TEMP1 + 3
SET TO TEMP1

1. shuttle van
2. tour bus
3. guideway bus
4. train
5. monorail

FREQB#
SET TEMP1 BASED ON L10 (1- 8): 3 5 10 10 15 15 20 20
SET TEMP2 BASED ON L10 (1- 8): 5 10 15 20 30 30 40 60
IF DEPARTTIME>1 AND DEPARTTIME<6 SET TO TEMP1
OTHERWISE SET TO TEMP2

SERV1B#
SET BASED ON L11 (1- 8): 1 1 2 2 3 1 2 3

1. No food or drink sold on board
2. Snacks, drinks sold on board
3. Snacks, drinks, meals sold on board

SERV2B#
SET TEMP1 BASED ON L21 (1- 8): 1 1 1 1 1 2 2 2
IF TEMP1=2 AND DESTTYPE=6 SET TEMP2 = 2 *(WINTER)*
IF TEMP1=2 AND LUGGAGE1=1 SET TEMP2 = 2 *(SUMMER)*
IF TEMP1=2 AND DESTTYPE=3 SET TEMP2 = 3
OTHERWISE SET TEMP2 = 1
SET TO TEMP2

1. Seasonal ski lockers to rent at resort stations (WINTER)
2. Free bicycle storage provided on-board (SUMMER)
3. Baggage checked through to resort hotels

SVTIME#
IF XFERDENV=1 SET TEMP1 BASED ON L11 (1-8): 90 90 90 90 120 120 120 120
OTHERWISE SET TEMP1 BASED ON L11 (1-8): 5 10 10 15 20 20 25 30
SET TO TEMP1

SVFARE#
SET TEMP1 BASED ON L21 (1-8): 50 50 100 100 150 150 200 200
SET TO TEMP1

IVTIMEB#
SET TEMP1 BASED ON ALTMODE# (1-5): 53 60 60 60 70
SET TEMP2 = LHDIST * 60 / TEMP1
SET X BASED ON L12 (1- 8): 70 80 90 100 100 110 120 130
SET TEMP3 TO X% OF TEMP2, THEN ROUND TO NEAREST 5 MINUTES
IF ALTMODE#<3 SET TEMP3 = IVTIMEA#
SET TO TEMP3

EMODEB#
IF DESTTYPE=6 SET TEMP1 BASED ON L13 (1-8): 1 1 1 1 2 2 2 2
IF DESTTYPE=3 SET TEMP1 BASED ON L13 (1-8): 1 1 1 2 2 3 3 3
OTHERWISE SET TEMP1 BASED ON L13 (1- 8): 2 2 3 3 3 3 4 4
SET TO TEMP1

1. Walk
2. Walk or take a shuttle
3. Transfer to a shuttle
4. Transfer to a bus and a shuttle

ETIMEB#
SET TEMP1 BASED ON L14 (1- 8): 2 2 5 5 5 5 10 10
SET TEMP2 BASED ON L14 (1- 8): 2 2 5 5 5 5 10 10
SET TEMP3 BASED ON L14 (1- 8): 0 0 5 5 10 10 15 20
SET TEMP4 BASED ON L14 (1- 8): 5 10 15 20 20 30 30 40
SET TEMP5 BASED ON EMODEB# (1-4) TEMP1 TEMP2 TEMP3 TEMP4
IF EMODEB#>2 SET TEMP5 = TEMP5 + ALTETIME
SET TO TEMP5

TOTIMEB#
SET TEMP2 = FREQB# / 2
IF TEMP2>20 SET TEMP2 = 20
SET TO ALTATIME + IVTIMEB# + ETIMEB# + TEMP2

FAREB#
SET TEMP1 BASED ON ALTMODE# (1-5): 20 10 15 15 15
SET TEMP2 = LHDIST * 2 * TEMP1 / 100
SET X BASED ON L16 (1-8): 40 65 85 100 100 125 150 200
SET TEMP3 TO X% OF TEMP2, THEN ROUND TO NEAREST $5
SET TEMP2 BASED ON L17 (1-8): 0 5 10 15 15 20 25 30
SET TEMP4 = TEMP3 + TEMP2 - 15
IF TEMP4<0 SET TEMP4 = 0
SET TO TEMP4

KFAREB#
SET X BASED ON L18 (1-8): 25 50 50 50 50 75 75 100
SET TEMP1 TO X% OF FAREB#
SET TO TEMP1

TOCOSTB#
SET TEMP1 = 1 + GROUPSIZE
IF GROUPKIDS>0 SET TEMP1 = TEMP1 - GROUPKIDS
SET TEMP1 = TEMP1 * FAREB#
IF GROUPKIDS>0 SET TEMP1 = TEMP1 + (GROUPKIDS * KFAREB#)

SET TO TEMP1 + ECVAL2

IF ALTMODE#>1 SET STEMP TO ‘Restrooms provided.’
OTHERWISE SET STEMP TO ‘’

IF ALTMODE#>3 AND ALTESTOP=10 SET STEMP2 TO (connecting bus from Idaho Springs)
IF ALTMODE#>3 AND ALTESTOP=12 SET STEMP2 TO (connecting bus from Empire)
IF ALTMODE#>3 AND ALTESTOP=17 SET STEMP2 TO (connecting bus from Frisco)
IF ALTMODE#>3 AND ALTESTOP>23 SET STEMP2 TO (connecting bus from Eagle Airport)
IF ALTMODE#>3 AND ALTASTOP=10 SET STEMP2 TO (connecting bus to Idaho Springs)
IF ALTMODE#>3 AND ALTASTOP=12 SET STEMP2 TO (connecting bus to Empire)
IF ALTMODE#>3 AND ALTASTOP=17 SET STEMP2 TO (connecting bus to Frisco)
IF ALTMODE#>3 AND ALTASTOP>23 SET STEMP2 TO (connecting bus to Eagle Airport)

IF SITE=2 OR SITE=3 SET STEMP3 TO ‘ from Denver Airport’
OTHERWISE SET STEMP3 TO ‘’

IF SITE=2 SET STEMP4 TO ‘ from Eagle Airport’
IF SITE=3 SET STEMP4 TO ‘ from Aspen Airport’
OTHERWISE SET STEMP4 TO ‘’

CHOICEINTRO#
Choice # out of NPAIRS:
Suppose that you had the following two options for your trip:

- Traveling STEMP4 by MODE, or
- Traveling STEMP3 by ALTMODE# STEMP2.

Please look at the pictures of the ALTMODE# to get an idea of what the service might be like.

When making your choices, please also keep in mind your return trip from DEST to ORIG, as well as any travel you have done/will do while staying at DEST.

CHOICE#
1: Travel STEMP4 by MODE
- It takes ACCESSTIME min. to get to the vehicle
- The weather conditions are WEATH# ***(WINTER ONLY)***
- Traffic congestion is CONGL#
- Travel time in the vehicle is IVTIMEA#
- EGRESSMODE takes EGRESSTIME min.
- The round trip FFLAB is FCOSTA# PCLAB#
Total one way time is TOTIMEA#, total round trip cost is TOCOSTA# ECLAB1

(ONLY IF SITE=1 OR SITE>3)
2: Travel STEMP3 by ALTMODE# STEMP2
- It takes ALTATIME# to get to ALTASTOP station
- The service runs every FREQB#.
- STEMP SERV1B#
- SERV2B#
- Travel time in the vehicle is IVTIMEB#
- EMODEB# to the DESTTYPE takes ETIMEB#
- The round trip fare is FAREB# for adults, KFAREB# for kids under 12
Total one way time is TOTIMEB#, total round trip cost is TOCOSTB# ECLAB2

(ONLY IF SITE=2 OR SITE=3)
2: Travel STEMP3 by ALTMODE# STEMP2
- It takes ALTATIME# to get to ALTASTOP station
- The service runs every FREQB#.
- Travel time in the vehicle is IVTIMEB#
- EMODEB# to the DESTTYPE takes ETIMEB#
- The round trip fare is FAREB# for adults, KFAREB# for kids under 12
Total one way time is TOTIMEB#, total round trip cost is TOCOSTB# ECLAB2
Also, by flying only to Denver, you would save SVTIME# in one way travel time, and SVFARE# per person in round trip airfare.

Which would you have chosen for your trip?
1. **Travel STEMP4 by MODE**
2. **Travel STEMP3 by ALTMODE#**
3. **Neither one**

ASK IF CHOICE=3
NEITHER
How do you think you would have traveled instead?

1. **To a different place**
2. **On a different day**
3. **At a different time of day**
4. **When the weather is better**
5. **For a longer stay**
6. **Not traveled at all**
7. **Other (specify)**

End of loop on choice #

>>>> Section 6. Questions about possible new trips induced by the new mode <<<<

CURRTRIPS
In the last 3 months, approximately how many trips have you made in the Inter-mountain portion of the I-70 corridor of a distance of 20 miles or more? [Each one-way trip counts as one].

____**Give a number in the range 0 to 999**

(this question uses the levels from the 5th (last) choice screen)*
ANYMORE
Suppose that ALTMODE5 service had been available in the corridor during that period, as you saw in the last choice situation (service every FREQB5, travel time to ALTESTOP of IVTIMEB5, at a fare of FAREB5) Do you think you would have made more trips in total in the corridor than you actually did during the last 3 months?

1. **yes, definitely**
2. **yes, probably**
3. **no, probably not**
4. **no, definitely not**
5. **don't know**

ASK IF ANYMORE<3
NEWTRIPS
About how many extra trips do you think you would have made during the last 3 months in addition to the CURRTRIPS you actually made? [Each one-way trip counts as one].

____**Give a number in the range 1 to 999**

>>>> Section 7. Socioeconomic questions about the respondent and household <<<<

ASK ONLY IF SITE=2 OR SITE=3 *(regional airport interview)*
CRASH
Has the recent airplane crash at Aspen Airport changed your ideas about the safety of flying in the mountains?

1. **yes, very much**
2. **yes, somewhat**
3. **no, not much**
4. **no, not at all**
5. **didn't hear about it**

Appendix B. I-70 Ridership Survey

HHSIZE

To close, the next questions are for analysis purposes only, to ensure that we have a representative sample of travelers.

How many persons live in your household, including yourself?

____Give a number in the range 1 to 99

NKIDS

How many of the people in your household are children under 18 years of age?

____Give a number in the range 1 to HHSIZE

NWORK

How many of the people in your household are employed?

____Give a number in the range 1 to HHSIZE

HHVEHS

How many motor vehicles in working condition for mountain travel are available for use by your household?

____Give a number in the range 1 to 99

AGE

What is your age?

1. **under 12**
2. **12 to 17**
3. **18 to 24**
4. **25 to 39**
5. **40 to 54**
6. **55 to 65**
7. **65 or older**

SEX

What is your gender?

1. **male**
2. **female**

HHINC

What is your estimated total annual household income in 2000, before taxes?

1. **up to $15,000**
2. **$15,001 to 25,000**
3. **$25,001 to 35,000**
4. **$35,001 to 45,000**
5. **$45,001 to 55,000**
6. **$55,001 to 75,000**
7. **$75,001 to 100,000**
8. **$100,001 to 150,000**
9. **$150,001 to 200,000**
10. **more than $200,000**
11. **don't know**
12. **don't want to say**

END

That was the last question.

Thank you very much for your participation!

B.5 The Survey Fieldwork

Trained interviewers, who intercepted suitable respondents and conducted the interviews using laptop computers to administer the survey, carried out all surveys. The survey was programmed using the WinMINT software from Hague Consulting Group.

The winter survey was carried out from March 9 through April 6, 2001, at the following intercept sites:

1. Denver International Airport
2. Eagle County Airport
3. Pitkin County Airport
4. Breckenridge Ski Area
5. Vail Ski Area
6. Winter Park Resort
7. Copper Mountain Resort
8. Keystone Resort
9. Loveland Ski Area
10. Idaho Springs restaurants
11. Frisco Safeway
12. West Vail Safeway
13. Denver sporting goods store (REI)
14. Total gas station
15. Leadville Safeway
16. Other retail stores
17. New Castle/Rifle Grocery
18. King Soopers in Littleton
19. Denver Region shopping mall

In total, about 1,300 valid winter interviews were completed at these sites. An additional 800 responses were obtained by RRC Market Research, who administered a web-based version of the survey over the Internet with members of their Skier Panel.

The summer version of the survey was carried out between June 30 and August 12, 2001, at the following sites:

1. Denver International Airport
2. Eagle County Airport
3. Pitkin County Airport
4. Breckenridge Ski Area
5. Vail Ski Area
6. Winter Park Resort
7. Copper Mountain Resort
8. Keystone Resort
9. Georgetown

10. Idaho Springs restaurants
11. Black Hawk and Central City casinos
12. Frisco
13. Silverthorne
14. Avon
15. Edwards
16. Shrine Pass
17. Gypsum
18. New Castle
19. Glenwood
20. Dillon/Marina
21. Herman Gulch
22. Empire/Campgrounds
23. Eagle (not the airport)
24. Aspen (not the airport)

Approximately 1,500 valid summer interviews were completed at these sites.

B.6 Market Segmentation

Table B-3. Overview of Market Segments

Segment	Description	Pers.	Veh.
DayRec	Day trip recreation from the Front Range	68	24
Hotel	Hotel/motel recreation from the Front Range	8	3
2ndHome	2^{nd} home/other recr. from the Front Range	6	2
CorRec	Recreation from origins within the corridor	2	1
Gaming	Gaming trips to Black Hawk/Central City	10	4
VisitFR	Visit friends, relatives in the corridor	20	8
Work	Commute to work in the corridor	10	7
CorOth	Other corridor destinations (e.g. shopping)	10	4
Reverse	From corridor to Front Range destinations	3	1
Airports	From airports to corridor destinations	20	6
Total	All segments combined	157	60

With approximate market size in thousands of person and vehicle trips/day, on I-70 at Idaho Springs on a Saturday in February.

Table B-4. Sample Percentages and Means by Market Segment

Segment	DayRec	Hotel	2ndHome	CorRec	Gaming	VisitFR	Work	CorOth	Reverse	Airport
Female (%)	33	43	32	41	56	58	46	56	46	37
Age under 25 (%)	12	8	11	13	0	18	13	13	16	8
Age 55 or older (%)	9	10	19	15	76	14	7	11	16	21
Hhold income under $35K (%)	8	4	6	5	3	6	7	10	9	6
Hhold income over $100K (%)	28	37	48	24	28	30	18	22	19	37
Persons in household	2.5	3	3.1	3	2.1	2.7	2.8	3.3	3.5	2.9
Children under 18 in hhold	0.5	0.7	0.6	0.5	0.1	0.6	0.6	0.6	0.6	0.8
Workers in household	1.9	1.8	1.9	1.9	1.2	1.8	2	1.9	2.1	1.8
Vehicles in household	2.1	2.3	2.5	2.4	1.8	2.3	2.3	2.3	2.5	2.4
Segment	**DayRec**	**Hotel**	**2ndHome**	**CorRec**	**Gaming**	**VisitFR**	**Work**	**CorOth**	**Reverse**	**Airport**
Staying overnight (%)	0	100	100	37	29	66	9	21	24	96
Traveling alone (%)	12	6	8	13	12	31	87	34	32	18
Adults in travel party	2.6	2.8	2.7	2.5	2.4	2.1	1.2	2	2.1	2.9
Children under 12 in travel party	0.2	0.5	0.4	0.2	0	0.2	0	0.3	0.2	0.3
Traveling by transit (%)	0	2	2	1	3	1	2	3	1	31
Transfer to shuttle at dest. (%)	31	5	2	3	0	1	1	1	1	1
Need to use car at dest. (%)	0	82	85	24	17	47	7	13	18	55
Segment	**DayRec**	**Hotel**	**2ndHome**	**CorRec**	**Gaming**	**VisitFR**	**Work**	**CorOth**	**Reverse**	**Airport**
Departing before 8AM (%)	75	23	19	23	8	10	60	12	15	4
Reporting no congestion (%)	20	25	22	48	44	37	63	46	37	44
Reporting heavy congestion (%)	29	22	23	12	1	7	9	16	15	14
Reported in-vehicle time (min)	101	124	122	66	68	96	52	72	100	109
Est.time without congestion (min)	83	106	104	58	62	86	46	62	88	97
Est time due to congestion (%)	18	15	15	12	9	10	12	14	12	11
Would pay toll to avoid cong. (%)	65	67	68	39	56	51	39	43	51	40
Segment	**DayRec**	**Hotel**	**2ndHome**	**CorRec**	**Gaming**	**VisitFR**	**Work**	**CorOth**	**Reverse**	**Airport**
Trips made in last 3 months	12	7	11	24	15	16	80	26	30	
Extra induced trips	2	2	1	2	1	2	2	2	2	
Would make induced trips (%)	30	33	25	37	23	36	28	32	35	

Table B-5. Average Auto and Transit Costs and Times Presented in the SP Scenarios by Segment

Segment	DayRec	Hotel	2ndHome	CorRec	Gaming	VisitFR	Work	CorOth	Reverse	Airport
Option A: By auto										
In-vehicle time (min)	122	156	156	86	93	124	68	93	130	142
Access time (min)	4	3	4	1	4	2	1	3	1	12
Egress time (min)	7	3	2	3	3	2	2	2	3	1
Total time (min)	**133**	**163**	**162**	**90**	**100**	**128**	**72**	**98**	**134**	**155**
Fuel cost ($ round trip)	17	29	29	14	13	17	9	14	21	52
Parking cost ($ round trip)	2	3	1	2	1	0	0	0	2	2
Rental cost ($ round trip)	2	12	19	7	8	3	0	6	1	106

Segment	DayRec	Hotel	2ndHome	CorRec	Gaming	VisitFR	Work	CorOth	Reverse	Airport
Total cost ($ round trip)	**22**	**43**	**48**	**23**	**23**	**20**	**10**	**20**	**23**	**161**
Option B: By transit										
Headway (min)	17	21	24	21	19	23	15	21	22	25
In-vehicle time (min)	77	97	95	61	67	85	49	67	90	111
Access time (min)	21	23	22	11	16	19	11	12	8	5
Egress time (min)	4	6	13	11	11	13	19	17	25	15
Total time (min)	**110**	**135**	**142**	**93**	**103**	**127**	**86**	**106**	**133**	**142**
Adult fare ($ round trip)	21	28	26	19	22	24	17	20	28	36
Child fare ($ round trip)	12	17	15	11	13	14	10	12	17	22
Total cost ($ round trip)	**58**	**90**	**79**	**47**	**53**	**57**	**20**	**45**	**63**	**95**

B.7 Technical Details of the Stated Preference Approach

B.7.1 Principles of the SP Methodology

Stated preference (SP) methods are designed to analyze the preference for a particular product or service as a function of the features or attributes that define that product or services. In contrast to simpler, stated intentions approaches which ask respondents if they would use a new product in a single hypothetical context, the SP approach asks for responses in various carefully defined market contexts so that the overall attractiveness of a product can be broken down into the attractiveness of its individual features. This is analogous to the classical approach in microeconomics, where the demand for a product or service is a function of its utility, which is, in turn, a function of price, quantity, quality, and other relevant attributes. They are both decompositional approaches. The key distinction is that most research in microeconomics has been based on observed market behavior, or RP, while the SP approach is based on stated preferences or stated choices in hypothetical market situations. As described below, SP methods have evolved over time to closely reflect the econometric methods used to collect and analyze actual market (RP) data.

The key assumptions behind the SP approach are:

- Preferences among hypothetical market alternatives will accurately reflect preferences among real alternatives in an actual market situation
- Preferences for the alternatives can be measured on a latent continuous scale, such as attractiveness or “utility”
- By using proper experimental design techniques to define the alternatives, the preferences can be explained as a function of the attributes of the alternatives
- Once the preference function has been estimated, it can be used to determine the attractiveness of any alternatives that are defined using the same set of attributes
- By defining the set of alternatives that will be available in a future market situation and then determining their relative attractiveness, the frequency with which each of those alternatives will be chosen (market shares) can be predicted.

Of course, these assumptions can be valid only if the hypothetical market context is realistic and relevant to the respondents and if the survey is carefully designed and properly carried out. Also the resulting predictive model can be assumed to be valid only within the range of product attributes that was included in the survey contexts.

B.7.2 Historical Background

SP methods were introduced in the field of marketing research in the early 1970s. One of the earliest methods was “trade-off analysis,” where respondents would rank various combinations of two attributes in order of preference. Another approach, “conjoint analysis,” used a fractional factorial experimental design to vary several attributes at a time to create a number (typically in the range from 8 to 16) of “full profile” descriptions of a product or service. The respondent would then rank these alternative descriptions in order of preference.

As Green and Srinivasan (1978) and Louviere (1988) describe, most SP methods used in the 1970s and early 1980s were variations on the conjoint analysis approach. Sometimes, respondents were asked to rate each alternative on a metric scale rather than ranking them. In other cases, respondents were simply required to choose one alternative over the rest—often used in pairwise choice contexts. At that time, there was no consensus as to how the responses should be analyzed or to how the resulting models should be applied to predict choices. In many cases, the procedures adopted were rather ad hoc, heuristic methods. A common approach in conjoint analysis was to estimate a separate predictive model for each respondent in the sample and then to simulate each respondent’s choices assuming that the alternative with the highest preference “score” would be chosen over the rest. Such methods, however, had little basis is statistics or in economic choice theory.

Also during the 1970s and early 1980s, the methodology of discrete choice analysis was developed and applied widely in the prediction of demand for transportation, housing, and energy services (Ben-Akiva and Lerman 1985). This methodology provided statistical methods such as logit or probit analysis, which were consistent with microeconomic choice theory (see below). Although these methods were developed and applied mainly using RP data, it was recognized that they could be applied in the same manner to SP data from hypothetical survey contexts. As a result, SP methods have developed over the last 10 years to closely resemble RP methods, both in the type of data collected (discrete choices from a set of realistic alternatives) and in the way the data is analyzed (typically logit estimation). In fact, methods have been developed to use RP and SP data simultaneously to estimate models, which take advantage of the strongest features of both approaches (Hensher and Bradley 1993). Over time, these developments have led too much more widespread use and acceptance of SP methods in virtually all areas of market demand analysis.

Over time, experience has shown that making SP survey choice contexts both realistic and relevant to respondents can greatly enhance the validity of the data. This realization has led, in turn, to various methods for customizing SP experiments to individual respondents. In particular, the use of computers to help generate the SP choice alternatives on the basis of prior responses has opened up many new possibilities (Bradley 1988). Computers are often used to generate customized, individualized paper-based surveys for mailout/mailback or combination mailout/telephone surveys. In situations where face-to-face interviews are possible (such as malls and airports), the SP options can be generated in “real time” during a computer-assisted personal interview (CAPI).

B.7.3 SP Analysis Method and Options

The objective of SP analysis is to estimate a preference function that can be used to predict market choices. This function indicates the relative importance of differences in the levels of the relevant choice attributes. Depending on the method used, these relative levels of importance may be referred to as “importance weights,” “preference weights,” “part-worths,” or “utility coefficients.” They are indicated by the *b*s in Equation 1 below:

(1) $P = b_1.X_1 + b_2.X_2 + ... + b_K.X_K$, where

P is a measure of preference or attractiveness and the *X*s are (functions of) the values of the attributes used to describe the alternatives.

Some SP methods such as conjoint analysis have relied on simplistic approaches for estimating preference functions. Typically, rating scores or rank order scores of the alternatives are interpreted directly as the preference function on a continuous scale (*P* above). Then, ordinary least-squares (OLS) regression is used to estimate the coefficients (*b*s above). In some more sophisticated approaches, rank order responses are assumed to provide only ordinal information, and estimation approaches, such as linear programming or weighted monotonic regression, are used. In any of these approaches, a problem arises in applying the resulting preference functions to predict choices in hypothetical scenarios. A common approach is to simulate the choices for each individual, using the rule that the alternative with the highest preference score is chosen. Such a rule, however, is not based on any statistical or economic theory and does not take into account the fact that an alternative with an attractiveness much greater than the alternatives is more likely to be chosen than one which is only slightly more attractive than the other alternatives.

In other areas of market research, particularly in transportation and energy demand research, discrete choice methods have been developed to estimated preference functions based on choice data. These methods, such as logit and probit analysis, have a foundation in microeconomic theory, and are consistent with the analysis approaches most commonly used with RP data (Ben-Akiva and Lerman 1985). As computer hardware and software for applying these approaches has become more widely available, logit analysis has become the most widely used and best accepted method for analyzing SP data.

B.7.4 Logit Model Estimation

Logit analysis is based on the assumption that, although only a discrete “A, B or C” choice is observed in the marketplace, there is an unobserved, or “latent” attractiveness measure that is used to make that choice. In other words, if there are two choice alternatives, A, and B, each has an underlying attractiveness, or “utility” *V,* so that:

A is chosen if $V_A > V_B$, and
B is chosen if $V_A < V_B$.

It is further assumed that the utility function V is a function of the attributes used to define each alternative:

(2) $V_A = b_1.X_{A1} + b_2.X_{A2} + ... + b_K.X_{AK}$, where

the *b*s are utility coefficients to be estimated and the *X*s are (functions of) the values of the attributes used to describe each alternative.

This definition of the utility function is exactly analogous to the preference function defined in Equation 1. Note that the function of the *X*s must be strictly additive, termed “linear in the parameters”. This is not as restrictive as it may seem, however. Each X value may actually be a function of a number of variables, such as a multiplicative interaction between two SP attributes or an interaction between an SP attribute and a background characteristic of the respondent (for example, separate cost variables for different income groups, or else cost divided by income). The *X*s could also include quadratic or logarithmic functions of the attributes.

To estimate the parameters, it is further assumed that there is an unobserved component of utility, or “random error term” associated with each alternative so that the “true” utility is:

(3) $U_A = V_A + e_A = b_1.X_{A1} + b_2.X_{A2} + ... + b_K.X_{AK} + e_A$

If it is also assumed that:

1. the random error terms e have the shape of the Gumbell distribution (very similar to a normal distribution), and

2. these error terms are identically and independently distributed (IID) across alternatives and across respondents

then the logit probability function is obtained for choosing A over B:

(4) $p(A) = p[V_A > V_B] = exp(V_A) / (exp(V_A) + exp(V_B))$, where

p(A) is the probability of choosing alternative A over B and $exp(V_i)$ is the exponential of the estimated utility of alternative *i*.

When $V_A = V_B$, this equation predicts a 50/50 share for each alternative. As one utility becomes greater than the other, the probability changes with the familiar S-shaped logistic curve, first diverging sharply from 50/50, and then flattening out as one alternative becomes much more attractive than the other. Because it is a probabilistic model, the equation will always predict some small market share for every alternative, even when it seems to be logically dominated by the others. (Such "illogical" choices can also be observed in real life and are usually found in observed choice data.)

The notation and logic above can easily be extended to a choice from among three alternatives or more. A model with three or more alternatives is usually referred to as a "multinomial logit" (MNL) model.

The primary advantages of the logit model compared to other discrete choice methods is that it is relatively simple to estimate and to apply. Estimation is done using the maximum likelihood method. Across a sample of *N* respondents, values are found for the coefficients in the utility function *V* such as to maximize the predicted probability of all the choices observed in the data:

(5) find $b_1, b_2, \ldots, b_K$ to maximize $L = \log[\, p(C_1) \times p(C_2) \times \ldots \times p(C_N)\,]$,

where $p(C_n)$ is the logit probability for the alternative chosen by respondent *n*, as given by Equations 2, 3, and 4.

The computer software finds the best set of values using an iterative search procedure based on the partial derivatives of the likelihood function (5) with respect to the coefficients. The analysis for this project was done using Hague Consulting Group's ALOGIT software, one of the most widely-used logit estimation packages in the world.

B.7.5 Measures of Model Fit

The overall fit of a logit model can be assessed using the final log-likelihood value (*L* in Equation 5), or a proportional measure called rho-squared.

(6) $Rho^2 = 1 - L(B) / L(0)$, where

L(B) is the final log-likelihood value with all coefficients at their estimated values and *L(0)* is the initial log-likelihood value with all coefficients at zero

This measure is similar to the R-squared statistic used to assess the fit of regression models. There is, however, no standard rule of thumb for judging rho-squared values. It will depend on many things, such as the number of alternatives and the overall market shares. Typical rho-squared values are in the range of 0.10 to 0.30.

The likelihood and rho-squared statistics tend to be useful for comparing one model to another similar model, but not for judging the overall validity of a model. For that purpose, the values and t-statistics of the separate coefficients are used.

B.7.6 Coefficient Values and t-Statistics

Just as in regression, the t-statistic is equal to the value of the coefficient divided by the standard error of the coefficient in estimation. Based on the assumption that the error in an estimate is normally distributed around its true value, then there is a 95 percent probability that the true value will lie within plus or minus 1.96 standard errors of the estimated value. In other words, the higher the t-statistics, the higher the precision of the estimates. If the t-statistic is 2.0 or higher, then there is more than 95 percent confidence that the coefficient's true value is different from zero.

Just as important as t-statistics in judging the results are the relative values of the coefficients themselves. Coefficients are generally interpreted relative to each other. For example, the coefficient on a variable which means cost over time, such as interest rate, divided by the coefficient of an up-front cost such as transaction fees, gives an indication of the relative importance of immediate costs versus repeated costs, and thus an indication of the time horizon or discount rate used in making the tradeoffs. A similar example in transportation is the tradeoff between the purchase cost of a new vehicle versus the likely annual fuel cost of that vehicle. These types of tradeoff ratios are often judged to determine whether the model results are reasonable given what is already known about the market.

B.7.7 Options for Market Segmentation

One of the key considerations in SP analysis is to segment the market in the most meaningful manner to identify the groups with the lowest and highest market potential. The more successfully the population can be segmented, the more accurate the resulting forecasts can be.

There are three main approaches for segmentation:

1. Estimate a separate model for each individual in the sample: While this was done in many early applications of conjoint analysis, it does not appear to be a statistically sound approach, and it is not compatible with discrete choice methods such as logit analysis, which require reasonable sample sizes to give valid results. (Note: This approach might become valid with repeated RP data collected over time, but it is not likely to be valid using data from a single SP survey.)
2. Break the sample down a-priori into separate market segments and then estimate a separate model for each segment.
3. Simultaneously test several different segmentation variables in a single model: In some cases, it is not obvious *a priori* which segmentation variables are most important, or there may not be enough data in each segment to estimate completely separate models. For example, differences across predefined segments may not be so large, and more important differences may be found according to other respondent-specific variables, the answers given to various attitudinal questions, and so on. In addition, some of these variables may only influence the importance of specific SP attributes. For example, a certain segmentation variable may primarily influence how respondents react to cost variables, while other segmentation variables have more influence on the importance of qualitative features of the product.

B.7.8 Options for Model Application

Assuming a single model per segment (approach 2 above), the method for applying the logit models is straightforward:

1. Define the market scenario of interest in terms of the choice options (products) available and the attributes of each choice option. For example, which banks or institutions offer competing mortgage products, and what rates and fees do they offer?

2. Use the estimated utility coefficients for a given segment to calculate utilities for each option, as per Equation 2 above, and then to calculate the market choice share for each alternative within that segment, as per Equation 4.
3. Repeat step (2) to calculate each market segment and then use the relative sizes of the segments to expand and aggregate the predicted shares to represent the total market.

This type of model application can often be implemented in a spreadsheet format.

If segmentation approach (3) above is used, with a number of respondent- and context-specific variables entering into the utility functions, then it can be the case there are hundreds or thousands of possible combinations of these variables, and each of these combinations yield different predictions of market shares. In that case, the easiest and most flexible approach is to calculate choice shares separately for every individual in the sample and to weight and aggregate these separate predictions to arrive at an overall forecast. This is essentially the same approach as above, but treating each respondent as if he or she were a separate segment. This approach is somewhat more complex to apply in a spreadsheet format, as it requires repeated operations on each record of a large database. In some cases, the greater amount of information and flexibility offered by such a model warrants the additional complexity in application.

B.7.9 Confidence Intervals and Model Sensitivity

Although the t-statistics indicate confidence intervals around each separate utility coefficient, there is no standard or straightforward way to generate confidence intervals around predictions based on discrete choice models. There are many sources of possible error in the forecasting procedure, including:

- Estimation error in the models (for example, imprecise estimates)
- Specification error in the models (for example, missing variables)
- Error in the exogenous scenario inputs (for example, in estimates of current fare levels or the size of each segment in the current market)

Each of these types of errors can have an effect on the forecasts, and it is unknown if the second or third types of errors exist. There are some rather complex techniques to test sensitivity of forecasts of the first type of error by drawing sets of coefficients randomly from the entire variance/covariance structure of the estimates, using these coefficients to generate forecasts, repeating the procedure hundreds of times with new sets of coefficients, and then studying the distribution and variably across all sets of forecasts which have been generated. Unfortunately, this type of “bootstrapping” approach is very time-consuming and expensive and is rarely attempted outside academic research. Given the other sources of possible error listed above, which may be (and probably are) even larger, such an exercise is probably not worth the considerable effort and may even be misleading.

So, although it is straightforward to test the sensitivity of the forecasts to the attribute levels, such as changing the interest rates or product definitions in the scenarios, there is no reliable way to say what the margin of error around those forecasts is. With longer-range forecasts of new technologies or products, one often has to be satisfied with knowing that a carefully designed and executed study will provide the best objective prediction that is possible.

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Appendix C
2035 Travel Demand

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Appendix C. 2035 Travel Demand

C.1 Background for I-70 PEIS Travel Demand Modeling

The Programmatic Environmental Impact Statement (PEIS) team developed a travel demand forecasting model to develop 2025 forecasts as a part of the PEIS. At the onset, there was no existing Metropolitan Planning Organization's (MPO) travel demand model along the I-70 Mountain Corridor upon which the team could build the model. The team needed to establish the Corridor-specific traffic analysis zones, collect demographic and social-economic data, and conduct a ridership survey to construct the bases of the forecasting model. In addition, the nature of traffic in the Corridor that combines work trips during weekdays and recreational trips during weekends makes the modeling effort unique from a typical urban traffic model. As a result, there were few examples that the team could use to validate the outcome. Throughout the model building process, the team worked extensively with technical specialists from Federal Highway Administration (FHWA), Colorado Department of Transportation (CDOT), the Denver Regional Council of Governments (DRCOG), and local planning agencies to ensure that the data collected and the process of modeling were within the reasonable range of expectations. The team also formed a peer review panel that consisted of experts from FHWA, Massachusetts Institute of Technology, University of California-Davis, DRCOG, University of Colorado-Denver, Portland Metro, and a leading ridership survey consultant to examine the accuracy of inputs and the reasonableness of outcomes from the model. Additionally, independent consultant expert reviews were conducted periodically.

With the passage of time, a need to consider updating the planning horizon year to 2035 has developed. This document summarizes the proposed approach to prepare 2035 forecasts

C.2 Summary of Approach

Two methods were used to develop travel demand in the PEIS: (1) a four-step transportation-planning model implemented in TransCAD to forecast the 2025 travel demand and (2) a linear trend analysis of existing traffic data and 2025 traffic forecasts to predict the travel demand beyond 2025. These approaches were determined unsuitable for preparing 2035 because the four-step model is computationally intensive and not all of the required production (such as population and land use) and attraction (such as employment, forest visitation, and recreation use projections) data needed for the TransCAD runs are available for 2035. The linear trend approach does not consider the latest available socioeconomic and other data. For the preparation of 2035 forecasts, an approach of intermediate complexity between the four-step model and the regression trend analysis was developed. Attachment 1 provides additional details on the development of the 2035 Travel Demand Projection approach.

The approach selected for 2035 is a socio-economically based process that, through factored modeling, estimates 2035 travel demands at the 10 focal points in the Corridor used in the PEIS, by considering the socioeconomic growth anticipated for relevant "feeder areas" associated with each of nine trip purposes (see Table B-2 in Attachment 1). As an example of a feeder area, Front Range Day Recreation travel at the Genesee focal point is assumed to grow in proportion to the combined population of all metro Denver regions. All five model days (Winter Saturday, Summer Thursday, Summer Friday, Summer Saturday, and Summer Sunday) have been retained for analysis in 2035.

This approach considers all 10 Corridor travel demand study segments and focal points from the PEIS. Study segments were developed to represent patterns of trips and congestion, and similar land uses in the Corridor. Each study segment contains one focal point where travel demand and capacity are examined. The locations of study segments are shown on the map in **Figure C-1**. The PEIS evaluates both the Short-Term and Long-Term (Minimum Program and Maximum Program) components of the Preferred Alternative, as well as the other Action alternatives evaluated in the PEIS. The approach also provides an evaluation of the range of traffic operation characteristics associated with the Preferred Alternative, between short-term and possible long-term or ultimate effects.

This Technical Report provides an analysis of Baseline travel demand and the No Action alternative. Note that the Baseline reflects a theoretical calculation assuming unconstrained demand is loaded onto the existing and committed transportation network. The No Action alternative represents equilibrium between travel demand and supply with the existing and committed network. It is used in National Environmental Policy Act (NEPA) analysis to compare impacts against those of action alternatives. The PEIS presents comparisons of the No Action alternative and the action alternatives.

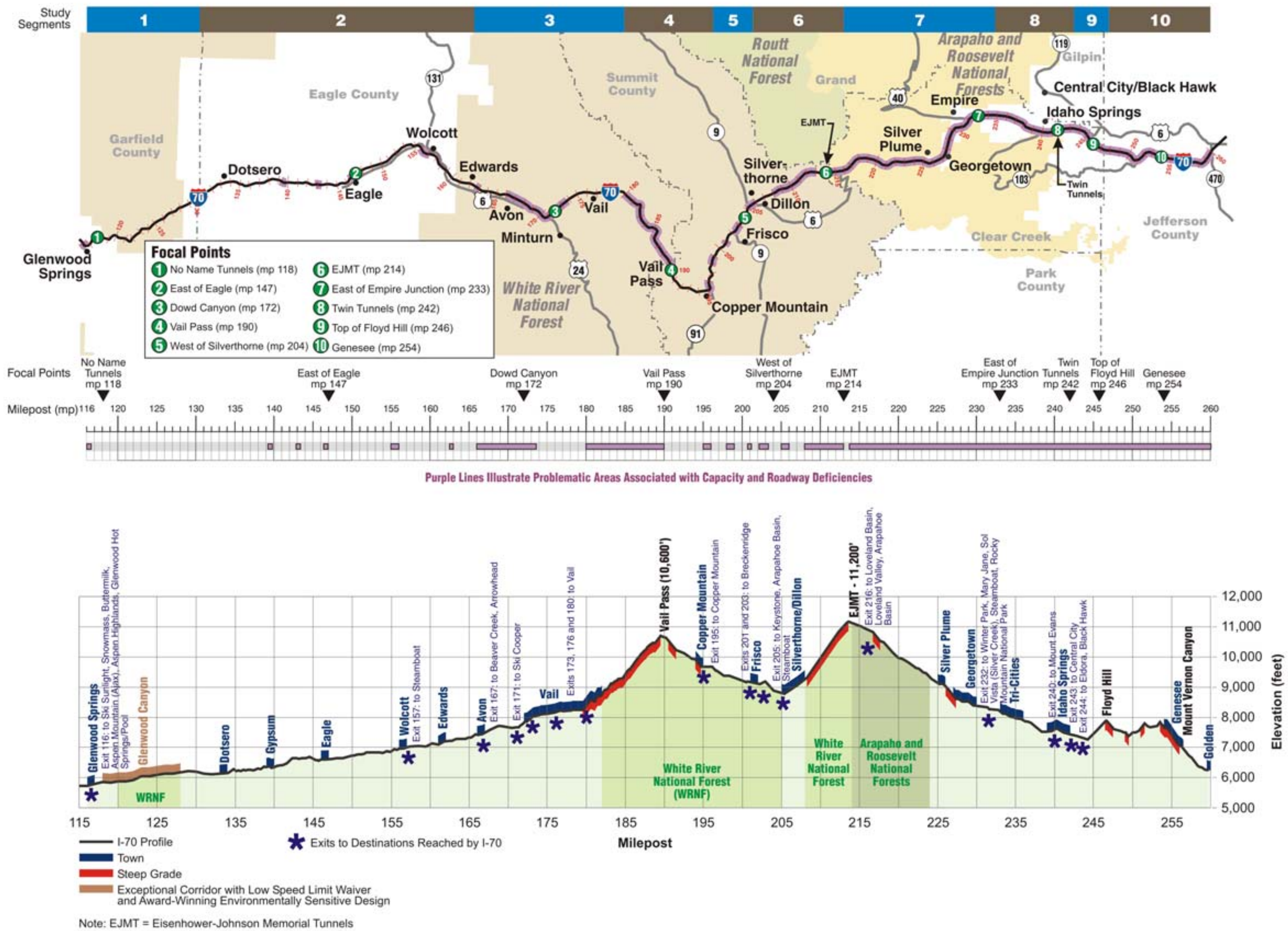
C.2.1 Coordination Efforts

To ensure that the socioeconomic-based factored modeling approach is applying valid techniques and produced reasonable results, the team circulated a document describing the approach among local modeling experts at the Colorado Department of Transportation and DRCOG. These experts offered constructive comments, which were incorporated into the modeling process and into this Technical Report. Among their comments were implications of the assumptions used in the proposed modeling process, which are described within the relevant parts of Attachment 1.

C.2.2 Technical Support of Consensus Recommendation Process

The approach to 2035 provides a travel demand forecast using the most recently available data. The Collaborative Effort recommended an initial set of limited highway improvements, coupled with a process to investigate the feasibility and implementation of high-speed, fixed guideway transit in the Corridor. As part of the Consensus Recommendation, Collaborative Effort team members are to meet every 2 years to review emerging traffic conditions on I-70 and the progress of transit development. This 2035 travel demand forecast and traffic analyses provides support for these biennial evaluations and to the 2020 assessment to determine appropriate future actions.

Figure C-1. Study Segments and Focal Points



C.3 Socioeconomic Data

As discussed above, the proposed factoring method for forecasting 2035 travel demand requires 2035 data for various socioeconomic variables. Different travel markets are assumed to grow in proportion to selected socioeconomic variables. This section describes the socioeconomic changes anticipated for the Corridor and related areas.

C.3.1 Population

Table C-1 shows the population estimates for the individual counties in the nine-county Corridor, which roughly doubled from 2000 to 2025. From 2025 to 2035, the Corridor population would increase by about an additional third. The population estimates shown for 2000 and 2025 were developed by Department of Local Affairs in 2002. Population forecasts for 2035 were released by Department of Local Affairs in 2008.

Among individual counties, Park and Lake counties are expected to have the greatest population increase from 2000 to 2025. To some extent, Park and Lake counties are "bedroom communities," with Park County supplying workers to the Front Range Region (those who live along the US 285 corridor) and to Summit County (those who travel via SH 9 and Hoosier Pass). Lake County houses people who work in Eagle and Summit counties (and who commute along US 24 and SH 91, respectively).

While Park County has the highest population growth rate between 2000 and 2025, it has the lowest "growth" rate from 2025 to 2035, losing just over 20 percent of its population. Overall, Park County grows at an average of 3.2 percent per year between 2000 and 2035, second only to Garfield County. **Table C-1** shows Clear Creek County having negative population growth between 2025 and 2035, while Lake County has substantially slowed growth from 2025 to 2035, compared to the 2000 to 2025 period.

Table C-1. Nine-County Corridor Population Estimates for 2000, 2025, and 2035

	Population			Average Annual Growth	
County	2000 (DOLA 2002)	2025 (DOLA 2002)	2035 (DOLA 2008)	2000-2025	2025-2035
Clear Creek	9,322	17,060	15,584	2.4%	-0.9%
Eagle	41,659	76,081	98,554	2.4%	2.6%
Garfield	43,791	80,879	147,157	2.5%	6.2%
Gilpin	4,757	7,175	8,099	1.7%	1.2%
Grand	12,442	25,598	28,101	2.9%	0.9%
Lake	7,812	18,458	20,611	3.5%	1.1%
Park	14,523	56,100	43,393	5.6%	-2.5%
Pitkin	14,872	23,719	28,736	1.9%	1.9%
Summit	23,548	42,561	53,840	2.4%	2.4%
Nine-County Total	**172,726**	**347,631**	**444,075**	**2.8%**	**2.5%**

Source: DOLA, State Demographer's Office, 2002, 2008

The reverse situation occurs with Garfield County. **Table C-1** shows its population almost doubling between 2000 and 2025, then not quite doubling again by 2035. When annual growth rates are considered, the 2025 to 2035 growth rate is more than double the 2000 to 2025 rate.

From 2000 to 2025, Gilpin and Pitkin counties show the lowest annual growth rates. The terrain in Gilpin County tends to limit economic opportunities to the gaming towns of Black Hawk and Central City. On the other hand, Pitkin County seems to be adopting growth-limiting measures to maintain its quality of life. Both counties show growth of less than 2 percent per year between 2025 and 2035.

Table C-2 shows the population of Front Range counties. The population of the seven-county region (with the formation of Broomfield County in 2002) is projected to rise from about 2.5 million in 2000 to approximately 3.5 million in 2025 and to approximately 4 million in 2035.

Table C-2. Population Growth of Front Range Counties

	Population			Average Annual Growth	
County	2000 (DOLA 2002)	2025 (DOLA 2002)	2035 (DOLA 2008)	2000-2025	2025-2035
Adams	400,054	659,082	708,160	2.0%	0.7%
Arapahoe	524,687	702,197	821,658	1.2%	1.6%
Boulder	290,662	435,550	385,667	1.6%	-1.2%
Broomfield*	0	0	85,877	N/A	N/A
Denver	502,710	637,469	731,658	1.0%	1.4%
Douglas	186,506	322,824	535,247	2.2%	5.2%
Jefferson	537,783	694,736	686,839	1.0%	-0.1%
Front Range Region Total	**2,442,402**	**3,451,858**	**3,955,107**	**1.4%**	**1.4%**

Source: DOLA, State Demographer's Office, 2002, 2008
*Notes: * Broomfield County was created by act of voters in November 2001. The year 2000 and 2025 population of areas becoming Broomfield County is tabulated with the previous county.*
N/A = not applicable.

Boulder and Jefferson counties show negative growth rates for the 2025 to 2035 period. The overall average annual growth rates for Boulder and Jefferson counties from 2000 to 2035 are 0.8 percent and 0.7 percent per year, respectively, the lowest two of the seven Front Range counties.

Douglas County is projected to have an overall 3.1 percent per year population growth from 2000 to 2035. Indeed, Douglas County was recently named as one of the fastest growing counties in the nation. **Table C-2** shows Douglas County growing at a faster rate after 2025 than before.

C.3.2 Employment

Table C-3 shows employment estimates for the Corridor counties for 2000, 2025, and 2035. Because the employment estimates for the Front Range Region are available only in total, it is also shown in **Table C-3**. Eagle, Lake, and Pitkin counties have the top three (in that order) annual employment growth rates for the 2000 to 2025 period, and then all show negative growth from 2025 to 2035.

Table C-3. Nine-County Corridor and Front Range Region Employment Estimates for 2000, 2025, and 2035

	Employment			Average Annual Growth	
County	2000 (DOLA 2002)	2025 (DOLA 2002)	2035 (DOLA 2008)	2000-2025	2025-2035
Clear Creek	3,509	5,529	6,822	1.8%	2.1%
Eagle	33,276	100,531	84,830	4.5%	-1.7%
Garfield	25,387	40,954	58,010	1.9%	3.5%
Gilpin	5,747	7,131	10,132	0.9%	3.6%

County	Employment			Average Annual Growth	
	2000 (DOLA 2002)	2025 (DOLA 2002)	2035 (DOLA 2008)	2000-2025	2025-2035
Grand	9,280	14,108	18,659	1.7%	2.8%
Lake	2,385	5,932	4,959	3.7%	-1.8%
Park	2,931	2,994	11,066	0.1%	14.0%
Pitkin	19,191	39,217	33,013	2.9%	-1.7%
Summit	23,242	44,261	53,492	2.6%	1.9%
Nine-County Total	**124,948**	**260,657**	**280,983**	**3.0%**	**0.8%**
Front Range Region Total	**1,367,174**	**1,972,984**	**2,354,733**	**1.5%**	**1.8%**

Source: Center for Business and Economic Forecasting, 2002, 2008.
Notes: The Front Range Region shown above is Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson counties.

Park County shows an unusual pattern of almost no employment growth from 2000 to 2025, and then 14 percent per year for the following 10 years. The net annual growth rate for Park County employment between 2000 and 2035 is 3.9 percent per year. Gilpin County's 2025 to 2035 annual growth rate is greater than its 2000 to 2025 rate.

Considering the overall 2000 to 2035 growth rate, the Front Range Region, Gilpin County, and Pitkin County grow the least—each at 1.6 percent per year—followed by Clear Creek County at 1.9 percent per year.

C.3.3 Recreation

Recreational forecasts are useful in gauging the potential for growth in certain trip purposes. Such forecasts can be compared against Corridor and Front Range population growth forecasts to see if recreational participation rates are expected to increase or decrease over time.

Many of the recreational destinations in the Corridor—including most ski resorts—are under the jurisdiction of the Forest Service. The National Visitor Use Monitoring Results report for the Arapaho-Roosevelt National Forests describes the data collection system that came in to use early this decade:

> *A four-year cycle of data collection was established. In any given year, 25 percent of the national forests conduct on-site interviews and sampling of recreation visitors. The first 25 percent of the forests included in the first four-year cycle completed sampling in December of 2000. The last 25 percent of the first, four-year cycle forests will complete their sampling in September 2003. The cycle begins again in October 2004. This ongoing cycle will provide quality recreation information needed for improving citizen centered recreation services.*

Therefore, depending on which year in the cycle a forest was surveyed, two or three sets of data may have been collected by the time this report was written. Of course, such data needs to be cleaned, edited, assembled, and analyzed before it can be used for forecasting purposes. The Forest Service has indicated that there are no available updated recreation use projections for summer or winter. Therefore, they have advised the continued use of the recreational demand forecasts used for 2025.

C.3.4 Aviation Traffic

Enplanements are used in calculating the trip productions (as distinguished from the other, attraction trip end) for two of the travel demand model's 21 trip purposes:

1. Out-of-State Air, which is part of the Stay Overnight group
2. Corridor to Airport or Front Range, which is part of the Colorado Non-Work group

The Federal Aviation Administration's (FAA) Terminal Area Forecast (TAF) is the primary source of enplanement projections; however, its forecasts only go through 2025. In a May 2008 presentation entitled "Master Plan Update Challenges and Opportunities," Denver International Airport (DIA) makes a 2030 forecast of 47 million enplanements. However, this figure includes transferring passengers with originating passengers. Further, originating passengers would have to be divided among those going to Front Range locations, Corridor residents, and Corridor visitors. No forecasts beyond 2025 appear to be available for other Corridor and Front Range airports of interest:

- Aspen/Pitkin County Airport (ASE)
- Colorado Springs Airport (COS)
- Eagle County Airport (EGE)
- Yampa Valley Regional Airport (HDN)

C.4 2035 Travel Forecasts

C.4.1 Demand

The focus of this section is the 2035 travel demand forecasts generated from the method described previously. A table for each model day presents the existing conditions and the Baseline scenarios together with the No Action forecasts. Columns of this table present the following information:

- The year 2000 observed count,
- The year 2025 Baseline forecast,
- The year 2035 Baseline forecast using the socioeconomic growth factoring method,
- The percentage growth in demand from 2025 to 2035,
- The year 2025 No Action forecasts,
- The 2035 No Action forecasts using the socioeconomic growth factoring method
- The forecast percentage growth in demand from 2025 to 2035 for No Action

Winter Saturday

Table C-4 shows that 2000 winter Saturday highway volumes vary from about 30,000 vehicles per day in Dowd Canyon, to about twice as many at Genesee. The volumes at focal points from No Name to Vail Pass (milepost 190), plus Floyd Hill and Genesee, roughly double by 2025, while the focal points from West of Silverthorne through the Twin Tunnels see more modest growth.

The 2035 Baseline forecast is roughly four times the 2000 value at No Name and East of Eagle and roughly triple the 2000 value for Floyd Hill. Vehicle trips at Dowd Canyon, Vail Pass, and Genesee are more than twice the year 2000 count. The 2035 forecast for the western part of the Corridor is as high as 60 percent greater than the 2025 Baseline forecast, while the Genesee forecast is about 10 percent greater than 2025. The volume growth at the west end of the Corridor is directly related to population growth in Eagle and Garfield counties.

Table C-4. Winter Saturday: Two-Way Volumes by Focal Point Baseline and No Action

	Baseline				No Action		
Focal Point	2000 Highway Vehicle Trips	2025 Highway Vehicle Trips	2035 Highway Vehicle Trips	Percent Growth from 2025 to 2035	2025 Highway Vehicle Trips	2035 Highway Vehicle Trips	Percent Growth from 2025 to 2035
No Name	11,700	29,500	47,200	60%	29,500	46,600	58%
East of Eagle	19,700	48,300	75,900	57%	48,300	75,100	55%
Dowd Canyon	30,200	60,900	82,500	36%	60,900	82,000	35%
Vail Pass	17,900	36,200	46,500	29%	36,000	37,000	3.0%
West of Silverthorne	39,900	57,700	69,500	20%	52,100	52,600	0.9%
Eisenhower-Johnson Memorial Tunnels	36,200	58,200	66,300	14%	52,400	56,800	8.3%
East of Empire	49,600	84,200	95,700	14%	68,200	73,200	7.4%
Twin Tunnels	57,000	88,100	100,800	14%	70,100	76,400	9.0%
Floyd Hill	49,300	129,400	147,800	14%	109,700	121,000	10%
Genesee	62,300	136,300	150,900	11%	116,800	126,000	7.9%

Source: JFSA.

Under the No Action alternative, the 2035 winter Saturday volumes at the two westernmost focal points—where no trip suppression is anticipated by 2035—are more than 50 percent greater than their 2025 forecasts. Traffic at Dowd Canyon is expected to increase by 35 percent over 2025 levels, while the increases at the other focal points are limited to 10 percent or less. Note that the forecasted volume at No Name is approximately 10,000 vehicles per day greater than at Vail Pass in 2035. Also, the volume East of Eagle is anticipated to be greater than that of West of Silverthorne or East of Empire.

Summer Thursday

On 2000 summer Thursday, the lowest vehicle count occurs at No Name, where it is under one-third of the Genesee count (see **Table C-5).** Both counts at Vail Pass and the Eisenhower-Johnson Memorial Tunnels are less than half the Genesee count. The Twin Tunnels 2000 count is about 6,000 vehicles higher than in Dowd Canyon. By 2025, these volumes have reversed themselves, with Dowd Canyon 1,200 vehicles higher. West of Silverthorne and East of Empire have also exchanged rank position, with East of Empire 1,300 vehicles higher in 2025. Also in 2025, the volume East of Eagle is forecasted to be 2,400 vehicles higher than at the Eisenhower-Johnson Memorial Tunnels.

In 2035, the No Name focal point shows the greatest increase over the 2025 Baseline, 58 percent. Dowd Canyon and Vail Pass are expected to have about one-third more traffic than in 2025. Volumes West of Silverthorne are 23 percent above 2025. From the Eisenhower-Johnson Memorial Tunnels to Floyd Hill, the growth rate is approximately 10 percent, while the growth rate at Genesee is 4 percent.

Table C-5. Summer Thursday: Two-Way Volumes by Focal Point Baseline and No Action

	Baseline				No Action		
Focal Point	2000 Highway Vehicle Trips	2025 Highway Vehicle Trips	2035 Highway Vehicle Trips	Percent Growth from 2025 to 2035	2025 Highway Vehicle Trips	2035 Highway Vehicle Trips	Percent Growth from 2025 to 2035
No Name	20,900	32,400	51,000	58%	32,400	51,600	60%
East of Eagle	26,000	65,300	94,300	45%	65,300	92,000	41%
Dowd Canyon	43,600	81,300	109,100	34%	81,300	94,500	16%
Vail Pass	25,900	45,900	60,400	32%	45,900	57,900	26%
West of Silverthorne	45,000	71,300	87,400	23%	68,200	82,700	21%
Eisenhower-Johnson Memorial Tunnels	34,500	62,900	69,800	11%	61,100	63,900	4.6%
East of Empire	43,200	72,600	80,000	10%	70,400	72,900	3.6%
Twin Tunnels	49,800	80,100	89,100	11%	77,600	81,900	5.5%
Floyd Hill	46,900	109,800	121,900	11%	108,600	133,400	23%
Genesee	69,400	124,200	129,200	4%	32,400	51,600	60%

Source: JFSA.

Under the No Action alternative, the 2035 summer Thursday volume West of Silverthorne and the more western focal points ranges from about 20 to 60 percent more than the 2025 forecast. Floyd Hill volumes are also expected to be 23 percent greater than 2025 levels. From Eisenhower-Johnson Memorial Tunnels to Genesee—excluding Floyd Hill—an increase of no more than 6 percent is expected.

During this weekday when work and local non-work trips dominate, 2035 volumes East of Eagle and in Dowd Canyon are expected to exceed those of the Eisenhower-Johnson Memorial Tunnels, East of Empire, and Twin Tunnels. Also, in 2035, volumes West of Silverthorne are projected to exceed those East of Empire.

Summer Friday

The 2000 count at Dowd Canyon, shown in **Table C-6**, is almost 3,000 vehicles greater than that at the Eisenhower-Johnson Memorial Tunnels. By 2025, this gap is expected to widen to about 22,000 vehicles. No Name volumes remain below those of Vail Pass—by 2,100 vehicles in 2000 and 4,400 vehicles in 2025.

The socioeconomic factoring procedure estimates 49 percent more vehicles at No Name on summer Friday in 2035 than in 2025. At East of Eagle, the growth rate is 39 percent. The 2035 forecasts for Dowd Canyon and Vail Pass are 26 percent and 22 percent greater than 2025, respectively. A 12 percent growth rate is projected at the Eisenhower-Johnson Memorial Tunnels.

Table C-6. Summer Friday: Two-Way Volumes by Focal Point Baseline and No Action

	Baseline				No Action		
Focal Point	2000 Highway Vehicle Trips	2025 Highway Vehicle Trips	2035 Highway Vehicle Trips	Percent Growth from 2025 to 2035	2025 Highway Vehicle Trips	2035 Highway Vehicle Trips	Percent Growth from 2025 to 2035
No Name	24,500	42,600	63,300	49%	42,600	62,300	46%
East of Eagle	31,400	67,700	93,900	39%	67,700	95,400	41%
Dowd Canyon	48,400	90,200	113,800	26%	90,200	104,800	16%
Vail Pass	26,600	47,000	57,400	22%	47,000	59,300	26%
Eisenhower-Johnson Memorial Tunnels	45,700	68,600	76,800	12%	62,400	64,600	3.5%

Source: JFSA.

Under the No Action alternative, the increase in summer Friday travel between 2025 and 2035 becomes more pronounced as one moves west, ranging from a 4 percent increase at the Eisenhower-Johnson Memorial Tunnels to a 46 percent increase at No Name. The 2035 No Name volume forecast is roughly comparable to the volume forecast at the Eisenhower-Johnson Memorial Tunnels and greater than that over Vail Pass.

Summer Saturday

In 2000, the summer Saturday count at Dowd Canyon is approximately equal to that at the Eisenhower-Johnson Memorial Tunnels and approximately one-half that at Genesee (see **Table C-7**). No Name and East of Eagle counts are approximately one-half those of Dowd Canyon, while the Vail Pass count is just over one-half that of West of Silverthorne. The Twin Tunnels volume is roughly the average of the Eisenhower-Johnson Memorial Tunnels and Genesee counts.

Table C-7. Summer Saturday: Two-Way Volumes by Focal Point Baseline and No Action

	Baseline				No Action		
Focal Point	2000 Highway Vehicle Trips	2025 Highway Vehicle Trips	2035 Highway Vehicle Trips	Percent Growth from 2025 to 2035	2025 Highway Vehicle Trips	2035 Highway Vehicle Trips	Percent Growth from 2025 to 2035
No Name	22,500	35,200	54,200	54%	35,200	54,100	54%
East of Eagle	23,400	56,800	87,200	53%	56,800	87,800	54%
Dowd Canyon	42,200	63,500	84,500	33%	63,500	84,400	33%
Vail Pass	25,300	47,000	58,700	25%	46,800	48,100	2.8%
West of Silverthorne	47,800	67,200	80,300	20%	64,000	65,000	1.5%
Eisenhower-Johnson Memorial Tunnels	44,900	64,000	73,300	15%	61,400	62,400	1.6%

Focal Point	Baseline				No Action		
	2000 Highway Vehicle Trips	2025 Highway Vehicle Trips	2035 Highway Vehicle Trips	Percent Growth from 2025 to 2035	2025 Highway Vehicle Trips	2035 Highway Vehicle Trips	Percent Growth from 2025 to 2035
East of Empire	59,700	82,500	93,600	13%	77,200	77,900	0.9%
Twin Tunnels	67,000	87,800	100,300	14%	81,500	82,100	0.7%
Floyd Hill	62,500	133,800	152,800	14%	120,600	122,900	1.9%
Genesee	85,100	156,800	173,600	11%	139,100	141,300	1.6%

Source: JFSA.

By 2025, traffic at the Dowd Canyon, Vail Pass, West of Silverthorne, Eisenhower-Johnson Memorial Tunnels, East of Empire, and Twin Tunnels focal points have all grown by about 20,000 over their 2000 levels. Floyd Hill and Genesee 2025 volumes are approximately 70,000 more than the respective 2000 counts.

No Name and East of Eagle are expected to grow their summer Saturday volumes by more than half from 2025 to 2035. The 2035 forecast at Dowd Canyon is approximately one-third greater than that of the 2025 Baseline, while the 2035 forecast for Vail Pass is one-quarter greater. Twenty percent growth in traffic is expected West of Silverthorne between 2025 and 2035. At more easterly locations, the forecast is within 11 to 15 percent of the 2025 Baseline. It is interesting to note that the 2035 Baseline forecast for East of Eagle exceeds that for Dowd Canyon (by 2,700 vehicles), which, in turn, exceeds that of West of Silverthorne (by 4,200 vehicles).

On summer Saturday, the 2035 No Action volume is forecasted to be 54 percent greater than the 2025 volume at No Name and East of Eagle. The increase during these 10 years is expected to be 33 percent in Dowd Canyon. At the other seven focal points, the increase is less than 3 percent. The 2035 volume East of Eagle—fed in part by trips from Garfield County—is greater than the volume at Dowd Canyon or the Twin Tunnels the same year.

Summer Sunday

Consistent with much of the summer Sunday travel returning to the Denver metro area, **Table C-8** shows 2000 counts increasing eastward from about 24,000 at No Name to more than triple this figure at Genesee. The lone exception is Vail Pass, where 13,100 fewer vehicles than in Dowd Canyon cross.

Table C-8. Summer Sunday: Two-Way Volumes by Focal Point Baseline and No Action

Focal Point	Baseline				No Action		
	2000 Highway Vehicle Trips	2025 Highway Vehicle Trips	2035 Highway Vehicle Trips	Percent Growth from 2025 to 2035	2025 Highway Vehicle Trips	2035 Highway Vehicle Trips	Percent Growth from 2025 to 2035
No Name	24,300	40,000	61,100	53%	38,800	59,500	53%
East of Eagle	28,100	53,000	78,600	48%	50,200	74,600	49%
Dowd Canyon	40,500	62,700	80,300	28%	59,800	76,100	27%
Vail Pass	27,400	52,500	62,400	19%	50,300	59,200	18%
West of Silverthorne	49,000	69,600	81,600	17%	70,300	82,100	17%

	Baseline				No Action		
Focal Point	2000 Highway Vehicle Trips	2025 Highway Vehicle Trips	2035 Highway Vehicle Trips	Percent Growth from 2025 to 2035	2025 Highway Vehicle Trips	2035 Highway Vehicle Trips	Percent Growth from 2025 to 2035
Eisenhower-Johnson Memorial Tunnels	49,100	69,400	79,400	14%	70,100	78,300	12%
East of Empire	62,300	88,000	100,200	14%	87,200	97,200	12%
Twin Tunnels	67,700	89,900	103,100	15%	88,900	99,500	12%
Floyd Hill	63,400	129,200	147,800	14%	128,200	143,400	12%
Genesee	83,100	151,300	171,300	13%	150,400	167,800	12%

Source: JFSA.

The 2025 forecast ranges from about 40,000 at No Name to more than 150,000 at Genesee. East of Eagle exceeds Vail Pass by 500 vehicles, and West of Silverthorne exceeds the Eisenhower-Johnson Memorial Tunnels by 200. The Genesee forecast is approximately three times that of East of Eagle, and Floyd Hill is expected to see about 50 percent more vehicles than East of Empire or Twin Tunnels.

The 2035 Baseline forecast is more than 60,000 vehicle trips at No Name, more than 50 percent greater than 2025. East of Eagle, the growth rate is 48 percent greater than 2025. The 2035 forecast for Dowd Canyon is roughly double the 2000 count and 28 percent greater than the 2025 Baseline. The 2035 forecasts for the seven focal points east of Dowd Canyon are within 20 percent of the 2025 forecast, with a minimum growth rate of 13 percent forecast for Genesee.

Under the No Action alternative, Summer Sunday volumes in 2035 at No Name and East of Eagle are estimated to be approximately 50 percent greater than the corresponding volume in 2025. At Dowd Canyon and Vail Pass, the increase ranges from 2 to 3 percent. A 1 percent increase is forecasted for West of Silverthorne. Increases of 6 to 8 percent are projected between 2025 and 2035 for the Eisenhower-Johnson Memorial Tunnels through Floyd Hill, inclusive. The 2035 volume at Genesee is estimated to be about 4 percent lower than its 2025 volume. As occurs on summer Saturday, the 2035 volume East of Eagle is greater than that in Dowd Canyon.

Inducement Over or Suppression under Baseline

Table C-9 shows the additional person trips beyond the 2035 Baseline that the 2035 No Action alternative's travel represents. Suppressed trips are shown as negative numbers.

Under the No Action alternative, differences in 2035 are highly dependent on whether and the extent to which travel is suppressed in 2025. The greatest trip suppression occurs at the east end of the Corridor on summer Saturdays and Sundays (about 60,000 to 70,000 trips). Some western focal points are expected to experience induced travel on some model days. In some cases, these differences are small and not likely significantly different from the Baseline. On summer Thursday, the greatest trip suppression (20,800 trips) occurs in Dowd Canyon. About as many trips are suppressed on summer Friday at the Eisenhower-Johnson Memorial Tunnels. On summer Sunday, about 40,000 trips are suppressed West of Silverthorne, and about 30,000 trips are suppressed East of Empire, at the Twin Tunnels, and on Floyd Hill.

Table C-9. Two-Way Person Trips Induced by 2035 No Action Alternative

Focal Point	Winter Saturday	Summer Thursday	Summer Friday	Summer Saturday	Summer Sunday
2035 No Action					
No Name	-1,100	900	-700	100	500
East of Eagle	-1,500	-3,100	3,500	1,300	1,300
Dowd Canyon	-800	-20,800	-12,200	500	-34,600
Vail Pass	-17,900	-3,100	4,100	-20,600	-24,500
West of Silverthorne	-34,500	-7,200	NC	-31,300	-39,700
Eisenhower-Johnson Memorial Tunnels	-19,700	-8,200	-19,700	-22,400	-24,700
East of Empire	-47,400	-9,300	NC	-32,300	-29,200
Twin Tunnels	-51,900	-9,700	NC	-37,800	-29,600
Floyd Hill	-58,300	19,100	NC	-64,500	-30,400
Genesee	-56,600	-13,900	NC	-72,700	-61,300

Source: JFSA.
Notes: NC = Not Calculated.

C.4.2 Travel Time

Highway Travel Time

Table C-10 shows peak period highway travel times between Silverthorne and the C-470 interchange associated with the year 2000, the two Baseline conditions, and the two No Action conditions. The morning peak period is from 6:00 to 10:00 am. The afternoon peak period is from 3:00 to 7:00 pm.

Table C-10. Peak-Period Highway Travel Time and Speed between Silverthorne and C-470

Season, Day, and Direction	2000	2025 Baseline	2035 Baseline	2025 No Action	2035 No Action
Winter Saturday Westbound	1 h 25 min 39 mph	3 h 40 min 15 mph	3 h 55 min 14 mph	1 h 25 min to 2 h 28 to 38 mph	1 h 35 min to 2 h 10 min 25 to 35 mph
Summer Sunday Eastbound	1 h 40 min 33 mph	4 h 14 mph	4 h 15 min 13 mph	1 h 55 min to 2 h 55 min 19 to 29 mph	1 h 55 min to 2 h 55 min 19 to 29 mph

Source: JFSA.
Note: The Baseline travel time is a theoretical calculation assuming unconstrained demand is loaded onto the existing and committed highway.

In the year 2000, it took 1 hour and 25 minutes to drive from C-470 to Silverthorne on a winter Saturday. It took an additional 15 minutes to make the return trip on a summer Sunday. Under the 2025 Baseline condition, it is expected to take 3 hours and 40 minutes for a westbound trip on a winter Saturday and 4 hours for an eastbound trip on a summer Sunday.

For the 2035 Baseline, these travel times are each increased by 15 minutes beyond 2025. The reason that this increase is relatively limited—compared to the increase between 2000 and the 2025 Baseline—is that travel conditions under the 2025 Baseline are already considerably congested. For example, the 4-hour travel time from Silverthorne to C-470 during the summer of 2025 corresponds to a speed of about 14 mph. The additional traffic in 2035 simply cannot have much more of an effect.

Under the No Action alternative, travel time in the eastern part of the Corridor is expected to be slowest eastbound on summer Sunday, taking about 2 to 3 hours. Average speeds are about 5 to 10 mph faster winter Saturday westbound than on summer Sunday eastbound.

Peak-period travel times between Glenwood Springs and Silverthorne are summarized in **Table C-11**. On summer Friday 2035 under the Baseline scenario, the eastbound travel time is about 1 hour longer than in 2025 and not quite double the 2000 travel time. The summer Friday westbound travel time is just over 3 hours longer than 2025 and 4 hours longer than 2000. The resulting average speeds are 31 mph eastbound and 15 mph westbound. On summer Sunday, the 2035 travel time is 4 hours and 5 minutes, one-half hour longer than the same trip taken in 2025.

Under the 2025 No Action alternative, average travel speeds from Glenwood Springs to Silverthorne may be as high as about 45 mph on both summer Fridays and summer Sundays. However, if travelers are more tolerant of congestion, and, therefore, more people travel, summer Sunday travel speeds could fall below 40 mph. Even with this increased tolerance of congestion, summer Sunday eastbound travel speeds would still be faster than summer Friday westbound, when speeds are forecasted to average around 35 mph.

In 2035, the No Action summer Sunday eastbound travel time is expected to be about 20 to 30 minutes longer than in 2025, for an average speed around 35 mph. The summer Friday eastbound travel time is expected to increase 50 to 75 minutes over the 2025 travel time. The lower bound for summer Friday westbound travel time remains at two and a half hours, while the upper bound increases 40 minutes to almost three and a half hours. For both directions on summer Friday, 2035 speeds average around 25 to 35 mph.

Table C-11. Peak-Period Highway Travel Time and Speed between Glenwood Springs and Silverthorne

Season, Day, and Direction	2000	2025 Baseline	2035 Baseline	2025 No Action	2035 No Action
Summer Friday Eastbound	1 h 35 min 55 mph	1 h 55 min 46 mph	2 h 55 min 31 mph	1 h 55 min 46 mph	2 h 45 min to 3 h 10 min 28 to 33 mph
Summer Friday Westbound	1 h 35 min 55 mph	2 h 45 33 mph	5 h 55 min 15 mph	2 h 30 min to 2 h 45 min 33 to 36 mph	2 h 30 min to 3 h 25 min 25 to 36 mph
Summer Sunday Eastbound	1 h 40 min 54 mph	3 h 35 min 25 mph	4 h 5 min 22 mph	2 h to 2 h 20 min 38 to 45 mph	2 h 30 min to 2 h 40 min 34 to 35 mph

Source: JFSA.
Note: The Baseline travel time is a theoretical calculation assuming unconstrained demand is loaded onto the existing and committed highway.

Transit Travel Time

Negligible line-haul transit services existed in the Corridor in 2000, and no additional services are assumed to be provided under the No Action alternative. Because the AGS has an exclusive guideway, only the bus in mixed traffic from Glenwood Springs to Eagle County Airport is affected by automotive congestion. **Table C-12** shows the transit travel time for the two study segments where a bus operates in mixed traffic: Glenwood Springs to Eagle County Line, and Eagle County Line to Eagle County Airport. The AGS time from Eagle County Airport to Edwards is also shown, to provide details of the total transit travel time between the Eagle County Line and Edwards.

Winter Saturday westbound bus travel times are not expected to differ between 2025 and 2035 under the Combination Six-Lane Highway with AGS alternative. Eastbound on summer Sunday, the journey from

Glenwood Springs to the Eagle County Line is expected to lengthen by 1 minute from 17 to 18 minutes, thereby matching the winter Saturday time. The summer Sunday trip from Eagle County Line to Eagle County Airport is also expected to take 1 minute longer than it did in 2025 and 3 minutes longer than the trip on winter Saturday.

Table C-12. Transit Travel Time (Minutes) for Combination Six-Lane Highway with AGS

Year, Season, Day, and Direction	Glenwood Springs to Eagle County Line	Eagle County Line to Eagle County Airport	Eagle County Airport to Edwards	Total Eagle County Line to Edwards
2025 Winter Saturday Westbound	18	23	23	46
2035 Winter Saturday Westbound	18	23	23	46
2025 Summer Sunday Eastbound	17	25	23	47
2035 Summer Sunday Eastbound	18	26	23	48

Source: JFSA.
Note: Totals may not add because of independent rounding.

C.4.3 Hours of Congestion (LOS F) and Problem Areas

Table C-13 shows the annual hours of congestion (LOS F) for each of the 10 focal points, by direction, for the year 2000, and for the 2025 and 2035 Baseline scenarios. In 2000, six focal points have no congestion in either direction:

1. No Name
2. East of Eagle
3. Dowd Canyon
4. Vail Pass
5. West of Silverthorne
6. Genesee

Additionally, Floyd Hill eastbound does not experience any congestion in 2000. The greatest duration of congestion in 2000 occurs eastbound East of Empire, at 260 hours. Westbound, the longest duration of congestion—130 hours—occurs at the Floyd Hill lane drop.

By 2025, only No Name and East of Eagle remain free of congestion, although Vail Pass and West of Silverthorne do not experience congestion westbound. Eastbound congestion ranges from 100 hours, at both Dowd Canyon and Vail Pass, to 740 hours at the Twin Tunnels. Only the Eisenhower-Johnson Memorial Tunnels, East of Empire, Twin Tunnels, and Genesee exceed the 365-hour threshold for inclusion in the Problem Areas. Westbound, the congestion ranges from 560 hours at Dowd Canyon to 1,550 hours at Genesee. Because of westbound congestion, Dowd Canyon and Floyd Hill were added to the Problem Areas.

Table C-13. Annual Hours of LOS F by Direction for 2000, 2025 Baseline, and 2035 Baseline

	Eastbound			Westbound		
Focal Point	2000	2025 Baseline	2035 Baseline	2000	2025 Baseline	2035 Baseline
No Name	0	0	0	0	0	0
East of Eagle	0	0	169	0	0	148
Dowd Canyon	0	100	1,688	0	560	2,674
Vail Pass	0	100	429	0	0	1,015
West of Silverthorne	0	174	1,962	0	0	0
Eisenhower-Johnson Memorial Tunnels	120	580	1,083	20	719	1,732
East of Empire	260	490	1,683	80	590	794
Twin Tunnels	200	740	2,411	70	690	938
Floyd Hill	0	300	476	130	1,100	1,525
Genesee	0	584	818	0	1,550	3,426

Source: JFSA.
Note: Cells shown in red shading indicate greater than 365 hours of LOS F annually, which for the Baseline scenarios was the threshold used to determine the Problem Areas in the PEIS.

Under the 2035 Baseline, No Name is the only focal point to experience no congestion in either direction. The lowest traffic volumes in the Corridor typically occur at No Name. No Name is within the Glenwood Canyon section of I-70, where four-lane widening was completed in 1992. Because of the (relatively) recent improvements to Glenwood Canyon and its environmentally sensitive nature, no further improvements were contemplated here in the PEIS.

West of Silverthorne westbound experiences no congestion under the 2035 Baseline. Here, I-70 is three lanes ascending from the US 6 and SH 9 exit at Silverthorne to the SH 9 exit at Frisco. The three lanes are adequate for the volume forecast to occur by 2035. Some congestion is anticipated East of Eagle in 2035—169 hours eastbound and 148 hours westbound—but not enough to exceed the threshold for inclusion in the Problem Areas.

Eastbound at the eight easternmost focal points, the duration of congestion ranges from 429 hours per year over Vail Pass to 1,962 hours per year West of Silverthorne. Eastbound at the Frisco SH 9 interchange (milepost 203), a two-lane on-ramp merges with two mainline lanes. I-70 is briefly three lanes going uphill and then drops to two lanes before descending to Silverthorne. Therefore, a third eastbound auxiliary lane from Frisco to Silverthorne is included in the model for the Highway and Combination alternatives for evaluation in the PEIS.

Note that Vail Pass was included in the Problem Areas in the PEIS because of grade, curvature, and safety concerns. By 2035, both directions of Vail Pass are also anticipated to exceed the 365-hour congestion threshold for identifying the Problem Areas. Improvements in the form of an auxiliary lane in each direction on the west side of Vail Pass (milepost 180 to milepost 190) are contemplated as part of the Minimal Action alternative, the Highway alternatives, and the Combination (Build Simultaneously) alternatives.

Other segments of the Problem Areas are addressed by providing a six-lane highway in Dowd Canyon and from the Eisenhower-Johnson Memorial Tunnels West Portal to Floyd Hill or by providing a high-quality fixed transit guideway between Eagle County Airport (milepost 142) and C-470. Additional lanes were not contemplated for Jefferson County (except for a few miles of westbound auxiliary lane) because this section of I-70 is already six lanes and lies within an urban corridor, where residents are more familiar with congestion.

As part of the 2035 preparation process, it became necessary to determine if other segments of I-70 needed to be added to the Problem Areas on a more spatially detailed basis. **Table C-14** provides the information to conduct that analysis and presents the 2035 Baseline annual hours of LOS F from one interchange to the next.

While **Table C-14** does not have every interchange-to-interchange segment, it contains enough to determine if any modifications to the Problem Areas are necessary. For example, the segment between the Glenwood Springs interchange and the No Name interchange (milepost 119) is forecast to have no hours of congestion in either direction in 2035. Because the interchanges within Glenwood Canyon function as rest areas and day recreation sites, noticeable changes in I-70 volumes are not expected to occur, so the Glenwood Springs to No Name segment is representative of the larger Glenwood Springs to Dotsero segment.

Table C-14. 2035 Baseline Hours of Congestion (LOS F) by Interchange Segment

From Interchange	To Interchange	Eastbound Annual Hours of LOS F	Westbound Annual Hours of LOS F	Needs to be Included in Problem Areas?
Glenwood Springs	No Name	0	0	No
Eagle Airport	Eagle	169	336	No
Eagle	Wolcott	296	148	No
Edwards	Avon	365	261	No
Avon	Post Blvd.	603	619	Yes
Post Blvd.	Eagle-Vail	353	342	Yes
Eagle-Vail	Dowd Junction	261	663	Yes
Dowd Junction	Vail West Entrance	1,688	2,674	Yes
Vail West Entrance	Vail Main Entrance	133	2,860*	No*
Vail Main Entrance	Vail East Entrance	133	2,568*	No*
Vail East Entrance	Vail Pass (Shrine Pass Road)	429	1,015	Yes
Officers Gulch	Frisco Main Street	263	256	No
Frisco Main Street	Frisco SH 9	279	142	No
Frisco SH 9	Silverthorne	1,962	0	Yes
Silverthorne	Eisenhower-Johnson Memorial Tunnels West Portal	2,133	0	Yes
Eisenhower-Johnson Memorial Tunnels West Portal	Loveland Pass	1,083	219	Yes
Silver Plume	Georgetown	900	935	Yes
Empire	Lawson	976	543	Yes
Downieville	Dumont	976	597	Yes
Idaho Springs West	Idaho Springs SH 103 (Mount Evans)	1,140	165	Yes
Idaho Springs East	Hidden Valley	1,140	565	Yes
Hidden Valley	US 6 Gaming	575	638	Yes
US 6 WB On	US 6 WB Off	NC	1,553	Yes
Hyland Hills	Beaver Brook	287	NC	No
Beaver Brook	El Rancho	NC	1,525	Yes

From Interchange	To Interchange	Eastbound Annual Hours of LOS F	Westbound Annual Hours of LOS F	Needs to be Included in Problem Areas?
El Rancho	Evergreen Parkway	383	1,474	Yes
Chief Hosa	Genesee	335	1,529	Yes

Source: JFSA.

Notes: NC = not calculated

Cells shown in red shading indicate greater than 365 hours of LOS F annually, which was the threshold used to determine the Problem Areas in the PEIS.

** Although these two segments within the Town of Vail exceed the 365 annual hours of LOS F threshold used to determine the Problem Areas, they result solely from the downstream bottleneck at Dowd Junction. When the section of I-70 in Dowd Canyon (that is, Vail West Entrance to Dowd Junction) is widened to three lanes (for example, under the Highway or Combination alternatives), the congestion within the Town of Vail also disappears. For this reason, the Town of Vail is not added to the Problem Areas despite exceeding the nominal hours of LOS F threshold.*

Similarly, since the Eagle County Airport to Eagle segment is expected to experience fewer than 365 annual hours of congestion in either direction, and I-70 volumes generally increase as one moves east in Eagle County from Dotsero to Vail (while capacity remains relatively constant), it is safe to conclude that the Dotsero to Eagle County Airport segments will also experience 365 or fewer hours of congestion.

Avon (milepost 167) to Avon East Entrance (milepost 168) is the westernmost segment of I-70 to exceed the 365-hour threshold. In the PEIS, the entire section of I-70 from Avon to east of Vail West Entrance is included in the Problem Areas for one or more of the following reasons:

- 2025 Baseline volumes were expected to exceed capacity (that is, operate at LOS F) for more than 365 hours a year.
- 2025 ramp traffic was expected to back up onto the I-70 mainline.
- The I-70 mainline or an interchange experiences greater than average accident rates.
- Sharp curves are present (design speeds are lower than adjacent portions of the roadway).
- Steep grades are present.

This section of I-70 also includes Eagle-Vail (milepost 169) to Dowd Junction, which is expected to exceed 365 hours of LOS F westbound in 2035, and Dowd Canyon (that is, Dowd Junction to Vail West Entrance), which **Table C-13** also shows, exceeds 365 hours of LOS F westbound in 2025.

The next section, from Vail West Entrance to Vail East Entrance (milepost 180), deserves special consideration. Traffic simulation results indicate that this section will see more than 2,500 hours of LOS F westbound. However, that mainline statistic is not the whole picture. This congestion results when traffic originating in the Town of Vail enters I-70 and merges with already high mainline volumes. Notice that **Table C-14** also indicates the westbound section of I-70 from Vail West Entrance to Dowd Junction will experience a similar duration of congestion. Other traffic simulations showed that when this bottleneck was removed—by providing a six-lane highway within Dowd Canyon—the congestion occurring between the three Vail interchanges also dissipated. For this reason, it was determined that the section of I-70 in the Town of Vail did not need to be added to the Problem Areas.

The situation in Dowd Canyon and Vail differs from that of Clear Creek County, where essentially the whole county was added to the Problem Areas because of queue spillback and traffic dependencies. Specifically, in the case of Clear Creek County, through volumes tend to dwarf locally generated traffic. Therefore, widening I-70 between any pair of adjacent interchanges (say Georgetown Hill from Georgetown, milepost 228, to Silver Plume, milepost 226) would only reveal capacity deficiencies elsewhere (say Bakerville, milepost 221, to Herman Gulch, milepost 218) along the roadway. The situation in Vail is different because the Town of Vail generates a larger volume of traffic, and the

Frontage Roads within Vail are capable of accommodating that traffic, so widening only the section within Dowd Canyon would be necessary to alleviate the congestion here.

The next segment of I-70 shown in **Table C-14** to exceed the 365-hour threshold is from the Frisco SH 9 interchange to the Silverthorne interchange. As described earlier, this segment was identified by the West of Silverthorne focal point exceeding the 365-hour threshold under the 2025 Baseline (see **Table C-13**).

Table C-14 shows the segment of I-70 from the Silverthorne interchange to the Eisenhower-Johnson Memorial Tunnels West Portal is expected to experience 2,133 hours of LOS F eastbound under the 2035 Baseline. This segment of I-70 was included in the Problem Areas in the PEIS by reason of steep grades and sharp curves. The (eastbound) Johnson Tunnel bore (West Portal to Loveland Pass Interchange, milepost 216) is also shown to exceed the 365-hour threshold. The Eisenhower-Johnson Memorial Tunnels was included in the Problem Areas in the PEIS; indeed the Transit, Highway, and Combination alternatives all provide for a third bore at this location.

The remaining segments of I-70 shown in **Table C-14** to exceed the 365-hour threshold are included within Clear Creek and Jefferson counties. As stated earlier, the entire length of I-70 within these two counties was included in the Problem Areas in the PEIS for reasons of capacity, geometry, safety, or grade.

In summary, the congestion anticipated under the 2035 Baseline does not result in any expansion of the Problem Areas presented in the PEIS, as shown in **Figure C-1**. However, within the Problem Areas, the duration of LOS F at any particular location is forecasted to increase from 2025 to 2035.

Table C-15 presents the annual hours of LOS F for each of the 10 focal points, by direction, under the No Action and Combination Six-Lane Highway with AGS alternatives.

Under the No Action alternative, no congestion is expected in 2025 at No Name or East of Eagle in either direction, or at Vail Pass or West of Silverthorne westbound. By 2035, congestion in either direction East of Eagle is roughly 150 hours, while congestion westbound over Vail Pass last for not quite 250 hours. In either future year, the greatest amount of congestion is expected to occur at Genesee westbound—a location dominated by trips directed to the Denver metro area. Westbound congestion at Floyd Hill reflects the presence of the lane drop (from three to two lanes) there. Eastbound congestion at the Eisenhower-Johnson Memorial Tunnels is also the result of a lane drop.

Table C-15. Annual Hours of LOS F by Direction for 2025 and 2035 No Action Alternative

	Eastbound		Westbound	
Focal Point	2025 No Action	2035 No Action	2025 No Action	2035 No Action
No Name	0	0	0	0
East of Eagle	0	169	0	148
Dowd Canyon	100	1,688	560	2,069
Vail Pass	31	388	0	237
West of Silverthorne	92	684	0	0
Eisenhower-Johnson Memorial Tunnels	499	1,083	316	1,447

	Eastbound		Westbound	
Focal Point	2025 No Action	2035 No Action	2025 No Action	2035 No Action
East of Empire	305	1,140	249	590
Twin Tunnels	618	2,123	214	455
Floyd Hill	260	268	617	862
Genesee	525	555	1,004	2,340

Source: JFSA.

Note: Cells shown in red shading indicate greater than 365 hours of LOS F annually.

C.5 Summary

The steps in developing the 2035 travel data set and preparation of the PEIS involved the following three tasks:

1. Calculating the 2035 travel performance of all studied alternatives in the PEIS
2. Determining specific travel performance of the Preferred Alternative – Minimum Program for 2020, 2025, and 2035
3. Conducting the analysis of impacts on air quality, noise, social and economic values, and energy use

Calculating the travel performance first involved creating spreadsheets that produce the initial estimates of 2035 travel demand, following the process described in Section 0 and Attachment 1. Then origin-destination (OD) matrices were developed for input to the VISSIM traffic simulator. Travel times were compared to travelers' tolerance of congestion, and, where necessary, demand levels were adjusted, as described in Attachment 1. 2035 travel demand data was used to analyze impacts associated with that forecast year for the PEIS.

Attachment 1. Development of the 2035 Travel Demand Projection Approach

For reasons described herein, neither the four-step model nor the linear trend analysis used in the PEIS is recommended for projecting travel demand for 2035. Instead, an advantageous approach is described, which takes into account socioeconomic forecasts for 2035, yet avoids extraneous detail associated with a four-step model run.

A1.1 Overview

The following three travel demand forecasting approaches have been considered:

1. The socioeconomic-based forecasting approach proposed for developing 2035 forecasts and PEIS

   The socioeconomic-based factored modeling approach predicts 2035 travel by first splitting 2025 travel volumes by trip purpose, then determining a growth rate for each trip purpose, and then applying the growth rate to the relevant component of 2025 travel. The growth rate is determined for each focal point and trip purpose based on the feeder area influencing that travel market and the socioeconomic variable driving those trips (often the number of households).

2. The four-step travel demand model used to produce 2025 forecasts for the PEIS

   The four-step travel demand model explicitly accounts for the processes of trip generation, trip distribution, mode choice, and travel assignment. It was implemented in a TransCAD macro script that typically takes about 6 hours to run for each model day and scenario considered. The four-step model produces voluminous output, one component of which is a collection of hourly OD matrices indexed by interchange entering or leaving I-70. These OD matrices are used by the traffic simulation package, VISSIM, to estimate travel times on I-70.

3. The linear time trend approach used to examine the year at network capacity in the PEIS

   The linear trend approach estimates travel demand for a forecast year beyond 2025 by constructing a straight line between observed year 2000 traffic levels and the 2025 forecasts associated with a particular alternative or scenario. By extending this line to later years, forecasts for those years can be estimated. The primary application of the linear trend approach is to examine the ultimate capacity of each alternative, defined as the year that the alternative would reach network capacity.

Table 1 presents advantages and disadvantages of the three modeling approaches. The socioeconomic-based factored modeling approach was selected because it represents a compromise between the detail of a four-step model and the simplicity of a linear time trend analysis. Other advantages of the socioeconomic-based approach include its spreadsheet implementation, its ability to use county- or regional-level socioeconomic forecasts, and its concentration of calculations to the 10 focal points considered in the PEIS. Some disadvantages are that the 2035 demands are calculated independent of changing travel times. Specific advantages and disadvantages of each approach are included within the discussion of that approach below.

Table 1. Summary of Advantages and Disadvantages to Demand Modeling Approaches

Approach	Advantages	Disadvantages
Socioeconomic-Based Factored Modeling Approach	▪ Retains gravity model relationships of four-step demand model ▪ Spreadsheet implementation ▪ Socioeconomic data may be as aggregate or disaggregate as desired ▪ Maintains consideration of trip purposes ▪ Limits forecasts to focal points	▪ Not as detailed as four-step demand model ▪ Assumes negligible change to impedances
Four-Step Demand Model	▪ Provides fine resolution for volumes between focal points and off I-70 ▪ Generates exit-to-exit trip tables used by VISSIM	▪ Requires speed balancing loops ▪ Complex calculations ▪ Input changes may produce counter-intuitive results ▪ Requires computational time ▪ Requires post-model adjustments
Linear Time Trend	▪ Simple calculation ▪ Does not require projections of socioeconomic variables ▪ Suitable for far future forecasts	▪ Insensitive to differential socioeconomic growth rates ▪ May not consider individual trip purposes

Source: JFSA.

A1.2 Socioeconomic-Based Approach for 2035 Travel Forecasts

A1.2.1 General Description

DOLA has released county-level population and employment forecasts for 2035, and the DRCOG has developed 2035 TAZ-level projections of populations, households by income, and employment by sector. Although TAZ-level data is desirable, it is not available for all but the easternmost end of the Corridor. Therefore, the 2035 analysis uses socioeconomic forecasts by county. In the case of the DRCOG region east of the Corridor, the seven-county region (Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson COUNTIES) is often considered as a whole.

The 2035 analysis assumes that growth in trips (by purpose) is proportional to the growth in population or employment between 2025 and 2035 for a relevant feeder area (see Section A1.2.7 and Table 2). Trips at different focal points have different feeder areas, as do trips of different purposes. Further, because the purpose mix varies by model day, direction, and focal point, different growth rates result for each of these considerations.

A1.2.2 Derivation from Gravity Model

The gravity model is one of the four steps used by TransCAD, which performs trip distribution. By basing the proposed approach on the gravity model, the relationship is maintained to the full four-step model, while simplifying it for more efficient turnaround in producing 2035 forecasts. The gravity model states that trips for OD pair are proportional to productions, attractions, and friction factor determined by travel time or impedance, divided by sum of productions or attractions for all TAZs. That is,

$$T_{ijp} = P_{ip} \frac{K_{ijp} A_{jp} f_p(t_{ij})}{\sum_{\text{all zones } j} A_{jp} f_p(t_{ij})},$$

or

$$T_{ijp} = A_{jp} \frac{K_{ijp} P_{ip} f_p(t_{ij})}{\sum_{\text{all zones } i} P_{ip} f_p(t_{ij})},$$

where

- i and j are TAZs
- p is the trip purpose under consideration
- T_{ijp} is the number of trips produced in TAZ i and attracted to TAZ j for purpose p
- P_{ip} is the number of trip ends produced in TAZ i for purpose p
- A_{jp} is the number of trip ends attracted to TAZ j for purpose p
- K_{ijp} is the socioeconomic adjustment factor for production-attraction (PA) pair ij and purpose p
- $f_p(\cdot)$ is the impedance or friction factor function for purpose p
- t_{ij} is the travel time or impedance between PA pair ij

Since productions and attractions are balanced,

$$\sum_{\text{all zones } i} P_{ip} = \sum_{\text{all zones } j} A_{jp} .$$

Further, assume $t_{ij} = t_{ji}$.

By assuming no change to the trip generation rates, to the socioeconomic adjustment (K-) factors, or to the impedance or friction factor function values, the growth in the number of trips as a function of the relative growth in productions and attractions can be approximated. That is,

$$T_{ijp}^{2035} = T_{ijp}^{2025} h_p\left(\frac{P_{ip}^{2035}}{P_{ip}^{2025}}, \frac{A_{jp}^{2035}}{A_{jp}^{2025}}\right) = T_{ijp}^{2025} h_p(g_P, g_A)$$

where $h_p(\cdot,\cdot)$ has a functional form to be determined, and g_P and g_A are the production and attraction growth rates as defined by the equation. Various forms for $h_p(\cdot,\cdot)$ considered are described in the next section.

A1.2.3 Definition of Travel Growth Rate by Trip Purpose

For the 2035 analysis, the functional form selected was either $h_p(\cdot,\cdot) = g_P$ or $h_p(\cdot,\cdot) = g_A$, depending on trip purpose. The production growth rate, g_P, is used for the following trip purposes:

- Work
- Local Non-Work
- Gaming
- Front Range Day Recreation
- Corridor Day Recreation
- Stay Overnight
- Colorado Non-Work

Growing trips proportionally to the growth in productions implicitly assumes that activity participation rates (which are embedded in trip generation rates) remain constant into the future.

The attraction growth rate, g_A, is used for Out-of-State Auto trips and for Truck, RV, and External trips, as this would tie growth in these trips to a socioeconomic variable relating to the Corridor. For these purposes, trips are produced at the study area boundary.

This formulation allows a simplified specification, since it is not necessary to determine a single growth rate from a combination of production and attraction growth rates. This formulation is particularly advantageous when, for example, attraction forecasts, such as skier visits, are not available. This formulation effectively assumes no change to other trip end considered.

A1.2.4 Implications of Assumptions

The socioeconomic factoring method makes several simplifying assumptions. As was noted earlier, friction factors and trip impedances (travel times) are assumed to remain constant in the future. Also, the socioeconomic adjustment or K-factors used by the gravity model are also assumed to be constant. This section describes some of the implications of these assumptions.

One potential concern from assuming constant friction factor function values is that this assumption could lead to predicting longer duration trips in future years; that is, an increased average travel time. However, as travel demand and, therefore, congestion increases over time, it is likely that travelers' tolerance of congestion and, therefore, longer duration trips also increases. One criticism of socioeconomic adjustment factors is that it is impossible to predict how they might change over time. Indeed, most travel demand models assume constant socioeconomic adjustment factors. The I-70 four-step travel demand model uses socioeconomic adjustment factors only to moderate trips made between the two sides of Vail Pass; therefore, the assumption of no change to these factors over time is likely reasonable.

Because trips at a focal point represent the sum of trips between specific PA or OD pairs, the focal point volume can be calculated in a similar manner as that of a single zonal interchange, using an aggregation of production and/or attraction TAZs. This calculation assumes no change in route choice for a given OD pair between 2025 and 2035, although congestion is increasing. Explicit consideration of route choice is an advantage of the four-step process (route choice being one of the four steps). However, no large changes in route choice are expected because of the limited number of alternative routes to I-70 and because population, employment, and, therefore, congestion are also growing in those alternative route corridors. That is, because the 2025 forecasts already consider diversions to alternative routes, the factored 2035 forecasts also reflect these diversions. It is also possible that travel reduced during a subsequent constraint step (see Section A1.2.5) represents travel diverted to another route or rescheduled to another day, rather than being completely suppressed (that is, not made at all).

A1.2.5 Trip Suppression or Reduction of Over-Inducement

Trip suppression or inducement is always defined in relation to the corresponding year's Baseline scenario. Let this relationship be expressed as follows:

$$T_{ijp}^{y,Alt} = I_{ijp}^{y,Alt} T_{ijp}^{y,BL}$$

where $T_{ijp}^{y,Alt}$ is the number of trips between origin-destination pair *ij* for purpose *p* in year *y* under the alternative given. Similarly, $T_{ijp}^{y,BL}$ is the corresponding number of trips under the Baseline scenario for year *y*. The term $I_{ijp}^{y,Alt}$ is the inducement or suppression rate for the OD pair being examined. $I_{ijp}^{y,Alt} > 1$

corresponds to trip inducement while $I_{ijp}^{y,Alt} < 1$ corresponds to trip suppression, since fewer than the Baseline number of trips are accommodated.

In developing the 2025 travel demand forecasts, trip suppression was the only consideration in obtaining simulated travel times and comparing those against travelers' tolerance of congestion. However, as shown, using the proposed socioeconomic factoring approach for 2035 forecasts introduces another consideration. Consider a Combination alternative having 12 percent induced travel in 2025. The factoring approach results in it having an initial level of 12 percent induced travel in 2035. However, since the 2035 Baseline volume is greater than that of the 2025 Baseline, but capacity is unchanged between the two years, the Combination alternative is not able to accommodate all of the 12 percent induced travel in 2035. This property of the socioeconomic factoring approach is called "over-inducement." The second step of applying travelers' tolerance to congestion results in calculating the appropriate level of inducement (or suppression) for 2035.

Because the same socioeconomic growth rates are applied to the Baseline scenario and the alternatives, the initial 2035 forecast for each alternative implicitly reflects the level of induced or suppressed travel present in the 2025 forecast. Mathematically,

$$T_{ijp,initial}^{2035,Alt} = T_{ijp}^{2025,Alt} h_p\left(g_P, g_A\right) = I_{ijp}^{2025,Alt} T_{ijp}^{2025,BL} h_p\left(g_P, g_A\right) = I_{ijp}^{2025,Alt} T_{ijp}^{2035,BL}$$

Because population and employment generally increase over time—that is, $h_p(g_P,g_A) > 1$—travel demand also grows. However, because no new capacity is assumed to be provided after 2025, congestion also grows. Therefore, it is unreasonable to expect the level of inducement or suppression to be the same in 2035 as in 2025. Instead, we expect $I_{ijp}^{2035,Alt} < I_{ijp}^{2025,Alt}$ when the socioeconomic drivers of transportation increase over time. For example, if an alternative such as No Action is suppressed 2 percent below the Baseline in 2025, it may be suppressed by 3 or 4 percent in 2035. Similarly, a Combination alternative may have 12 percent induced travel in 2025 but may be able to accommodate only 8 percent induced travel in 2035.

How is the final level of inducement or suppression for 2035 determined? The level of inducement or suppression is determined by considering travelers' tolerance for congestion, as was done for 2025 demands. Travel times for the initial level of 2035 demand are tested using the travel time simulator VISSIM (or estimated using the relationships developed by VISSIM). Any alternative with an initial travel demand resulting in congestion greater than travelers' willingness to bear (defined as an average speed of 30 mph over the eastern or western networks by a panel of technical staff knowledgeable of the Corridor) has its demand reduced until it meets that speed threshold. The final level of demand determines the final trip inducement or suppression level for 2035.

Once the final number of highway vehicle trips are calculated from the travel time sensitivities, the final number of highway person trips can be calculated assuming constant vehicle occupancy or by allocating reduced trips to certain trip purposes. (While the latter is more realistic, the former is computationally more straightforward.) Depending on the final number of person trips, this result may represent trip suppression (fewer trips than the Baseline level) or a reduction of over-inducement (more trips than Baseline, but fewer than initially predicted by the factoring method).

Note that the travel demands of all alternatives are "constrained" by travelers' tolerance to congestion. Only the Baseline scenario reflects an unconstrained demand situation.

A1.2.6 Relationship to the Four-Step Model

As discussed above, the proposed approach follows from the gravity model trip distribution step of the four-step model. The proposed approach incorporates sensitivities from the four-step TransCAD model that are embedded in the 2025 forecasts, as described below:

- First, the four-step model plays a role in the development of the 2035 travel demand projections in that the volumes by trip purpose at each of the focal points (see, for example, the second column of Table 3), which are used to reflect differential growth rates in different trip types, come directly from the output of the 2025 TransCAD model runs.
- The proposed approach builds on the 2025 projections modeled by TransCAD in that the 2035 forecasts are determined incrementally from the 2025 forecasts. That is, the factoring approach does not create 2035 travel demand levels synthetically from 2035 socioeconomics the way a four-step model would but uses the socioeconomic growth from 2025 to 2035 to determine the corresponding growth in travel demand during the same period.
- The proposed approach is not solely a spreadsheet approach—the traffic simulator VISSIM is used extensively to estimate travel times and determine the limits of trip inducement or suppression. Traffic simulation is important because travel time and congestion relationships are highly non-linear when demands approach capacity, as is expected at many locations in 2035.
- The factoring approach is expected to be consistent with the four-step model approach. Essentially the only new data available at this stage are the 2035 county-level population and employment forecasts from DOLA. Allocating these forecasts to TAZs proportionally to 2025 TAZ levels results in all TAZs in a county having the same growth rate, and, therefore, the results of the four-step model is identical to the factoring approach, although more numerous computations are required to obtain the same result.

A1.2.7 Socioeconomic Growth Associated with Focal Points

The socioeconomic factoring method for developing 2035 forecasts requires the analyst to determine which socioeconomic variables for which feeder areas are associated with the productions or attractions of trips through a focal point. Identification of the dominant socioeconomic variables comes from knowledge of relative trip generation rates. The areas that produce the majority of productions or attractions can be determined by either aggregating PA matrices by county or observing assigned link flows by purpose, taking into account the predominant flow direction (from production to attraction or vice versa) on that model day. **Table 2** summarizes the socioeconomic variables and areas that influence travel growth at focal points. The variables associated with productions and attractions of each trip purpose are shown at the top of the table, and the areas influencing travel at each focal point are shown below.

In estimating 2035 trips, it is assumed that the average household size remains constant between 2025 and 2035; therefore, that population—which is readily available—can be used instead of households. Under this assumption, both have the same growth rates.

Table 2. Feeder Areas for Socioeconomic Growth Used to Establish Travel Growth at Focal Points

Trip Purpose	Work		Local Non-Work		Gaming	
Trip End	Production	Attraction	Production	Attraction	Production	Attraction
Typical Socioeconomic Variables	Households	Total Employment	Households	Retail and Service Employment	Households	Devices
No Name	Garfield County	Eagle County	Garfield County	Eagle County	Garfield and Pitkin County	Gaming Area
East of Eagle	Garfield County	Eagle County	Eagle County	Eagle County	Garfield and Pitkin County	Gaming Area
Dowd Canyon	Eagle and Garfield Counties	Eagle County	Eagle County	Eagle County	Eagle, Garfield, and Pitkin Counties	Gaming Area
Vail Pass	Eagle, Garfield, and Summit Counties	Eagle and Summit Counties	Eagle and Summit Counties	Eagle and Summit Counties	Eagle, Garfield, and Pitkin Counties	Gaming Area
West of Silverthorne	Clear Creek, Eagle, and Summit Counties	Eagle and Summit Counties	Summit County	Summit County	Eagle, Garfield, Pitkin, and Summit Counties	Gaming Area
Eisenhower-Johnson Memorial Tunnels	Clear Creek County and DRCOG Region	Eagle and Summit Counties	Clear Creek County	Summit County	Eagle, Garfield, Pitkin, and Summit Counties	Gaming Area
East of Empire	Clear Creek County and DRCOG Region	Grand and Summit Counties	Clear Creek County	Grand and Summit Counties	Clear Creek, Eagle, Garfield, Grand, Pitkin, and Summit Counties	Gaming Area
Twin Tunnels	Clear Creek, Grand and Summit Counties	DRCOG Region	Clear Creek County	DRCOG Region	Clear Creek, Eagle, Garfield, Grand, Pitkin, and Summit Counties	Gaming Area
Floyd Hill	Clear Creek, Grand, and Summit Counties	DRCOG Region	Clear Creek County	DRCOG Region	DRCOG Region	Gaming Area
Genesee	Clear Creek and Jefferson Counties	DRCOG Region	Clear Creek and Jefferson Counties	DRCOG Region	DRCOG Region	Gaming Area

Trip Purpose	Front Range Day Recreation		Corridor Day Recreation		Stay Overnight	
Trip End	**Production**	**Attraction**	**Production**	**Attraction**	**Production**	**Attraction**
Typical Socioeconomic Variables	**Households**	**Skier Visits**	**Households, Second Homes, Resort Stays**	**Skier Visits, Forest or Park Visits**	**Households and Enplanements**	**Second Homes and Hotel Beds**
No Name	N/A	N/A	Eagle County	Pitkin County	Garfield and Pitkin Counties	Eagle County
East of Eagle	N/A	N/A	Eagle County	Eagle County	Eagle and Garfield Counties	Eagle County
Dowd Canyon	DRCOG Region	Beaver Creek	Eagle County	Eagle County	Eagle County	Eagle County
Vail Pass	DRCOG Region	Eagle County	Eagle County	Summit County	DRCOG Region and Summit County	Eagle and Pitkin Counties
West of Silverthorne	DRCOG Region	Eagle County and Copper Mountain	Eagle and Summit Counties	Summit County	DRCOG Region	Eagle and Summit Counties
Eisenhower-Johnson Memorial Tunnels	DRCOG Region	Eagle and Summit Counties	Eagle and Summit Counties	Clear Creek, Jefferson and Summit County	DRCOG Region	Eagle and Summit Counties
East of Empire	DRCOG Region	Eagle, Grand, and Summit Counties	Jefferson County	Clear Creek, Grand, and Summit County	DRCOG Region	Eagle, Grand, and Summit Counties
Twin Tunnels	DRCOG Region	Eagle, Grand, and Summit Counties	Jefferson County	Clear Creek, Grand, and Summit County	DRCOG Region	Eagle, Grand, and Summit Counties
Floyd Hill	DRCOG Region	Eagle, Grand, and Summit Counties	Jefferson County	Clear Creek, Grand, and Summit County	DRCOG Region	Eagle, Grand, and Summit Counties
Genesee	DRCOG Region	Eagle, Grand, and Summit Counties	N/A	N/A	DRCOG Region	Eagle, Grand, and Summit Counties

Trip Purpose	Colorado Non-Work		Out-of-State Auto		Truck RV External	
Trip End	Production	Attraction	Production	Attraction	Production	Attraction
Typical Socioeconomic Variables	**Households**	**Households and DIA Enplanements**	**External Station Counts**	**Employment and Skier Visits**	**External Station Counts**	**Employment**
No Name	Eagle and Summit Counties	Pitkin County	Kansas, New Mexico, Utah, and Wyoming	Eagle County	Kansas, New Mexico, Utah, and Wyoming	Eagle County
East of Eagle	Eagle and Summit Counties	Pitkin County	Kansas, New Mexico, Utah, and Wyoming	Eagle County	Kansas, New Mexico, Utah, and Wyoming	Eagle County
Dowd Canyon	DRCOG Region, Eagle and Summit Counties	Eagle and Pitkin Counties	Kansas, New Mexico, Utah, and Wyoming	Eagle County	Kansas, New Mexico, Utah, and Wyoming	Eagle County
Vail Pass	DRCOG Region and Summit County	Eagle and Pitkin Counties	Kansas, New Mexico, Utah, and Wyoming	Summit County	Kansas, New Mexico, Utah, and Wyoming	Summit County
West of Silverthorne	DRCOG Region	Eagle and Summit County	Kansas, New Mexico, Utah, and Wyoming	Summit County	Kansas, New Mexico, Utah, and Wyoming	Summit County
Eisenhower-Johnson Memorial Tunnels	DRCOG Region	Summit County	Kansas, New Mexico, Utah, and Wyoming	Eagle and Summit Counties	Kansas, New Mexico, Utah, and Wyoming	Eagle and Summit Counties
East of Empire	DRCOG Region	Grand and Summit Counties	Kansas, New Mexico, Utah, and Wyoming	Eagle, Grand and Summit Counties	Kansas, New Mexico, Utah, and Wyoming	Eagle, Grand and Summit Counties
Twin Tunnels	DRCOG Region	Grand and Summit Counties	Kansas, New Mexico, Utah, and Wyoming	Grand and Summit Counties	Kansas, New Mexico, Utah, and Wyoming	Grand and Summit Counties
Floyd Hill	DRCOG Region	Grand and Summit Counties	Kansas, New Mexico, Utah, and Wyoming	Grand and Summit Counties	Kansas, New Mexico, Utah, and Wyoming	Grand and Summit Counties
Genesee	DRCOG Region	Grand and Summit Counties	Kansas, New Mexico, Utah, and Wyoming	Grand and Summit Counties	Kansas, New Mexico, Utah, and Wyoming	Grand and Summit Counties

Source: J.F. Sato and Associates.

A1.2.8 Numerical Example

A numerical example helps illustrate application of the socioeconomic-based factored modeling method. Table 3 shows details of a sample calculation for westbound Baseline highway person trips at Dowd Canyon on winter Saturday. The second column gives the 2025 trips by purpose. For each purpose, the feeder area (see Table 2) and socioeconomic variable determining trip growth is specified in column 3. Columns 4 and 5 show the values of this socioeconomic variable for 2025 and 2035, respectively. Column 6 shows the growth rate for that feeder area and socioeconomic variable; that is, column 5 over column 4 minus 1. Column 7, the 2035 westbound Baseline highway person trips, is calculated by applying the growth rate of column 6 to the 2025 trips in column 2. Trips by purpose can then be totaled.

Table 3. Sample Calculation of Highway Person Trips: Winter Saturday Westbound at Dowd Canyon

Trip Purpose	2025 Baseline Highway Person Trips	Feeder Area and Socioeconomic Variable	2025 Value	2035 Value	Growth Rate	2035 Baseline Highway Person Trips
Work	11,700	Eagle and Garfield Population	157,000	245,700	57%	18,300
Local Non-Work	10,100	Eagle Population	76,100	98,600	30%	13,100
Gaming	900	Eagle, Garfield, and Pitkin Population	180,700	274,400	52%	1,400
Front Range Day Recreation	300	DRCOG Population	3,452,000	3,955,000	15%	300
Corridor Day Recreation	20,000	Eagle Population	76,100	98,600	30%	25,900
Stay Overnight	10,800	Eagle Population	76,100	98,600	30%	14,000
Colorado Non-Work	3,900	DRCOG, Eagle, and Summit Population	3,571,000	4,108,000	15%	4,500
Out-of-State Auto	1,200	Eagle Employment	100,500	84,800	-16%	1,000
Truck, RV, External	4,200	Eagle Employment	100,500	84,800	-16%	3,500
Total	**63,100**				**30%**	**82,000**

Source: JFSA.
Note: Totals may not add because of independent rounding.
The DRCOG region shown above is Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson counties.
Clear Creek and Gilpin counties are members of DRCOG; however, they were treated separately for purposes of calculating 2035 trips.

Attachment 2. 2035 No Action Travel Forecast Approach

Attachment 2 provides a description of the process used to develop 2035 forecasts for the No Action Alternative. In contrast, Attachment 1 describes the process to develop 2035 travel demand forecasts in general. Due to the limited capacity of the No Action Alternative, the desired amount of travel in 2035 cannot be fully accommodated. Attachment 2 therefore provides details on how the amount of 2035 travel is suppressed due to No Action capacity conditions.

The amount of travel under the No Action Alternative in 2035 is assumed to have demand levels slightly higher than those of 2025. Such an assumption is reasonable because demand levels in 2025 at some focal points are suppressed below the baseline demand. Therefore very little growth in traffic at these locations – associated primarily with peak spreading- is expected.

The 2035 No Action forecasts presented in this Technical Report were developed using the following general process:

1. First, the socioeconomic factoring method (described in Attachment 1 of this Technical Report) is used to forecast the 2035 Baseline volumes at each focal point. Baseline is a projection of travel demand before taking into account the suppression effect of highway capacity under the No Action Alternative.
2. 2035 Baseline travel times and speeds are calculated for each of the ten study segments from VISSIM using the 2035 Baseline travel demand (highway vehicle trips).
3. For segments where the Baseline speed was lower than travelers' tolerance to congestion (30 mph), the 2035 Baseline demand was reduced (suppressed) until the resulting speed was within the tolerance to congestion, resulting in the 2035 No Action demand.
4. The 2035 Baseline vehicle occupancy is used to convert the No Action vehicle trips to person trips.

Several focal points do not encounter trip suppression in 2025, volumes for these focal points are expected to increase. The actual value of the volume increase would depend on diverse factors, including initial 2000 and 2025 volume levels, capacity of the roadway, changes in fuel costs, and changes in weather and other motivations for Front Range residents to go to the Corridor. Some of these variables—such as fuel costs and weather—cannot be known in advance and would be responsible for variation around an underlying trend. The socioeconomic factoring method increases these trips in proportion to population and employment forecasts. However, it is possible that the growth predicted by the socioeconomic factoring method is greater than can be accommodated on I–70 while still providing acceptable travel speeds to motorists. In such a case, demand begins to be suppressed so that the remaining volume is able to be accommodated at the minimum tolerable speed.

The 2035 No Action forecast of person trips in the peak direction on weekdays (westbound) and weekends (eastbound) is shown in Table 1. The number of person trips at the focal points varies from a little under 50,000 at both the No Name Tunnels and Vail Pass on weekdays, to over 200,000 on weekends East of Genesee. The table shows that weekend volumes are greater than weekday volumes for each of the ten focal points. At the four easternmost focal points from East of Empire to East of Genesee, the weekend demand is roughly double the weekday demand.

On weekdays, 65,300 westbound person trips are expected to pass the West of Silverthorne focal point in 2035—about the same level of travel as at the Twin Tunnels (63,500). 2035 demand within Eagle County is higher, at 71,100 person trips East of Eagle and 81,000 person trips through Dowd Canyon. The heaviest trip-making occurs in the eastern section of the corridor, where 96,400 person trips are expected to descend Floyd Hill, and 107,100 person trips pass East of Genesee in 2035.

On weekends, 2035 demand at the No Name Tunnels and over Vail Pass exceeds 70,000 person trips, which is about the same level as on weekdays East of Eagle. On weekends in 2035, the volume East of Eagle is forecasted to be greater than that in Dowd Canyon (91,200 versus 85,200 person trips), highlighting growth in population, employment, and local trip-making in Eagle County. West of Silverthorne, the number of 2035 weekend trips (95,500) are comparable to the weekday volumes at Floyd Hill (96,400). Weekend volumes East of Empire and at the Twin Tunnels are projected to exceed 100,000 person trips eastbound. East of Genesee, 210,400 people are anticipated to make eastbound weekend trips in 2035.

Table 1. 2035 No Action Person-Trip Demand Forecast

Location	Weekday Westbound	Weekend Eastbound
No Name Tunnels	47,500 *	70,200
East of Eagle	71,100 *	91,200
Dowd Canyon	81,000 *	85,200
Vail Pass	46,600 *	74,500
West of Silverthorne	65,300	95,500
Eisenhower-Johnson Memorial Tunnels	53,400	90,300
East of Empire	57,200	109,200
Twin Tunnels	63,500	111,500
Floyd Hill	96,400	176,500
East of Genesee	107,100	210,400

Note: ** Indicates volume for Friday, other weekday volumes are for Thursday.*
Source: *JFSA*

Appendix D
Uncertainties in Forecasting to 2050

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Appendix D. Uncertainties in Forecasting to 2050

As the horizon year of a forecast increases, the uncertainty in the forecast compounds because the estimates in earlier, intermediate-year forecasts propagate forward in a cumulative fashion. For example, suppose a forecast for 2025 travel demand was somewhat low. A 2035 forecast that relies on this 2025 forecast is also likely to be low and subject to errors in the process of bringing the 2025 forecast forward to 2035 (using socioeconomic growth rates, for example). Then using those forecasts to extrapolate forward to 2050 incorporates the errors in the earlier forecast and combines them with whatever uncertainty exists in adding 15 more years to the forecast.

In practically all travel demand models, trip-making is tied to levels of socioeconomic activity, primarily population and employment. The State Demographer's Office of the Colorado Department of Local Affairs (DOLA) has made population and employment forecasts at the county level to 2035. The U.S. Census Bureau has published population projections on a state level through 2030 and on the national level through 2100 (although the projections for 2051 through 2100 are based on the 1990 Census). Local entities maintain consistency with the State Demographer's Office by using DOLA county forecasts as control totals and allocating socioeconomic variables to smaller geographies.

The Denver Regional Council of Governments has prepared socioeconomic forecasts to 2035. In addition to the lack of DOLA control totals, another source of uncertainty is how the Urban Growth Boundary / Area might change after the 2035 horizon of the current Metro Vision Plan.

Some Corridor counties have begun to tie socioeconomic forecasts to projections of "build-out," that is, the most intensive land use allowed by the current zoning code. The Summit County Comprehensive Plan anticipates that build-out will occur by 2030; at which time, the maximum number of dwelling units allowed will have been constructed. Currently, about two-thirds of the housing stock in Summit County is second homes, that is, owned by primary residents of other counties. Summit County is concerned about a lack of affordable housing for local residents and workers, and aims to reduce the proportion of out-of-county-owned housing in the future. The out-of-county ratio may also decrease as second home owners retire, sell their primary residence, and move to their Summit County home full time. Of course, the trip-making characteristics of a dwelling unit vary depending on whether the unit is occupied by workers or retirees, or whether it is used as a second home.

Eagle County is developing its own build-out forecast, and estimates its ultimate population will be around 80,000. This level of population corresponds roughly to the State Demographer's 2030 forecast of Eagle County's population (81,350 persons).

While build-out is calculated from developable area and zoning density restrictions, other considerations also limit growth in the Corridor and Front Range. Water is one such factor. Summarizing Colorado Water Conservation Board forecasts, I-70 Mountain Corridor PEIS project team analysis concluded that based on anticipated levels of development, there would be roughly an 87,000 acre-foot water shortage in the two major river basins that intersect the Corridor (the Colorado and the South Platte) in 2030 (see **Table D-1**). It is not clear how water consumption might change if practices such as xeriscape and grey-water reclamation become more common.

Table D-1. Colorado River Basin and South Platte River Basin Water Demand Projections

Entity	Water Demands			Existing Water Supply		Additional Water Needed
	1990	2010	2030	Avg Annual Yield	Dry Year Yield	2030
Colorado River Basin						
City of Aspen	4,113	7,336	N/A	7,287	6,656	680
Clifton Water District	3,187	4,575	7,140	14,400	14,400	0
Ute Water Conservancy District	6,800	11,500	19,900	41,000	24,000	0
Other basin entities (55% of basin population)	N/A	N/A	N/A	N/A	N/A	300
Total	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**980**
South Platte River Basin						
City of Aurora	39,000	61,800	75,000	63,000	N/A	12,000
City of Boulder	19,800	24,900	29,200	N/A	41,330	0
City of Englewood	8,212	10,100	11,000	10,100	10,100	1,000
City of Fort Collins	31,000	39,000	48,000	68,000	35,000	13,000
City of Loveland	8,990	12,973	20,684	23,053	15,460	5,300
Denver Water Board	249,000	325,000	376,000	375,000	345,000	31,000
East Cherry Creek Valley W&S District	2,802	10,823	15,540	11,870	11,870	3,700
East Larimer County Water District	3,000	4,000	6,000	4,200	3,500	2,500
Lefthand WSD (Niwot)	4,550	9,750	11,050	7,273	4,789	6,300
Other basin entities (15% of basin population)	N/A	N/A	N/A	N/A	N/A	11,200
Total	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**86,000**

Source: Colorado Water Conservation Board, March 2002.
Note: All measurements in acre-feet.
Legend:
N/A = Not available.

As the previous discussion illustrates, there is considerable uncertainty in forecasts of the resources that allow for the socioeconomic development that, in turn, drives trip-making. Values of the 2050 horizon year travel demand forecast should, therefore, be considered in light of the uncertainty about them and used as “order of magnitude” measures rather than trying to assert a high degree of statistical accuracy.

D.1 Method for Forecasting 2050 Horizon Travel Demand

In making the 2050 horizon travel demand forecast, the desire was to produce a range of values to reflect potential uncertainty in the projection. Since 2050 socioeconomic forecasts are not available, the 2050 horizon demand was estimated by extrapolating from the 2025 and 2035 travel demand levels. Note that because the travel demand forecasts do not assume new Corridorwide transit service, transit shares for the

2025 and 2035 demand —and, therefore, under the 2050 horizon—are low. Transit share resulting with various alternative improvements are discussed in Chapter 2 of the PEIS.

The high estimate uses exponential extrapolation, which assumes a constant growth rate from year to year. The formula for the high estimate is then

$$T_{2050,high} = T_{2025}\left(\frac{T_{2035}}{T_{2025}}\right)^{\left(\frac{2050-2025}{2035-2025}\right)} = T_{2025}\left(\frac{T_{2035}}{T_{2025}}\right)^{\left(\frac{25}{10}\right)} = T_{2025}\left(\frac{T_{2035}}{T_{2025}}\right)^{2.5}$$

where T is the number of vehicle or person trips by mode and direction at a given focal point.

The low estimate uses linear extrapolation, which corresponds to the same increase in the number of trips occurring each year. Linear extrapolation, therefore, corresponds to a decreasing growth rate over time, since in calculating the growth rate, the numerator is the same each year while the denominator increases over time. The formula for the low estimate is

$$\begin{aligned} T_{2050,low} &= T_{2025} + \left(\frac{2050-2025}{2035-2025}\right)\left[T_{2035} - T_{2025}\right] = T_{2025} + \left(\frac{25}{10}\right)\left[T_{2035} - T_{2025}\right] \\ &= 2.5T_{2035} - 1.5T_{2025} \end{aligned}$$

Growth rates for the high estimate and for the first year (2035–2036) and last year (2049–2050) of the low estimate were examined and found to be within the historical experience of Corridor and Front Range county population and employment growth, as **Table D-2** shows.

Table D-2. Comparison of Maximum and Minimum Annual Population and Trip Growth

Quantity	Minimum Annual Growth Rate	Maximum Annual Growth Rate
County Population: Front Range (1880–2000)	-0.5%	11.6%
County Population: Corridor (1900–2000)	-10.5%	12.7%
Total Person Trips: 10 Focal Points (2035–2050)	0.5%	3.4%

D.2 Relationship to Year at Network Capacity

Now, given that the 2050 horizon travel demand can be forecast using the method described in **Section D.1**, one might assume that the horizon demand was compared against a measure of alternative demand or capacity to determine whether an alternative would be able to accommodate the 50-year demand. . However, this is not precisely the method used to evaluate alternatives.

Instead, a broader concept of network capacity was used to evaluate the alternatives.

Network capacity is defined over a long segment:

- Silverthorne to C-470 for the Eastern Corridor
- The Eagle-Garfield County Line to Silverthorne for the Western Corridor

Note that Glenwood Canyon is excluded from the network capacity calculation; its current configuration likely represents the maximum footprint to be provided transportation facilities in the Canyon. No alternative would include additional highway lanes or a transit guideway within Glenwood Canyon.

Network capacity does consider the peak day and direction:

- Summer Sunday eastbound for the Eastern Corridor
- Summer Friday westbound for the Western Corridor

However, the comparison that network capacity makes is not demand at an individual focal point, but whether the average travel speed throughout the entire segment is greater than travelers' tolerance to congestion (corresponding to 30 mph, below which some travelers are assumed to cease making trips). In using the average speed over a long segment, network capacity allows a corridor-wide level assessment of an alternative for the long term 2050 horizon.

Calculating network capacity involves the following steps:

1. Calculating (by linear interpolation and extrapolation) the number of highway vehicle trips at each focal point, in five-year increments
2. Calculating the travel time on each study segment based on the volume forecast and the relationships derived from VISSIM traffic simulations of representative alternatives
3. Summing the total travel time for each part of the Corridor and comparing against the tolerance to congestion

Note that the formula used in Step 1 is identical to the linear formula used to develop the low estimate of the 2050 horizon, except that the demand of each particular alternative is used.

VISSIM simulations were run for different demand levels to develop the volume-speed relationships used in Step 2.

In Step 3, if the average travel speed is less than 30 mph, then trip suppression is assumed to occur, and an alternative is said to have exceeded network capacity in that year. The year at network capacity is, therefore, the last year (at five-year intervals) in which an alternative does not see suppressed travel demand.

Because a linear trend analysis is used to develop both the 2050 horizon travel demand and the year at network capacity, there will be considerable correlation between the two measures. As an example, the 2050 person trip capacity for the Preferred Alternative – Maximum Program (55 mph) was estimated at a few focal points for comparison with the 2050 horizon, as shown in **Table D-3**. The Preferred Alternative capacity would be within or greater than the range of the 2050 horizon, and thus would have network capacity at 2050. The analysis showed this was not the case for 2055; therefore, the Preferred Alternative would reach network capacity in 2050.

Table D-3. Comparison of 2050 Preferred Alternative Person Trip Capacity with 2050 Person Trip Demand

Focal Point	Day and Direction	Preferred Alternative Person Trip Capacity	2050 Horizon– Low Estimate Person Trip Demand	2050 Horizon – High Estimate Person Trip Demand	Comparison
No Name	Summer Friday WB	66,800	66,100	74,600	within range
Dowd Canyon	Summer Friday WB	115,000	110,000	114,000	slightly above range
EJMT	Summer Sunday EB	150,000	129,000	132,000	above range
Twin Tunnels	Summer Sunday EB	201,000	168,000	172,000	above range
West of C-470 (East of Genesee)	Summer Sunday EB	319,000	277,000	284,000	above range

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Appendix E
I-70 Safety and Congestion Problem Areas

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Appendix E. I-70 Safety and Congestion Problem Areas

E.1 Overview

Appendix E describes the Corridor safety and travel demand characteristics of the Corridor. The purpose of this report is to provide supporting information to **Chapter 1** of the I-70 Revised Draft PEIS descriptions of existing and projected 2035 travel demand, roadway deficiencies and safety issues.

There are a wide variety of travel patterns within the 144-mile section of I-70 under study. Some portions are dominated by long-distance trips, while others are primarily commuting trips. Recreational trips for both outdoor attractions and indoor casinos compose a large portion of travel in other locations on certain days.

To develop a more coherent and complete discussion of travel patterns, the PEIS study area was divided into 10 segments. These segments were chosen so that each segment represents a particular pattern of trips—when these trips occur and for what purposes. Segments were also chosen to reflect similar land uses along I-70 and to have natural breakpoints in congestion.

For example, over the course of a year, travelers crossing Vail Pass—the study segment between Vail East Entrance and Copper Mountain—are making primarily long-distance trips, for day and overnight recreation, and freight movement purposes. (Annually, 13 percent of the vehicles crossing Vail Pass are trucks.) In contrast, between Copper Mountain and Silverthorne, a greater percentage of annual trips are made for local commuting and shopping within Summit County.

Travel patterns on the Corridor also vary throughout the week and throughout the year. On the eastern end of the Corridor, weekend travel routinely exceeds weekday travel during the tourism and recreational seasons of summer and winter. On the western end, commuters cause weekday travel to exceed weekend travel. Summer and winter travel patterns vary.

Each segment contains one **focal point** where travel demand and capacity are examined in detail. For each focal point, three or four typical days were studied, including a weekday and a weekend in both winter and summer. In the western part of the Corridor, a Friday was also examined because the combination of weekday commuting and weekend recreation travel often results in Fridays having greater traffic volumes than Thursdays, the typical weekday in this study.

The winter season is represented by February, while August travel volumes are typical of the whole summer. Thursday count and model data are used to study weekday travel patterns; although Mondays and Fridays may have higher volumes, their demand patterns mix typical weekday trips (such as commuting to work) with typical weekend trips (such as traveling between a primary residence and a second home in the Corridor area). Because most weekday trips are not discretionary, weekday travel patterns in the summer and winter are similar. Therefore, only the summer weekday is presented. Generally, summer weekdays have somewhat higher volumes than in winter.

Moving east from the western Corridor terminus, this section discusses the Corridor one segment at a time, with highway **capacity** and **level of service (LOS)** shown for both 2000 and 2035 for each segment. Levels of service are measurements that characterize the quality of operational conditions within a traffic stream and their perception by motorists and passengers.

The 2035 Baseline LOS projects what the travel conditions would be like ***if*** all of the demand for travel on a peak model day in 2035 were to be satisfied on the existing and planned (No Action) highway network.

This section examines the important question of whether the existing transportation system in the Corridor can accommodate the expected growth in development, population, employment, and recreation. It examines this question one study segment at a time in a consistent format. For each segment, the information provided is organized as follows:

Levels of Service (LOS) are described in terms of:

- Speed
- Travel time
- Freedom to maneuver
- Traffic interruptions
- Comfort and convenience

The six levels of service are designated by the letters **A** through **F,** with A representing the best operating conditions (light, free-flow traffic) and F the worst (stop-and-go traffic). Each level represents a range of operating conditions.

The lower boundary of LOS E (between LOS E and LOS F) is considered to be operating **at capacity,** at which point the traffic stream cannot dissipate any traffic disruptions, such as stalled vehicles or crashes.

- Length and termini of the study segment
- Corridor towns, highway linkages (major interchanges), and landmarks
- A map of the segment, including areas of concern
- A discussion of current roadway deficiencies, such as curves, grades, safety concerns, or capacity bottlenecks
- Results of the analysis of the traffic counts
- Results of computer modeling for 2035 Baseline demand

Table E-3 through **Table E-31** report the weekend daily volume as the highest of either the Saturday or Sunday peak model day for that season. The highest hourly volume during the 48-hour weekend period is shown for the peak hour. In some cases, the highest daily volume occurs on one day and the highest hourly volume on a different day.

Modeling future travel demand is based on estimated levels of population and employment growth and projections of Corridor uses by 2035. The details of the travel model are given in **Appendix A, Travel Model**, and generally included the following:

- Existing and projected highway system and transit system networks
- Land use zoning and master plans from each county and local government and federal lands
- Trip generation rates derived from the I-70 User Study and other sources
- Trip distribution factors
- Mode choice factors
- Seasonal controls
- Day of week factors
- Time of day factors
- Highway operation and delay procedures
- Transit route choice factors

To assist in the determination of future demand and future need for mobility, the Baseline condition represents the magnitude of the projected need for travel based on the factors outlined above. The travel demand for the Baseline condition is not the same as for the No Action alternative. The Baseline traffic condition is based on the existing transportation network and the travel demands resulting from the recreation, population, and employment forecasts.

E.1.1 Recreation Forecast

Recreation trips into, out of, and within the Corridor area are forecast directly and are based on industry marketing surveys, then compared on an order-of-magnitude basis with other data, such as hotel beds by town or second homes by town. Because of the proprietary nature of some of these data, it is difficult to determine the absolute number of trips for different types of recreation. However, forecast volumes for each recreational category were discussed with local tourism bureaus, the Forest Service, and others to determine the reasonableness of each estimate.

E.1.2 Population and Employment Forecast

The 2035 Baseline population and employment forecast was developed from socioeconomic data projected by the Colorado Department of Local Affairs (DOLA) and the counties, and assumes that future Corridor transportation capacity will not limit development between 2000 and 2035. That is, the 2035 Baseline population and employment forecast represents the anticipated levels of growth, from which different transportation alternatives may be tested. Because the 2035 Baseline population and employment forecast was developed without regard to the transportation network, the 2035 Baseline condition (travel performance) does not represent an equilibrium that may be observed in the future, but only a theoretical basis for comparison. The true future traffic equilibrium will depend on the selected alternative. Some alternatives may have inadequate infrastructure to support the Baseline demands, and thus result in trip suppression, while other alternatives may have adequate or extra capacity and result in better traffic conditions than in 2000.

Furthermore, it is not reasonable to expect the Baseline population, employment, and recreation use forecasts to be realized if severe congestion is experienced on I-70 or if the congestion is greatly reduced due to the implementation of high-capacity alternatives. That is, congestion may cause people to make fewer trips or not to live or work in the Corridor area. Conversely, congestion relief may allow Corridor users to make more trips or encourage more people to relocate to the Corridor area. The concepts of unmet and induced travel are explored further in **Appendix A, Travel Model**.

The Baseline travel demand need not equal that of the No Action alternative. Because no improvement would be made to the transportation network under the No Action and Minimal Action alternatives, these alternatives would represent a suppression of demand if the Baseline demand would result in intolerable levels of congestion. All other alternatives (the action alternatives) have been sized to address the future Baseline demand. All of the following discussion concerns the 2035 Baseline travel demand based on the future demand expected in 2035 by Corridor community governments and the state demographer, and the expected demand from Front Range travelers.

E.2 Data Sources for Current Congestion

Calibrating a travel model requires specific information on current traffic patterns. This PEIS uses several types of traffic counts:

- Mainline traffic counts
- Selected interchange ramp counts based on known volume patterns
- Crossing road counts at interchanges
- Interchange turning movement counts
- Vehicle classification counts

Table E-1 indicates the locations of the different types of counts that were performed. The results of the traffic counts are discussed in **Appendix A, Travel Model**.

Table E-1. Location of Traffic Counts

Type	Location
Mainline traffic counts (hourly)	East of Glenwood Springs (No Name Creek) Eagle to Wolcott (east of Eagle) West of Vail West Entrance (Dowd Canyon) West of CO 91 (Copper Mountain, east of Vail Pass) EJMT East of Idaho Springs (near the Twin Tunnels) East of Genesee Mountain
Interchange ramp counts (hourly)	On- and off-ramps of 39 interchanges between mileposts 133 and 259
Crossing road counts at interchanges (hourly)	Locations near 22 interchanges in winter and 13 interchanges in summer
Interchange turning movement counts (hourly)	18 interchanges on the Corridor
Vehicle classification counts	Dowd Canyon

E.3 Safety Issues

Safety issues in the roadway were determined by measuring the **weighted hazard index (WHI) for the 1996 to 2001 period.** The WHI compares the weighted accident rate, measured as follows: comparing **weighted accidents** at a location (higher weight given to a higher severity accident) per **million vehicle miles of travel** to the statewide average weighted accident rate for similar roadways, and determining whether the observed rate is higher than the statewide average. If a WHI is greater than zero, it signifies that the location in question has a higher weighted accident rate than the statewide average and is, therefore, a potentially problematic area in terms of either the number of accidents observed or their severity. Updated weighted hazard index data for the 2001 to 2005 period is available in the *I-70 Mountain Corridor PEIS Safety Technical Report.*

E.4 Corridor Capacity

The travel model also considers any constraints to the current capacity of I-70 due to steep and twisting mountain grades (for example, extended grades of up to 7 percent at Vail Pass, on the west side of the EJMT, and at Mount Vernon Canyon in Jefferson County) and by slow-moving vehicles. Note that heavy vehicles use a considerable portion of the ideal roadway capacity both on upgrades where engine power to haul heavy loads is limited, and on longer downgrades where low gears must be used to regulate speed through engine break, and thus maintain control of the vehicle.

Calculating Capacity

Capacity is calculated using various factors, including:

- Lane width
- Shoulder width
- Number of lanes
- Geometric constraints
- Drivers' familiarity
- Percentage of slow-moving vehicles
- Weather

The combined effects of these steep mountain passes, sharp curves, and slow-moving vehicles are key factors that limit the capacity of the Corridor. Additional factors affecting capacity include winter driving conditions, lack of familiarity of some travelers with the mountain conditions, inadequate capacity at certain interchanges, and the cross-sectional dimensions of the roadway.

Capacity analysis provides a means of estimating the maximum amount of traffic that can be accommodated by the roadway while maintaining its prescribed operational qualities. It includes a set of procedures for estimating the traffic-carrying ability of the highway over the range of LOS.

E.5 Corridor Segment Descriptions, Existing and Projected Baseline Travel Demand

The following sections profile each Corridor segment, including physical descriptions, maps, photographs, details of roadway deficiencies including capacity and safety issues, and existing and Baseline travel demand for the segment. Note that the Baseline scenario does not assume any new Corridor-wide transit systems. The segment focal point descriptions provide an overview of the roadway segment, current and 2035 level of service, Baseline annual peak hours of congestion, and Baseline peak hour travel time. Current and future mainline capacity constraints are also described including average daily traffic, peak hour volume, peak hour LOS hours of congestion, and the hourly capacity at LOS E. This information is provided for 2000 and 2035.

E.5.1 Segment 1, Glenwood Springs to Eagle County Line

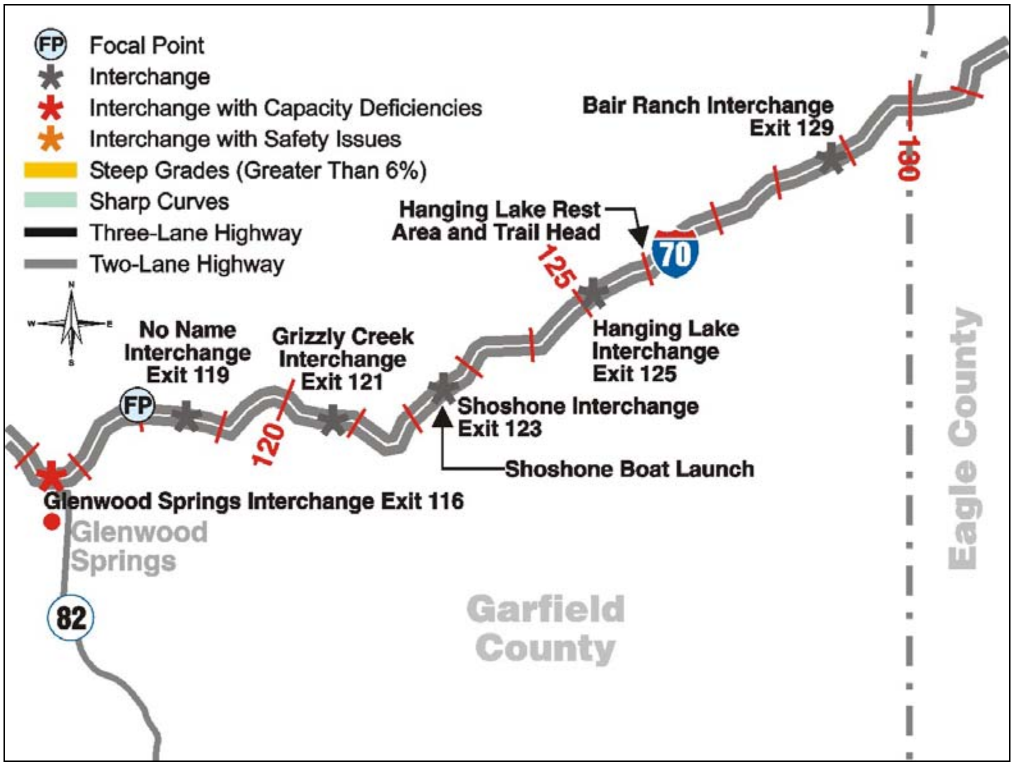
Segment Description

Study Segment 1 (mileposts 116 to 130) is located within Garfield County and extends a total of 13.9 miles between the town of Glenwood Springs and the Garfield/Eagle County line (See **Figure E-1**). At Glenwood Springs, SH 82 leads south from I-70 to Pitkin County, the town of Aspen, and the surrounding ski areas.

This segment is dominated for much of its distance by the narrow Glenwood Canyon, which is approximately 12 miles long. I-70 is two lanes in each direction throughout this segment and parallels the Colorado River.

Within Glenwood Canyon, a series of exits provide recreational access and rest area facilities before entering twin bores of the 3,900-foot Hanging Lake Tunnels. The Hanging Lake Tunnels allow I-70 not to impact the scenery in this area popular among hikers. About 2 miles to the east, the westbound (upper terrace) lanes of I-70 go through the short Reverse Curve Tunnel through a rock outcropping). Bair Ranch (milepost 129) is the last exit and rest area before the canyon widens and the speed limit increases from 50 mph to 75 mph at the start of the next study segment.

Figure E-1. Glenwood to Eagle County Line Study Segment



Roadway Deficiencies

While this segment was analyzed for potential roadway and interchange deficiencies, it was determined that this segment does not include steep grades (over 6 percent), sharp curves, or lane drops. The Glenwood Springs interchange (milepost 116), however, has inadequate ramp geometry, and off-ramp traffic currently backs up onto I-70. As shown in **Table E-2**, the Glenwood Springs interchange is not considered to have safety issues.

Table E-2. Roadway Deficiencies and Safety Assessment, Glenwood Springs to Eagle County Line

Location	Milepost	Deficiencies	Length (Miles)	Safety Issues (Measured by WHI[1])
Glenwood Springs interchange	116	Capacity: inadequate ramp geometry	N/A	-0.6

[1] *WHI = weighted hazard index. Positive WHI values indicate an above average accident rate. See Glossary. WHI data 1996 to 2001.*

Segment Focal Point: No Name Tunnels (Milepost 118)

Because this segment has few deficiencies and I-70 has been relatively recently reconstructed within Glenwood Canyon, few changes are considered necessary. Because this segment lacks a natural bottleneck, the No Name Tunnels location, which is the location of an automatic traffic recorder (ATR), was selected as the focal point of this segment. Information derived at this focal point included existing and projected traffic volumes and LOS. This information was used to assess the travel demand and eventually to compare the alternatives in response to this study segment. While peak-hour LOS at the focal point (No Name Tunnels) is B, occasional local congestion does occur during the summer on I-70 about 4 miles east of the focal point. This congestion is due to heavy recreation use at the Hanging Lake rest area and trailhead as well as at the Shoshone boat launch. The U.S. Forest Service currently employs two to three full-time employees in the summer to keep traffic flowing at Shoshone. A bus system has been suggested from Glenwood Springs to Hanging Lake on key summer weekends to keep people from parking on the interstate shoulders.

Existing LOS

As shown in **Table E-3**, traffic in the canyon currently flows at LOS A during winter weekends in either direction, and eastbound during weekdays. During a few hours of Fridays and summer weekends, LOS B is observed in both directions. LOS B also occurs westbound on weekdays.

Table E-3. 2000 Capacity and Travel Performance, Glenwood Springs to Eagle County Line[1]

Direction and Time		Average Daily Traffic (ADT)	Peak-Hour Volume (PHV)	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	10,500	790	A	0	3,290
	Friday	11,900	880	B	0	3,290
	Winter Weekend	5,700	450	A	0	2,950
	Summer Weekend	13,000	1,040	B	0	2,970
Westbound	Weekday	10,400	880	B	0	3,180
	Friday	12,500	1,040	B	0	3,180
	Winter Weekend	6,000	550	A	0	2,950
	Summer Weekend	11,300	980	B	0	2,890

Focal point: No Name Tunnels (milepost 118)
[1]See section 2.3 for discussions related to capacity and travel performance factors provided on this table.

2035 Baseline LOS

In the future, LOS E or better is expected on weekends, and LOS B or C is expected on weekdays (see **Table E-4**). Due to rigorous planning and design to maintain/enhance natural environment, this is regarded as the ultimate roadway capacity the canyon would offer. In the Baseline scenario, this segment would have no peak-day hours of congestion in 2035.

Table E-4. 2035 Baseline Capacity and Travel Performance, Glenwood Springs to Eagle County Line[1]

Direction and Time		Average Daily Traffic (ADT)	Percent Increase in ADT from 2000	Peak-Hour Volume (PHV)	Percent Increase in PHV from 2000	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	22,750	117	2,030	156	C	0	3,290
	Friday	22,445	130	2,685	206	D	0	3,290
	Winter Weekend	20,260	257	1,575	265	C	0	2,950
	Summer Weekend	32,200	148	2,730	162	E	0	2,980

Direction and Time		Average Daily Traffic (ADT)	Percent Increase in ADT from 2000	Peak-Hour Volume (PHV)	Percent Increase in PHV from 2000	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Westbound	Weekday	24,075	132	1,940	121	C	0	3,180
	Friday	31,335	150	1,565	50	B	0	3,180
	Winter Weekend	23,015	285	2,125	285	D	0	2,950
	Summer Weekend	26,870	137	2,315	137	D	0	2,890

Focal point: No Name Tunnels (milepost 118)
[1]See section 2.3 for discussions related to capacity and travel performance factors provided on this table.

The **baseline annual hours of congestion** (out of a possible 17,520 hours per year for both directions or 8,760 daytime hours) is none.

Baseline Peak-Hour Travel Times

Baseline peak-hour travel times for the 13.9 miles of Segment 1, Glenwood Springs to Eagle County Line, are projected to be **15** minutes at **57** mph in either direction, which are also the free-flow time and speed.

Mainline Capacity Constraints Beyond 2035

Assuming the growth rate in traffic between 2000 and the 2035 Baseline condition continues indefinitely, demand in Glenwood Canyon would first exceed the available westbound capacity on a 2050 summer weekend. Eastbound, demand would first begin to exceed capacity on summer weekends around 2040.

E.5.2 Segment 2, Eagle County Line to Edwards

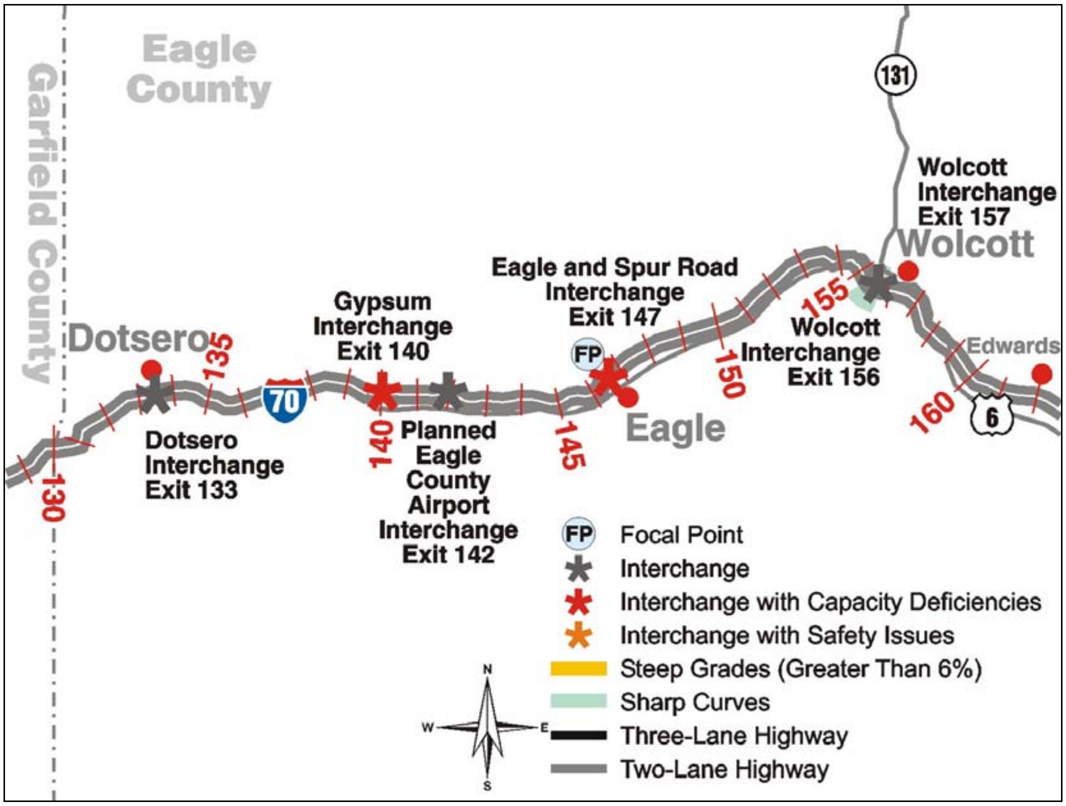
Segment Description

Study segment 2 (mileposts 130 to 163) is located within Eagle County and extends a total of 32.5 miles between the Garfield/Eagle County border and the Edwards interchange (see **Figure E-2**). In this segment, the posted speed limit increases from Glenwood Canyon's 50 mph limit to 75 mph east of the Eagle County line. This segment of I-70 passes through the towns of Dotsero, Gypsum, Eagle, Wolcott, and Edwards. At Wolcott, SH 131 begins at I-70 and leads north to Routt County.

The western portion of this segment is characterized by the broad Eagle River Valley. East of Eagle I-70 traverses the more confined Red Canyon. The Red Canyon area includes a sharp curve west of Wolcott, locally known as the Wolcott curve.

West of Gypsum, the environment traversed by the Corridor is rural in character, while portions of the Corridor area between Gypsum and Eagle are more urban in character with more development and larger populations. Between Eagle and Edwards, the Corridor environment is also rural in character.

Figure E-2. Eagle County Line to Edwards Study Segment



Roadway Deficiencies

Sharp Curves

In this study segment, several sharp curves are present on either side of Wolcott. The curves east of Wolcott are signed with a 70 mph advisory speed. West of Wolcott, the sharpest curve has an advisory speed of 65 mph eastbound and 60 mph westbound. This Wolcott curve has the lowest capacity between the Eagle County line and Edwards. The sharp curves west of Wolcott have an effect on the accidents observed there. This is evident from the high number of overturning and fixed object accidents (suggesting loss of control) recorded there, leading to a high WHI. The main accidents observed east of Wolcott are animal-vehicle collisions along with fixed object accidents.

Interchange Deficiencies

The populations of Gypsum and Eagle have grown rapidly over the last decade and are predicted to continue increasing in size. The predicted traffic associated with future growth is anticipated to exceed the capacity of the two local interchanges, as shown on **Table E-5**.

Table E-5. Roadway Deficiencies and Safety Assessment, Eagle County Line to Edwards

Location	Milepost	Deficiencies	Length (miles)	Safety Issues (Measured by WHI)	
				Below Average Accident Rate	Above Average Accident Rate
Gypsum interchange	140	Capacity: Unsignalized intersection; inadequate for future demand	N/A	-2.25	
Planned Eagle County Airport interchange	142	Capacity: New interchange planned to prevent overloading local roads	N/A	WHI cannot be calculated because this interchange did not exist in 2000	
Eagle and Spur Road interchange	147	Capacity: Inadequate ramp termini; signal configuration; traffic expected to back onto I-70	N/A	-1.08	
West of Wolcott eastbound and westbound (Wolcott curve)	Between 155–156	Safety: Sharp curve speed is 10 to 15 mph less than surrounding roadway; safety issue	0.4		2.11

Note: Positive WHI values indicate an above average accident rate.
WHI data 1996 to 2001

Segment Focal Point: East of Eagle (Milepost 147)

This section represents a transition from the wider Western Eagle Valley (from Dotsero to Eagle) to the narrower, more winding section near Avon. Posted speed limits are 75 mph in the section, although advisory speeds for curves are posted 65 mph eastbound and 60 mph westbound just west of Wolcott. Therefore, I-70 between Eagle and Wolcott is the focal point for this segment. Slight grades between Gypsum and Eagle also cause a minor capacity reduction in this segment.

Existing LOS

This segment, as in the rest of the west end of the Corridor, generally has a higher percentage (but not number) of heavy vehicles than the east end near Denver. As shown in **Table E-6**, this section of roadway operates at LOS B or better in 2000, for the four analysis days considered. ADT ranges from 10,000 vehicles in either direction to 16,000, with heavier volumes occurring during the summer. Peak-hour volumes range from 900 to 1,400 vehicles per hour (vph).

Table E-6. 2000 Capacity and Travel Performance, Eagle County Line to Edwards

Direction and Time		Average Daily Traffic (ADT)	Peak-Hour Volume (PHV)	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	12,900	1,010	B	0	3,400
	Friday	15,200	1,220	B	0	3,400
	Winter Weekend	9,600	940	B	0	2,960
	Summer Weekend	15,300	1,430	B	0	3,110
Westbound	Weekday	13,100	1,060	B	0	3,550
	Friday	16,200	1,270	B	0	3,550
	Winter Weekend	10,100	1,100	B	0	3,250
	Summer Weekend	13,100	1,290	B	0	3,220

Focal point: East of Eagle (milepost 147)

2035 Baseline LOS

In 2035, daily traffic is expected to roughly double to triple on all model days, with peak-hour volumes increasing accordingly (see **Table E-7**). With these increases, volume would reach over 4,000 vph during the westbound weekday peak hour. Eastbound, LOS E is expected on summer weekends, and other eastbound peak hours would experience LOS F. These travel volumes would be primarily associated with commuting and other local trips. Westbound weekday and Friday peak hours would operate at LOS F and winter weekend peak hours would operate at LOS E.

Table E-7. 2035 Baseline Capacity and Travel Performance, Eagle County Line to Edwards

Direction and Time		Average Daily Traffic (ADT)	Percent Increase in ADT from 2000	Peak-Hour Volume (PHV)	Percent Increase in PHV from 2000	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	42,680	255	3,940	308	F	2	3,400
	Friday	42,005	195	4,120	259	F	7	3,400
	Winter Weekend	33,100	240	2,900	215	E	0	2,960
	Summer Weekend	41,165	151	3,060	115	E	0	3,110
Westbound	Weekday	45,655	260	4,210	331	F	1	3,550
	Friday	46,470	204	4,080	241	F	1	3,550
	Winter Weekend	37,000	244	3,190	206	E	0	3,250
	Summer Weekend	43,135	211	3,215	169	E	0	3,220

Focal point: East of Eagle (milepost 147)

The **baseline annual hours of congestion** (out of a possible 17,520 hours per year for both directions or 8,760 daytime hours) is 777.

Baseline Peak-Hour Travel Times

Free-flow travel times and speeds for the 32.5-mile Segment 2, Eagle County Line to Edwards are:

Westbound: **26** minutes at **74** mph

Eastbound: **26** minutes at **75** mph

Baseline peak-hour travel times and speeds are projected to be:

Winter westbound: **39** minutes at **49** mph

Summer westbound: **35** minutes at **55** mph

Winter eastbound: **40** minutes at **48** mph

Summer eastbound: **231** minutes at **8** mph

Mainline Capacity Constraints Beyond 2035

Demand would first exceed capacity in the Wolcott curve area eastbound and westbound on weekdays, including Fridays, in 2025.

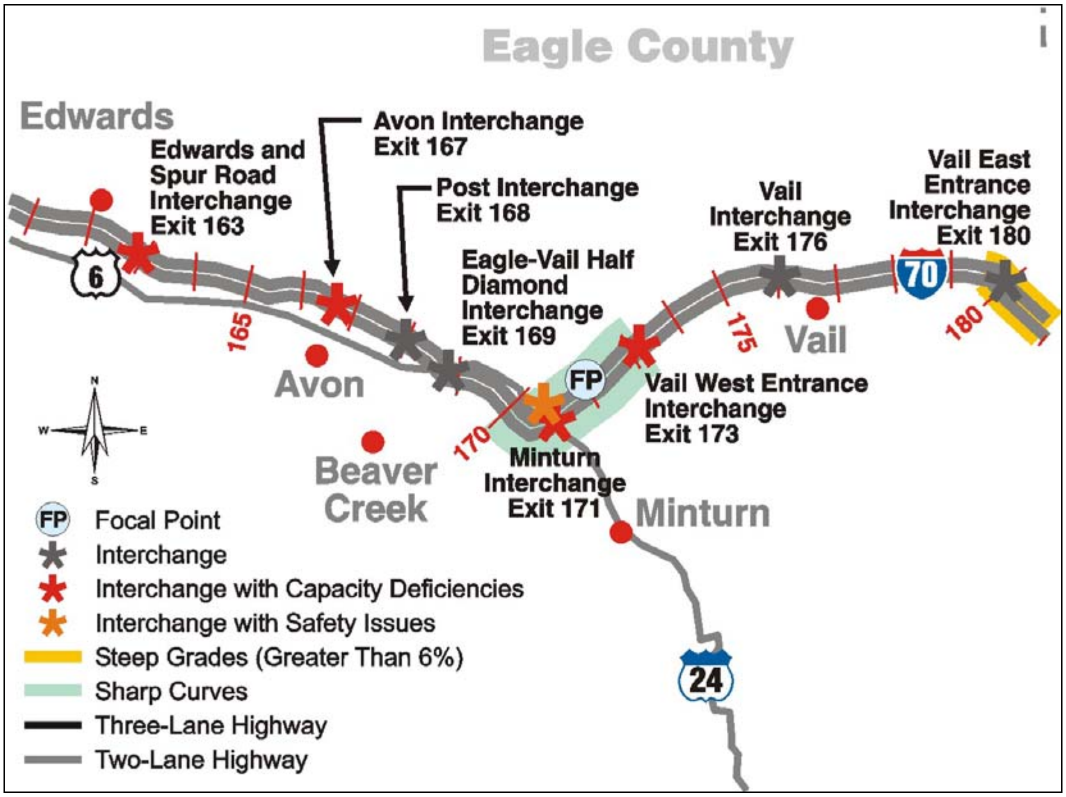
E.5.3 Segment 3, Edwards to Vail East Entrance

Segment Description

Study Segment 3 (mileposts 163 to 180) is located within Eagle County and extends a total of 17.1 miles between the town of Edwards and the Vail East Entrance (see **Figure E-3**). At the Minturn interchange along Dowd Canyon, US 24 leads south from I-70 to Lake County, the towns of Minturn and Leadville, and the Holy Cross Wilderness Area. East of Edwards, I-70 passes through the towns of Avon and Vail.

This segment of I-70 represents an area where two distinct travel patterns overlap. Many overnight recreation travelers—primarily from the Front Range—are destined for Vail, while employees working at the Vail ski area generally live farther west in Eagle County or Garfield County. Existing volumes within Vail are lower than those of Dowd Canyon; many workers from the west likely exit I-70 at the West Entrance and use either frontage road to reach their destination. As a resort area, Vail can be expected to have a higher share of unfamiliar drivers. These drivers may come from Eagle County Airport, Denver International Airport, or the Front Range.

Figure E-3. Edwards to Vail East Entrance Study Segment



Roadway Deficiencies

Table E-8 lists the following roadway deficiencies:

Sharp Curves

Most accidents in this area are in the sharp curves on either side of the Minturn interchange. Many occur when the road is icy or snowy. The I-70 alignment along Dowd Canyon is constrained by steep slopes of Eagle Valley, resulting in many tight curves. Dowd Canyon is the site of numerous collisions and landslide issues. The Whiskey Creek landslide complex in this area is on the state's landslide priority list due to the potential loss of service to I-70 and potential damming of the Eagle River. A continual eastbound grade of up to 4 percent further reduces capacity. Eighty-six percent of the accidents in this area occur during the winter. Seventy-seven percent of the accidents occur within the first 0.8 miles east of Minturn interchange. I-70 through Dowd Canyon is in need of increased lighting coverage to help address nighttime accident problems.

Interchange Deficiencies

Projected traffic in this area is anticipated to exceed the capacity of all interchanges in this study segment. Currently, there is a high level of intersection crashes at both the eastbound on-ramp and the eastbound off-ramp of the Minturn interchange.

Table E-8. Roadway Deficiencies and Safety Assessment, Edwards to Vail East Entrance

Location	Milepost	Deficiencies	Length (miles)	Safety Issues (Measured by WHI)	
				Below Average Accident Rate	Above Average Accident Rate
Edwards interchange	163	Capacity: Inadequate ramp termini; signal configuration; traffic expected to back up onto I-70	N/A	0.00	
Avon interchange	167	Capacity: Future westbound off-ramp volume backs up onto I-70	N/A	-0.58	
Avon to Post Boulevard (eastbound)	166.6–167.6	Safety: Moderate uphill grade, high truck volumes, and merging traffic decrease safety and capacity	1.0	-1.25	
Dowd Canyon					
West of Dowd Canyon [eastbound and westbound]	170 to 170.7	Safety: Sharp curve; design speed of curve is less than surrounding highway	0.7		1.96
Minturn interchange	171	Capacity and safety: Need right turn lane for eastbound ramps to reduce crashes	N/A		3.28
Dowd Canyon to Vail West Entrance	170.9 to 171.8	Safety: Design speed of sharp curve is less than surrounding highway	0.9		7.04
Vail West Entrance interchange	173	Capacity: Eastbound acceleration lane too short. Eastbound off-ramp traffic currently backs onto I-70 because of roundabouts also handling a large volume of local traffic	N/A	-1.02	

Note: Positive WHI values indicate an above average accident rate.
WHI data 1996 to 2001.

Segment Focal Point: Dowd Canyon (Milepost 172)

Edwards, Avon, and Eagle-Vail have close economic ties to Vail. The Beaver Creek ski area, south of Avon, is owned by Vail Resorts, and many winter visitors purchase packages allowing them to ski at both areas. ECO Transit’s most heavily used route serves the area between Edwards and Vail on US 6. The Dowd Canyon to Vail portion of I-70 is important, because US 6 is not available as a parallel alternate route. Therefore, this portion is chosen as the focal point. I-70 between Avon and Dowd Canyon has similar curves. Interchanges at Post Boulevard and US 6 (the Eagle-Vail Half-Diamond) and the attraction of new access to development and “big box” stores affect the capacity of I-70 by introducing weaving movements between interchanges.

Existing LOS

Table E-9 shows that I-70 between Dowd Canyon and Vail West Entrance functions at LOS D eastbound on Fridays and summer Sundays. The highway functions at LOS C westbound, and for all other analysis days in 2000.

Table E-9. 2000 Capacity and Travel Performance, Edwards to Vail East Entrance

Direction and Time		Average Daily Traffic (ADT)	Peak-Hour Volume (PHV)	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	21,700	1,680	C	0	3,090
	Friday	23,800	1,860	D	0	3,090
	Winter Weekend	13,900	1,070	B	0	2,700
	Summer Weekend	21,100	1,720	D	0	2,850
Westbound	Weekday	22,000	1,900	C	0	3,150
	Friday	24,600	2,080	C	0	3,150
	Winter Weekend	16,300	1,690	C	0	2,930
	Summer Weekend	21,500	1,660	C	0	3,020

Focal point: Dowd Canyon (milepost 172)

2035 Baseline LOS

As shown on **Table E-10**, the greatest growth in peak-hour travel between 2000 and 2035 is projected to occur on winter weekends. However, the worst congestion is expected on weekdays in 2035. Hours of congestion on Fridays would be 7 hours eastbound and 11 hours westbound. Other westbound weekdays would have the 13 hours of LOS F. Eastbound I-70 also would operate at LOS F for 6 hours on weekdays and 4 hours on summer Sundays.

Table E-10. 2035 Baseline Capacity and Travel Performance, Edwards to Vail East Entrance

Direction and Time		Average Daily Traffic (ADT)	Percent Increase in ADT from 2000	Peak-Hour Volume (PHV)	Percent Increase in PHV from 2000	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	51,435	139	4,235	151	F	6	3,090
	Friday	53,715	141	4,380	140	F	7	3,090
	Winter Weekend	36,125	160	3,625	238	F	7	2,700
	Summer Weekend	40,010	90	3,555	104	F	4	2,850
Westbound	Weekday	51,995	137	4,365	133	F	13	3,150
	Friday	55,330	120	4,535	123	F	11	3,150
	Winter Weekend	42,195	156	4,085	156	F	5	2,930
	Summer Weekend	40,190	84	2,985	84	E	0	3,020

Focal point: Dowd Canyon (milepost 172)

The **baseline annual peak-day hours of congestion** (out of a possible 17,520 hours per year for both directions or 8,760 daytime hours) is 4,320.

Baseline Peak-Hour Travel Times

For the 17.1-mile Segment 3, Edwards to Vail East Entrance, the free-flow travel time in either direction is **15** minutes, for a speed of **69** mph. The 2035 Baseline peak-hour travel times are projected to be:

Winter westbound: **23** minutes at **44** mph
Winter eastbound: **28** minutes at **36** mph
Summer westbound: **82** minutes at **12** mph
Summer eastbound: **66** minutes at **15** mph

Future Mainline Capacity Constraints

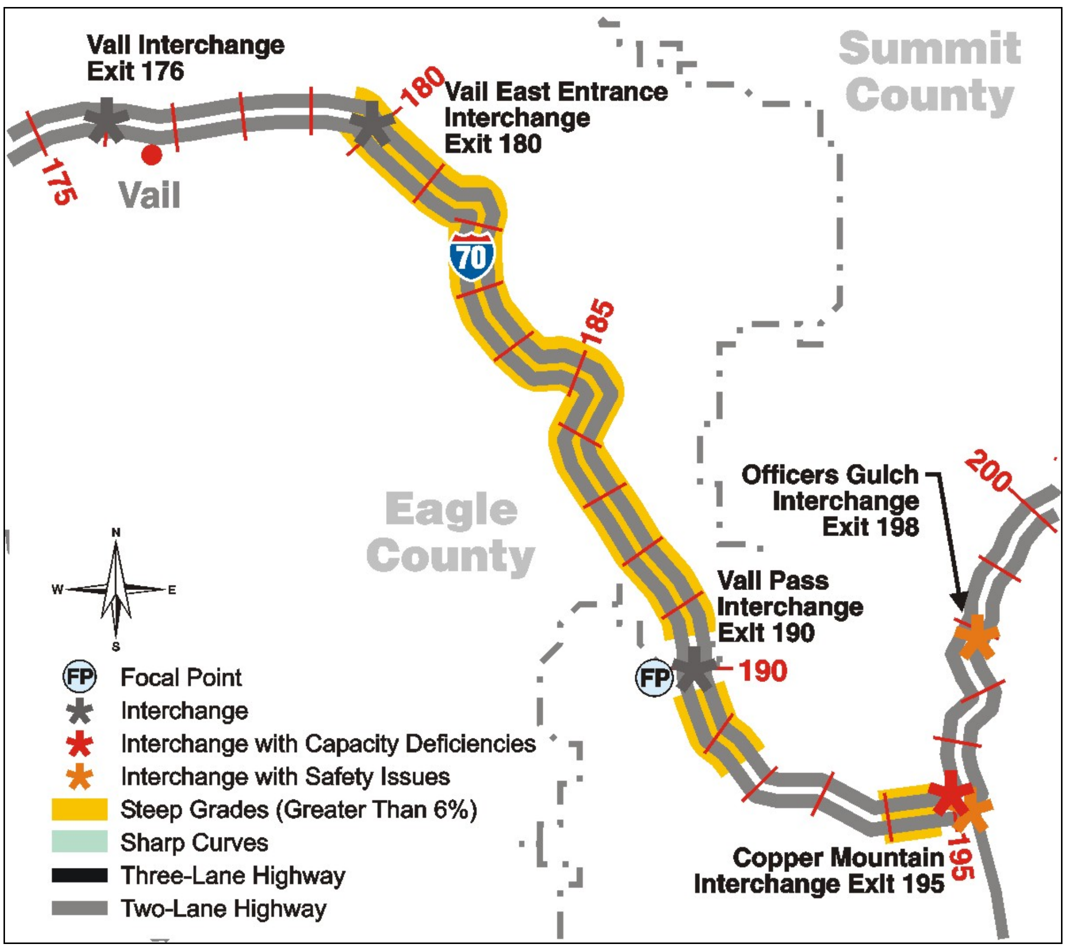
Demands in Dowd Canyon would first exceed the LOS E capacity eastbound and westbound on Fridays in 2015. By 2035, as **Table E-10** shows, demand would exceed capacity on all other model days and directions.

E.5.4 Segment 4, Vail East Entrance to Copper Mountain

Segment Description

Study Segment 4 (mileposts 180 to 195) spans both Eagle and Summit counties and extends a total of 15.4 miles between the town of Vail and Copper Mountain (see **Figure E-4**). Vail Pass (milepost 190) at 10,666 feet constitutes the second-highest pass along the Corridor and the dividing line between Eagle and Summit counties.

Figure E-4. Vail East Entrance to Copper Mountain Study Segment



Roadway Deficiencies

Table E-11 lists the following roadway deficiencies:

Steep Grades

A high frequency rate of traffic collisions occurs on Vail Pass. Two runaway truck ramps are provided along the steep downhill westbound lanes from Vail Pass to Vail Valley. Grades of up to 7 percent, sharp curves, lack of climbing lanes for slow-moving vehicles, and high-altitude weather all contribute to reduced capacity on the approaches to the Vail Pass summit. The steep downhill grades westbound west of Vail Pass along with curves and high altitude create unsafe driving conditions. Consequently, most accidents observed on the west side of Vail Pass are loss-of-control accidents occurring during bad weather conditions.

Table E-11. Roadway Deficiencies and Safety Assessment, Vail East Entrance to Copper Mountain

Location	Milepost	Deficiencies	Length (miles)	Safety Issues (Measured by WHI)	
				Below Average Accident Rate	Above Average Accident Rate
West side of Vail Pass, Uphill (eastbound)	Between 180–190	Capacity: Steep 7% grades limit highway capacity	9.5	-0.92	
West side of Vail Pass, Downhill (westbound)	Between 180–190	Safety: High amount of incident-related delay; steep grades, tight curves, and winter weather contribute to increased incident rate	9.5		0.77

Note: Positive WHI values indicate an above average accident rate.
WHI data 1996 to 2001.

While Figure E-4 shows steep grades on the east side of Vail Pass from milepost 190.3–191.6 and milepost 193.9–194.7, these are not indicated as having a safety or capacity deficiency.

Segment Focal Point: Vail Pass (Milepost 190)

Traffic volumes are lower over Vail Pass in comparison with both Eagle County to the west and Summit County to the east. At present, local trips primarily occur within the economic centers east and west of Vail Pass. Without these local trips in the traffic stream over the pass, trucks make up a larger portion of the traffic, and thus have a large influence on its capacity. Furthermore, the auto trips going over Vail Pass are more likely to be made by unfamiliar drivers. Grades are steepest on the west side of Vail Pass (up to 7 percent). East of Vail Pass, grades range from 2 to 6 percent.

Existing LOS

In 2000, Vail Pass is congested eastbound on summer weekends, and experiences LOS C on the ascent from Vail (see **Table E-12**). During the peak hours of other days, the pass operates at LOS B.

Table E-12. 2000 Capacity and Travel Performance, Vail East Entrance to Copper Mountain

Direction and Time		Average Daily Traffic (ADT)	Peak-Hour Volume (PHV)	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	12,600	990	B	0	2,670
	Friday	12,200	990	B	0	2,670
	Winter Weekend	8,400	800	B	0	2,170
	Summer Weekend	15,600	1,380	C	0	2,560
Westbound	Weekday	13,400	1,110	B	0	2,400
	Friday	14,400	1,130	B	0	2,400
	Winter Weekend	9,600	760	B	0	2,340
	Summer Weekend	13,000	1,070	B	0	2,540

Focal point: approaches to Vail Pass (mileposts 189 eastbound and 191 westbound)

2035 Baseline LOS

As shown in **Table E-13**, summer weekends eastbound and westbound are expected to be the most congested days and directions for Vail Pass in 2035, with increased traffic exceeding capacity for 8 and 6 hours respectively. Weekdays westbound would see the next greatest change with increased traffic exceeding capacity for 4 hours in the future. In 2035, eastbound Friday travelers should experience traffic exceeding capacity for 1 hour. Winter weekend eastbound is expected to experience traffic exceeding capacity for 3 hours.

Table E-13. 2035 Baseline Capacity and Travel Performance, Vail East Entrance to Copper Mountain

Direction and Time		Average Daily Traffic (ADT)	Percent Increase in ADT from 2000	Peak-Hour Volume (PHV)	Percent Increase in PHV from 2000	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	28,680	128	2,600	163	E	0	2,670
	Friday	25,800	111	2,210	123	F	1	2,670
	Winter Weekend	21,125	152	2,310	189	F	3	2,170
	Summer Weekend	34,910	124	3,030	119	F	8	2,560
Westbound	Weekday	29,305	119	2,395	115	F	4	2,400
	Friday	30,220	110	2,065	82	E	0	2,400
	Winter Weekend	23,840	149	1,885	149	D	0	2,340
	Summer Weekend	29,400	125	2,415	125	F	6	2,540

Focal point: approaches to Vail Pass (mileposts 189 eastbound and 191 westbound)

The **baseline annual peak-day hours of congestion** (out of a possible 17,520 hours per year for both directions or 8,760 daytime hours) is 1,153.

Baseline Peak-Hour Travel Times

At free-flow, the eastbound travel time for the 15.4-mile Vail to Copper Mountain segment, Segment 4, is longer than the westbound travel time because vehicles must ascend from Vail East Entrance (elevation 8,300 feet) to Vail Pass, at 10,666 feet, before descending to Copper Mountain (elevation 9,700 feet) for a net ascent of 1,400 feet. The westbound movement in this segment represents a net descent. The free-flow travel times and speeds are:

Westbound: **15** minutes at **63** mph   Eastbound: **16** minutes at **59** mph

Baseline peak-hour travel times are projected at:

Winter westbound: **28** minutes at **33** mph   Winter eastbound: **23** minutes at **40** mph

Summer westbound: **177** minutes at **5** mph   Summer eastbound: **30** minutes at **30** mph

Future Mainline Capacity Constraints

As shown in **Table E-13**, eastbound summer weekend demand is projected to exceed the LOS E capacity in 2025. Westbound weekday demand is projected to first exceed capacity in the year 2035.

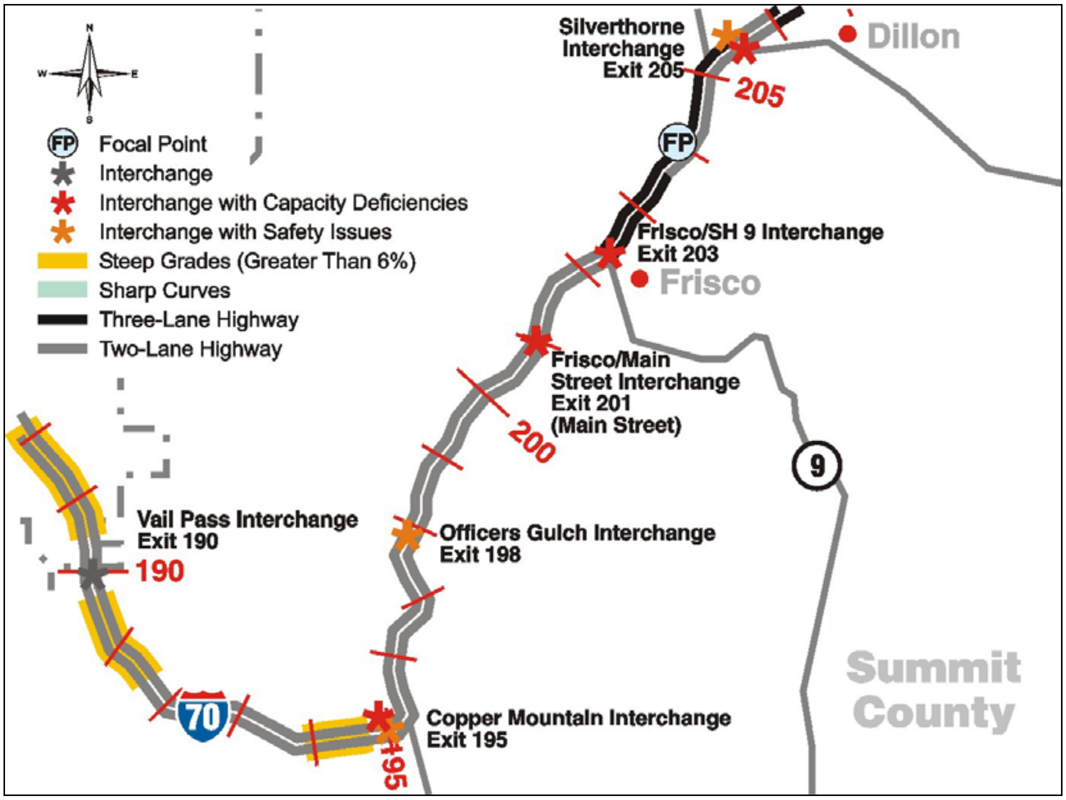
E.5.5 Segment 5, Copper Mountain to Silverthorne

Segment Description

Segment 5 (mileposts 195 to 205) is located within Summit County and extends a total of 10.2 miles between Copper Mountain and Silverthorne (see **Figure E-5**).

East of Copper Mountain, I-70 winds alongside Tenmile Creek, gently descending past Officers Gulch and Frisco exits at Main Street and Summit Boulevard (SH 9). Two access points are provided near Frisco, which then connect to SH 9 (milepost 203) and the town/resort area of Breckenridge. East of Frisco, I-70 ascends to a scenic overlook of Dillon Lake on the eastbound side, before descending to Silverthorne. Two lanes are provided eastbound, which causes a local drop in capacity. Westbound, an auxiliary lane allows for a three-lane segment between Silverthorne and the exit to SH 9.

Figure E-5. Copper Mountain to Silverthorne Study Segment



Roadway Deficiencies

Interchange Deficiencies

Safety concerns at Copper Mountain and Officers Gulch are caused by weather and interchange geometry. Curves near these two interchanges contribute to higher accident rates (as shown on **Table E-14**) due to short sight distances and reduced traction during winter weather, as is implied by a high percentage of loss-of-control accidents (fixed object, overturning, and sideswipe) observed at both locations. At the two Frisco interchanges, future traffic demand is projected to exceed capacity.

Table E-14. Roadway Deficiencies and Safety Assessment, Copper Mountain to Silverthorne

Location	Milepost	Deficiencies	Length (miles)	Safety Issues (Measured by WHI)	
				Below Average Accident Rate	Above Average Accident Rate
Copper Mountain interchange	195	Capacity and safety: ramp geometry in addition to grade and weather contribute to higher incident rate	N/A		1.01
Officers Gulch interchange	198	Safety: interchange is located on a curve; icy conditions contribute to higher incident rate	N/A		0.73

Location	Milepost	Deficiencies	Length (miles)	Safety Issues (Measured by WHI)	
				Below Average Accident Rate	Above Average Accident Rate
Frisco / Main Street interchange	201	Capacity: unsigned intersections have inadequate capacity; off-ramp traffic currently backs up onto I-70.	N/A	-2.07	
Frisco / SH 9 interchange	203	Capacity: westbound off-ramp has inadequate storage.	N/A	-0.75	
Northbound SH 9 to eastbound I-70 on-ramp	202.5–203	Capacity: eastbound on-ramp has inadequate capacity and acceleration lanes; a project is under design to address this ramp	0.5	-1.35	

Note: Positive WHI values indicate an above average accident rate.
WHI data 1996 to 2001

Segment Focal Point: West of Silverthorne (Milepost 204)

In addition to topography, this segment is a focus of traffic analysis because it is an area where local Summit County traffic combines with long-distance through movements. On many days, it is common for the traffic volume between Frisco and Silverthorne to be greater than that crossing the Continental Divide a few miles east. Mild grades and curves between Copper Mountain and the Frisco Main Street interchange reduce capacity elsewhere in this study segment.

Existing LOS

In 2000, the heaviest traffic between Copper Mountain and Silverthorne occurs on weekends. Eastbound I-70 operates at LOS D, with westbound I-70 experiencing LOS C or better. Limitations of the on-ramp from SH 9 in Frisco may further compound eastbound travelers' experience of this focal point. Weekday peak-hour travelers experienced LOS C during 2000. Capacity and travel performance for Segment 5 are shown in **Table E-15**.

Table E-15. 2000 Capacity and Travel Performance, Copper Mountain to Silverthorne

Direction and Time		Average Daily Traffic	Peak-Hour Volume	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	20,900	1,871	C	0	3,530
	Winter Weekend	18,600	2,615	D	0	3,050
	Summer Weekend	29,500	2,739	D	0	3,450
Westbound	Weekday	24,100	2,060	C	0	4,230
	Winter Weekend	21,300	2,391	C	0	4,250
	Summer Weekend	25,400	2,324	C	0	4,450

Focal point: west of Silverthorne, SH 9 (milepost 204)

2035 Baseline LOS

The existing general patterns – lighter traffic on weekdays and better levels of service westbound – is projected to change in the next 25 years, as shown on **Table E-16**. However, by this time, eastbound travel would exceed the LOS E capacity, experiencing congestion for 10 hours during typical summer weekends. On winter weekends, I-70 eastbound is expected to exceed LOS E during the peak 7 hours. On weekdays, eastbound travelers should see LOS E exceeded for 8 hours. Westbound travelers should expect LOS E on both summer and winter weekends, as well as Summer weekdays.

Table E-16. 2035 Baseline Capacity and Travel Performance, Copper Mountain to Silverthorne

Direction and Time		Average Daily Traffic (ADT)	Percent Increase in ADT from 2000	Peak-Hour Volume (PHV)	Percent Increase in PHV from 2000	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	38,385	80	3,400	82	F	8	3,530
	Winter Weekend	31,800	71	3,155	21	F	7	3,052
	Summer Weekend	47,530	69	3,640	33	F	10	3,450
Westbound	Weekday	46,915	98	4,180	103	E	0	4,230
	Winter Weekend	36,360	70	4,070	70	E	0	4,450
	Summer Weekend	42,170	76	4,090	76	E	0	4,450

Focal point: West of Silverthorne, SH 9 (milepost 204)

The **baseline annual peak-day hours of congestion** (out of a possible 17,520 hours per year for both directions or 8,760 daytime hours) **is** 2,093.

Baseline Peak-Hour Travel Times

For the 10.2-mile Segment 5, Copper Mountain to Silverthorne, the free-flow travel times and speeds are **9** minutes at **68** mph for either direction. Baseline peak-hour travel times are projected to be:

Winter westbound: **39** minutes at **15** mph

Summer westbound: **76** minutes at **8** mph

Winter eastbound: **12** minutes at **51** mph

Summer eastbound: **25** minutes at **24** mph

During peak eastbound summer Sunday travel conditions, the 25 mph average speed reflects a queue that would back up from the lane drop just west of the EJMT west portal, to beyond the Silverthorne interchange while the eastbound 8 mph is due to traffic conditions on Vail Pass.

Current and Future Mainline Capacity Constraints

Eastbound summer Sunday demand would first exceed the LOS E capacity around the year 2025 and Westbound traffic would experience LOS E soon after 2035.

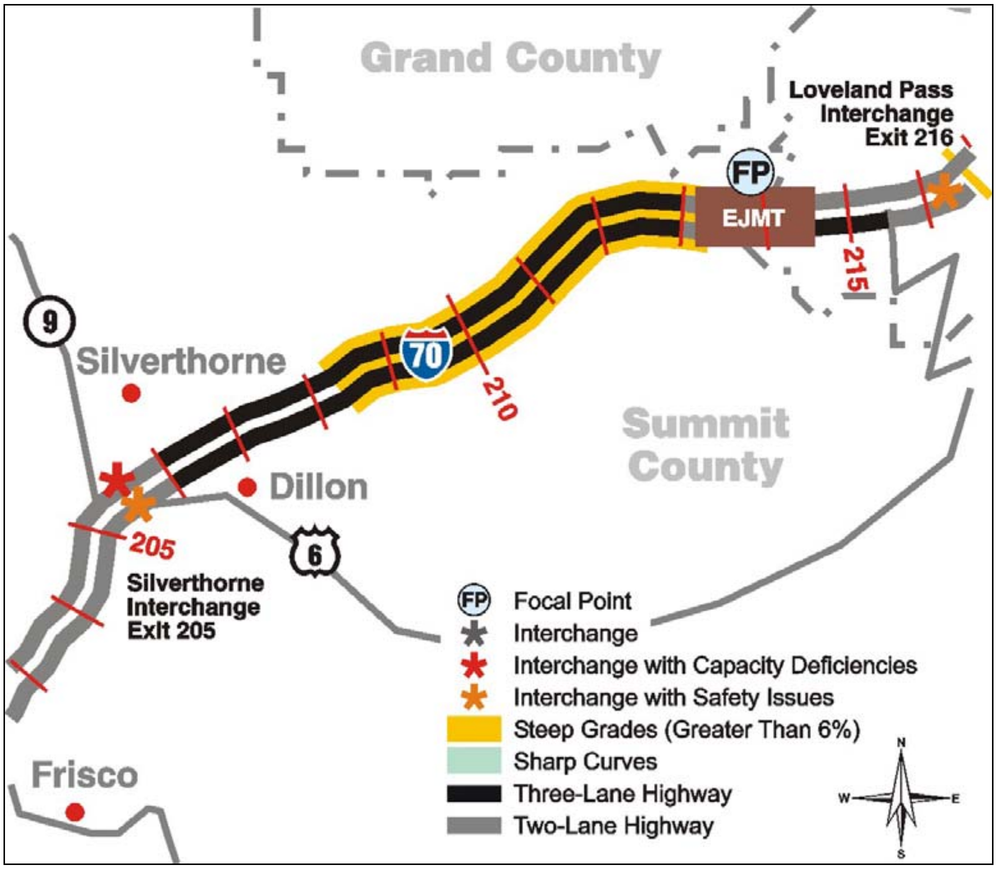
E.5.6 Segment 6, Silverthorne to Loveland Pass Interchange

Segment Description

Study Segment 6 (mileposts 205 to 216) is located within Summit and Clear Creek counties and extends a total of 10.8 miles between Silverthorne and the Loveland ski area (see **Figure E-6**).

The Silverthorne exit off I-70 provides access to US 6, which travels past the Keystone and Arapahoe Basin ski areas and then over Loveland Pass, which rejoins I-70 on the east side of the EJMT. To the north of Silverthorne is SH 9, towards the town of Kremmling in Grand County.

Figure E-6. Silverthorne to Loveland Pass Interchange Study Segment



Roadway Deficiencies

Table E-17 describes the following roadway deficiencies:

Steep Grades

There is a steep grade (average of 6 percent) along Straight Creek Canyon from milepost 208 to the west portal of the EJMT (milepost 213). The majority of the accidents observed in this section in the westbound direction occur in the winter during bad weather and roadway conditions. This is to be expected given the steep grades observed here. The accidents occurring most often are fixed object and rear-end accidents. A relatively high percentage of accidents involving rocks in the roadway are also observed here.

Interchange Deficiencies

High volumes on US 6 and SH 9 near the Silverthorne interchange, along with closely spaced intersections, contribute to incidents as vehicles turn on and off the interchange ramps. At Loveland Pass, the ramp acceleration and deceleration lanes are too short for safe merging.

Table E-17. Roadway Deficiencies and Safety Assessment, Silverthorne to Loveland Pass Interchange (US 6)

Location	Milepost	Deficiencies	Length (miles)	Safety Issues (Measured by WHI)	
				Below Average Accident Rate	Above Average Accident Rate
Silverthorne / US 6 / SH 9 interchange	205	Capacity and safety: High volumes at nearby intersections on US 6 and SH 9 contribute to congestion and incidents; future traffic expected to back up onto I-70	N/A		1.14
Straight Creek Canyon (westbound)	208–213	Safety: Steep grades and lane drop at west portal of EJMT	5		2.01
Loveland Pass interchange	216	Safety: Inadequate acceleration and deceleration lanes for safe merging	N/A		3.96

Note: Positive WHI values indicate an above average accident rate.
WHI data 1996 to 2001

Segment Focal Point: EJMT (Milepost 214)

From Silverthorne to the EJMT, I-70 is three lanes each direction. There is a steep climb along Straight Creek Canyon (average grades of 6 percent) from milepost 208 to the west portal of the EJMT (the segment's focal point) at approximately milepost 213. At the EJMT west portal, I-70 narrows to two lanes in each direction. I-70 crosses into Clear Creek County as it bores through the Continental Divide. The twin bores of the EJMT form the highest vehicular interstate tunnel in the nation at 11,158 feet.

On high volume days, queues are observed at the approaches to the tunnels. The primary bottleneck appears to be the eastbound uphill lane drop (from three to two lanes, with the left lane merging right) just before the tunnel entrance. Primarily trucks use the extra right-hand lanes. On the west side of the EJMT, two runaway ramps are provided in the westbound (downhill) direction. The three westbound lanes going uphill are narrower—at 11 feet each—than standard 12-foot lanes. Furthermore, volume within the tunnel is regulated so that queues from farther east do not spill back into the tunnel, to ensure adequate ventilation and avoid fire hazards. It is worth noting that in all cases, the tunnels do not reduce capacity nearly as much as do the interaction of steep grades at either approach and heavy vehicles in the traffic stream. At one time the heavy eastbound movement was helped by reducing westbound movements to one lane to allow three lanes eastbound through the tunnel. This practice was stopped once the westbound flow became too significant, causing congestion in that direction.

On the Clear Creek County side of the divide, there is a 3 to 5 percent grade from the exit to the Loveland and Arapahoe Basin ski areas (milepost 216) to the east portal (milepost 215). Eastbound I-70 widens from two lanes to three lanes between the east portal and the Loveland Pass on-ramp, yet its short distance (approximately 1 mile) provides limited benefit due to the left lane merging right and other downstream constraints.

Existing LOS

In 2000, congestion occurred on winter and summer weekends, with LOS F experienced eastbound (summer weekends for 2 hours and winter weekends for 2 hours) and westbound (winter weekends for 1 hour). Eastbound travel is more congested because three travel lanes climbing up from Silverthorne must merge into two before entering the EJMT. In contrast, westbound I-70 has only two lanes from Floyd Hill—about 30 miles east of the Divide—and some of that westbound traffic leaves I-70 at Empire

Junction or at the Loveland ski area (or in summer, at the trailheads at Bakerville and Herman Gulch), so less flow ultimately reaches the EJMT approach. Weekday traffic operates at LOS C or better because little weekday commuting currently occurs through the tunnels. Existing capacity and travel performance (as represented by year-2000 data) for Segment 6 is shown in **Table E-18**.

Table E-18. 2000 Capacity and Travel Performance, Silverthorne to Loveland Pass Interchange (US 6)

Direction and Time		Average Daily Traffic (ADT)	Peak-Hour Volume (PHV)	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	16,000	1,300	C	0	2,700
	Winter Weekend	16,900	2,500	F	2	2,280
	Summer Weekend	29,500	2,810	F	2	2,710
Westbound	Weekday	18,500	1,450	C	0	2,440
	Winter Weekend	19,400	2,450	F	1	2,430
	Summer Weekend	23,900	2,270	D	0	2,630

Focal point: Approaches to EJMT (milepost 213 eastbound and 215 westbound)

2035 Baseline LOS

By 2035, the model indicates that travel volumes would have increased sufficiently so that both approaches would operate at LOS F on weekends of both seasons, as shown in **Table E-19**. Weekday travel growth at the Divide would be most pronounced, with traffic doubling over 2000 levels. Weekday growth is projected to be such that westbound traffic would operate at LOS F for 12 hours, while eastbound traffic would be congested for 8 hours. The greatest eastbound projected demand remains on summer Sunday (12 hours of LOS F) and winter weekend (9 hours of LOS F). Westbound summer weekends are expected to experience LOS F for 8 hours.

Table E-19. 2035 Baseline Capacity and Travel Performance, Silverthorne to Loveland Pass Interchange (US 6)

Direction and Time		Average Daily Traffic (ADT)	Percent Increase in ADT from 2000	Peak-Hour Volume (PHV)	Percent Increase in PHV from 2000	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	31,940	99	3,190	146	F	8	2,700
	Winter Weekend	30,610	82	3,365	52	F	9	2,400
	Summer Weekend	46,520	58	3,995	49	F	12	2,850
Westbound	Weekday	36,970	100	4,595	218	F	12	2,440
	Winter Weekend	35,065	81	2,425	22	E	0	2,430
	Summer Weekend	38,620	62	3,915	73	F	8	2,630

Focal point: Approaches to EJMT (milepost 213 eastbound and 215 westbound)

The **baseline annual peak-day hours of congestion** (out of a possible 17,520 hours per year for both directions or 8,760 daytime hours) is 3,239.

Baseline Peak-Hour Travel Time

For the 10.8-mile Silverthorne to Loveland Pass Interchange (US 6) segment, the free-flow travel times and speeds are:

Westbound: **10** time is longer than westbound because of the ascent from Silverthorne (elevation 8,800 minutes at **64** mph Eastbound: **12** minutes at **53** mph

The eastbound travel feet) to the Loveland Pass interchange (elevation 10,900 feet). Baseline peak-hour travel times in Segment 6 are projected to be:

Winter westbound: **15** minutes at **43** mph   Winter eastbound: **92** minutes at **7** mph
Summer westbound: **14** minutes at **45** mph   Summer eastbound: **231** minutes at **3** mph

As with the previous segment (Copper Mountain to Silverthorne), an eastbound queue exists during the peak hours of a typical summer Sunday.

Current and Future Mainline Capacity Constraints

Eastbound summer and winter weekend travel and westbound winter weekend travel are currently exceeding capacity. Westbound and eastbound summer weekend travel began to exceed capacity by about the year 2005. Eastbound weekday travel is expected to be accommodated by current capacity until about 2025.

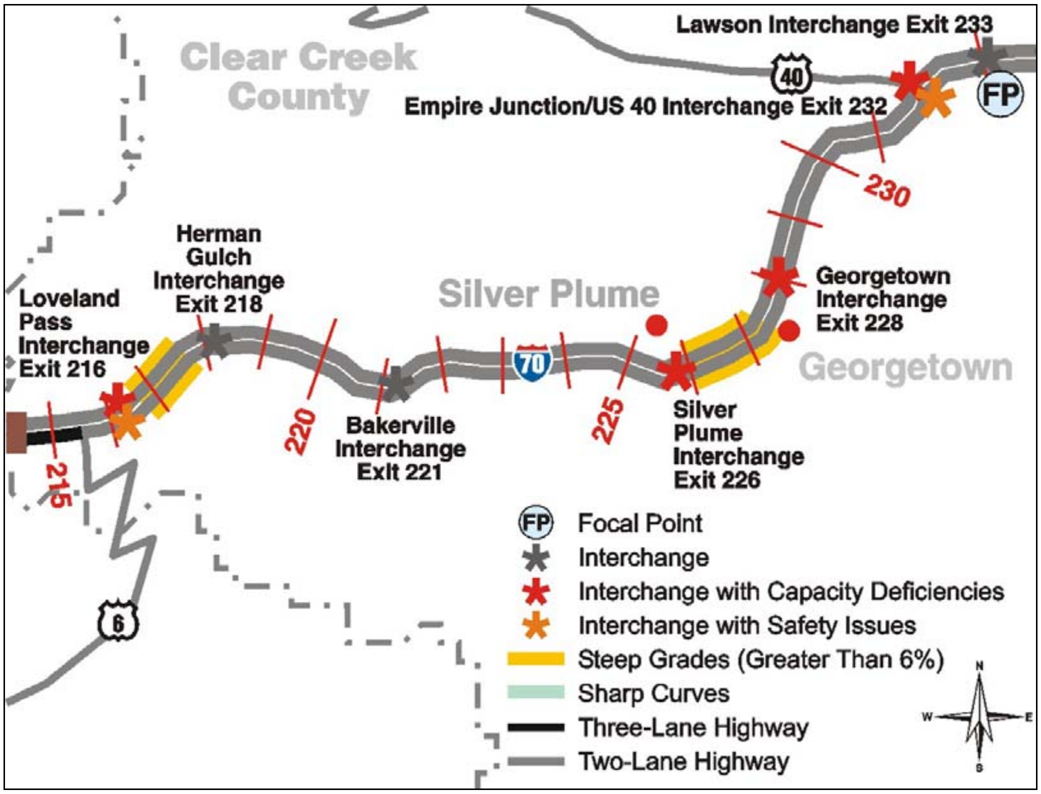
E.5.7 Segment 7, Loveland Pass Interchange to Downieville

Segment Description

Study Segment 7 (mileposts 216 to 234) is located in Clear Creek County, between the junction of US 6 at the Loveland Pass interchange and the town of Downieville (see **Figure E-7**).

I-70 descends from about 11,000 feet in elevation at the east portal of the EJMT to about 8,300 feet at Empire Junction, where US 40 joins I-70. US 40 provides access to the town of Empire, Berthoud Pass, Winter Park, and Grand County. From the EJMT, I-70 follows Clear Creek through the towns of Bakerville, Silver Plume, and Georgetown. The 6 percent grade along Georgetown Hill – between Silver Plume and Georgetown – requires eastbound (downhill) trucks to use a low gear. The up grade on Georgetown Hill often slows westbound trucks to 30 mph. The sheer cliff walls on the north of I-70 constitute the number one rockfall hazard in the state.

Figure E-7. Loveland Pass Interchange (US 6) to Downieville Study Segment



Roadway Deficiencies

Table E-20 lists the roadway deficiencies for Segment 7.

Steep Grades

While not greater than 6 percent, the uphill grades westbound from Bakerville to the EJMT cause trucks to slow. Trucks predominantly travel in the right westbound lane, making it difficult for traffic exiting or entering at the Loveland Pass and Bakerville interchanges to find a sufficient gap. Trucks navigating the grades of over 6 percent on Georgetown Hill tend to slow and use the right lane. Differences in speed contribute to a greater than average incident rate. Although not as steep, the roadway from the weigh stations at the Downieville interchange to the Empire Junction interchange experiences similar traffic patterns. A high percentage of accidents observed at Georgetown involve rocks on the roadway, which can be attributed to the sheer cliffs on the north side. Insufficient clearance between roadway and medians or embankments could explain the high percentage of fixed object accidents observed here. The eastbound section from Downieville to Empire experiences a high number of rear-end accidents, observed mostly during the evening peak period.

Interchange Deficiencies

At Silver Plume, short ramps are close to existing development. At the Georgetown interchange, future traffic volumes are forecast to exceed capacity. The eastbound direction of the Empire Junction interchange sees high incident rates caused by high volumes of mainline and merging traffic, short ramps, and inadequate acceleration and deceleration lanes.

Table E-20. Roadway Deficiencies and Safety Assessment, Loveland Pass Interchange (US 6) to Downieville

Location	Milepost	Deficiencies	Length (miles)	Safety Issues (Measured by WHI)	
				Below Average Accident Rate	Above Average Accident Rate
EJMT to Bakerville (westbound)	216.7–217.6	Safety: Steep grades contribute to many rear-end and side-swipe incidents near Bakerville and Loveland Pass; inadequate acceleration lanes	0.9		0.35
EJMT to Herman Gulch (eastbound)	216.7–217.6	Safety: Steep grades and narrow (2-foot) shoulders, left lane drops before eastbound Loveland Pass merges, violates driver expectation and contributes to incidents	0.9		1.21
Silver Plume interchange	226	Capacity: Ramps are close to existing developments; noise issues; public interest in moving ramps west	N/A	-1.47	
Georgetown to Silver Plume (westbound)	225.7–227.9	Capacity and safety: Steep 6% grades limit highway capacity	2.2		2.06
Silver Plume to Georgetown (eastbound)	225.7–227.9	Safety: Large number of rear-end, side-swipe and fixed object incidents; steep grades and speed differential among vehicles contribute to incidents	2.2		2.82
Georgetown interchange	228	Capacity: Unsignalized intersection, inadequate for future demand; expected to back up onto I-70	N/A	-0.77	
Empire Junction / US 40 interchange	232	Capacity and safety: High eastbound volumes, curve and short eastbound on and off-ramps, deceleration and acceleration lanes contribute to incidents	N/A		1.04
Downieville to Empire Junction (westbound)	232–234	Safety: Moderate grades and weaving movements between trucks returning from weigh station and autos exiting at Empire Junction reduced capacity	1.91	-1.05	
Empire Junction to Downieville (eastbound)	232–234	Safety: Moderate grades and frequent rear-end incidents as eastbound congestion causes vehicle to slow, stop, and/or change lanes	1.92		0.70

Note: Positive WHI values indicate an above average accident rate.
WHI data 1996 to 2001

Segment Focal Point: East of Empire Junction (Milepost 233)

A truck weigh station, located at Downieville, is sometimes shut down during periods of heavy I-70 volumes. Nevertheless, westbound trucks re-entering the traffic stream must climb an uphill grade. Additional capacity constraints occur eastbound as traffic from US 40 merges at a location of high turbulence due to the presence of numerous interchanges with very short ramps, as well as inadequate acceleration and deceleration lanes.

On weekends, and especially Sundays, heavy eastbound US 40 traffic merging into the heavy I-70 mainline can result in queues reaching as far back as the east portal of the EJMT. About 1 mile east of the US 40 Empire Junction interchange, a single off-ramp at Lawson (milepost 233) allows frustrated eastbound travelers to exit to the frontage road, trying to escape the I-70 congestion, because the frontage road continues through Idaho Springs to Hidden Valley, where it ends as it re-enters I-70.

Other bottlenecks in this study segment are Georgetown Hill—with a moderate curve on a 6 percent grade—and the steep grades between Loveland Pass and Herman Gulch.

Existing LOS

As is shown on **Table E-21**, travelers experience congestion for 2 to 5 hours on winter weekends in both directions and on summer weekends eastbound. On weekdays, the westbound lanes operate at LOS C, while the eastbound lanes offer LOS B or better.

Table E-21. 2000 Capacity and Travel Performance, Loveland Pass Interchange (US 6) to Downieville

Direction and Time		Average Daily Traffic (ADT)	Peak-Hour Volume (PHV)	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	21,500	1,600	B	0	3,880
	Winter Weekend	22,400	3,650	F	2	3,590
	Summer Weekend	38,800	4,086	F	5	3,730
Westbound	Weekday	21,700	1,740	C	0	3,210
	Winter Weekend	27,200	3,420	F	2	3,230
	Summer Weekend	30,100	3,400	F	1	3,260

Focal point: East of Empire Junction (milepost 233)

2035 Baseline LOS

By 2035, both directions will be projected to experience LOS F on weekends and weekdays, as shown in **Table E-22**. Weekday traffic is projected to have worsened to LOS F for both westbound and eastbound with 6 and 5 hours of congestion respectively. The greatest congestion is expected to occur eastbound on a summer Sunday, when 12 hours of congestion would occur.

Table E-22. 2035 Baseline Capacity and Travel Performance, Loveland Pass Interchange (US 6) to Downieville

Direction and Time		Average Daily Traffic (ADT)	Percent Increase in ADT from 2000	Peak-Hour Volume (PHV)	Percent Increase in PHV from 2000	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	37,120	73	3,880	143	F	5	3,880
	Winter Weekend	43,500	94	6,000	64	F	10	3,590
	Summer Weekend	58,825	52	5,205	27	F	12	3,730
Westbound	Weekday	41,910	93	5,845	236	F	6	3,210
	Winter Weekend	51,430	89	5,470	60	F	4	3,230
	Summer Weekend	48,365	61	4,790	41	F	2	3,260

Focal point: East of Empire Junction (milepost 233)

The **baseline annual peak-day hours of congestion** (out of a possible 17,520 hours per year for both directions or 8,760 daytime hours) is 2,735.

Baseline Peak-Hour Travel Time

The 18.0-mile Segment 7 descends eastbound, and the free-flow travel times and speeds are:

Westbound: **18** minutes at **60** mph

Eastbound: **16** minutes at **68** mph

Baseline peak-hour travel times for the Loveland Pass Interchange (US 6) to Downieville segment are projected to be:

Winter westbound: **32** minutes at **33** mph

Summer westbound: **47** minutes at **23** mph

Winter eastbound: **116** minutes at **9** mph

Summer eastbound: **164** minutes at **6** mph

Current and Future Mainline Capacity Constraints

Demand currently exceeds the LOS E capacity both westbound and eastbound on winter and summer weekends. Westbound summer weekday traffic exceeds capacity in the year 2010 while eastbound weekday volumes are projected to exceed capacity by 2035.

E.5.8 Segment 8, Downieville to Hidden Valley

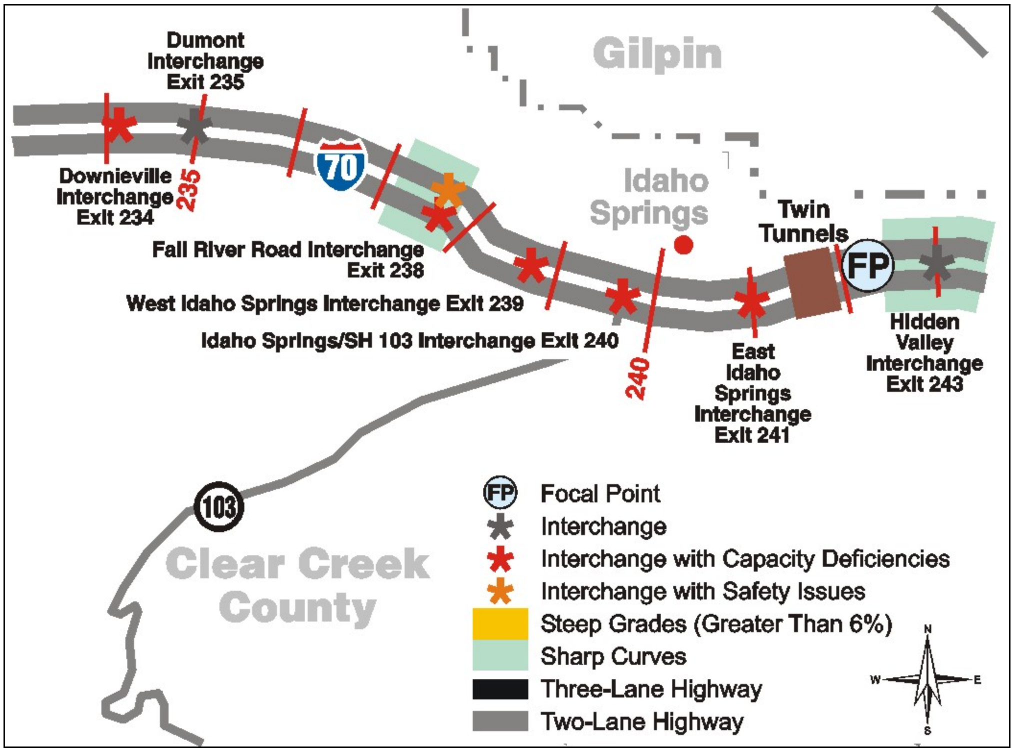
Segment Description

Study Segment 8 (mileposts 234 to 243) is located within Clear Creek County and extends a total of 8.8 miles between Downieville and Hidden Valley (see **Figure E-8**).

I-70 through this study segment passes the towns of Downieville, Dumont, and Idaho Springs. Directly east of Idaho Springs, I-70 traverses through the Twin Tunnels before encountering the Hidden Valley interchange. By 2005, this interchange will provide access to the gaming area of Central City.

Fall River Road, located between Dumont and Idaho Springs, is considered a high accident location due to its tight curves. Because Fall River Road currently has no connection to the frontage road, nearby residents and emergency services must take I-70 to reach other local destinations.

Figure E-8. Downieville to Hidden Valley Study Segment



Roadway Deficiencies

Table E-23 describes the following roadway deficiencies for Segment 8:

Table E-23. Roadway Deficiencies and Safety Assessment, Downieville to Hidden Valley

Location	Milepost	Deficiencies	Length (miles)	Safety Issues (Measured by WHI)	
				Below Average Accident Rate	Above Average Accident Rate
Downieville interchange	234	Capacity: Unsignalized intersection, inadequate for current demand; future traffic expected to back up onto I-70	N/A	-0.50	
Fall River Road (eastbound and westbound)	237.1–237.8	Safety: Design speed of sharp curve is less than that of surrounding portions of highway; affects incident rate and then incident congestion	0.7		1.31
Fall River Road interchange	238	Capacity and safety: Eastbound off-ramps and westbound acceleration lanes inadequate; no access to frontage road for local traffic	N/A		1.43
West Idaho Springs interchange	239	Capacity: Future intersection congestion expected	N/A	-1.58	
SH 103 interchange	240	Capacity: Narrow ramps; no turn bays on SH 103 between ramps; heavy pedestrian use	N/A	-1.09	

Location	Milepost	Deficiencies	Length (miles)	Safety Issues (Measured by WHI)	
				Below Average Accident Rate	Above Average Accident Rate
East Idaho Springs interchange	241	Capacity: Acceleration and deceleration lanes inadequate; very sharp curves (15 mph) on two off-ramps; heavy eastbound on-ramps traffic blocks eastbound off-ramps; future traffic expected to back up onto I-70	N/A	-1.77	

Note: Positive WHI values indicate an above average accident rate.
WHI data 1996 to 2001

Sharp Curves

Sharp curves near the Fall River Road interchange contribute to higher accident rates, especially during winter weather. This is evident in the high percentage of overturning and fixed object accidents observed.

Interchange Deficiencies

Most of the interchanges in this study segment have capacity and/or safety deficiencies. The Downieville interchange has insufficient capacity at the intersection of the ramps and the frontage road. The Fall River Road interchange has inadequate ramps and deceleration lanes. At the West Idaho Springs interchange, the Baseline levels of traffic are projected to exceed capacity. Both the SH 103 and the East Idaho Springs interchanges have substandard geometry. Heavy eastbound on-ramp volumes at the East Idaho Springs interchange prevent local eastbound traffic from exiting.

Segment Focal Point: Twin Tunnels (Milepost 242)

Three exits provide access to Idaho Springs (mileposts 239 to 241). In the eastbound direction, much of the traffic that may have diverted to the frontage road re-enters I-70 at the East Idaho Springs interchange (milepost 241). This results in turbulence as traffic merges and adjusts to the new flow rate as it prepares to enter the Twin Tunnels: two short two-lane tunnels at milepost 242 (one eastbound, one westbound), which constitute the focal point. As would be expected, the Twin Tunnels have narrow shoulders, which reduce capacity, and the tunnels are viewed as a bottleneck area of I-70.

East of the Twin Tunnels there is a stretch of the interstate with numerous lower-speed sharp curves as I-70 winds its way through Clear Creek Canyon. Capacity reductions also occur at the curves near Fall River Road, and at a moderate crest between the SH 103 (Mount Evans) interchange and the East Idaho Springs interchange.

Existing LOS

As shown on **Table E-24**, the Twin Tunnels currently experience congestion for 3 hours on winter weekends westbound and 2 hours eastbound. Summer weekends currently function at LOS F eastbound and LOS E westbound. Weekday traffic flows at LOS C or better.

Table E-24. 2000 Capacity and Travel Performance, Downieville to Hidden Valley

Direction and Time		Average Daily Traffic (ADT)	Peak-Hour Volume (PHV)	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	23,700	2,020	C	0	3,570
	Winter Weekend	26,100	3,510	F	2	3,420
	Summer Weekend	41,200	3,820	F	3	3,430
Westbound	Weekday	26,200	2,070	C	0	3,570
	Winter Weekend	30,900	3,910	F	3	3,420
	Summer Weekend	34,600	3,020	E	0	3,430

Focal point: Twin Tunnels (milepost 242)

Projected Baseline LOS

By 2035, the congestion on I-70 is projected to increase, as shown on **Table E-25**. Eastbound demand is projected to exceed capacity the longest (13 hours) on both summer and winter weekends. Westbound travel would also experience congestion on all days, but peak hour demand would be highest on weekdays, when congestion is expected to last for 7 hours.

Table E-25. 2035 Baseline Capacity and Travel Performance, Downieville to Hidden Valley

		Average Daily Traffic (ADT)	Percent Increase in ADT from 2000	Peak-Hour Volume (PHV)	Percent Increase in PHV from 2000	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	41,230	74	4,085	103	F	9	3,570
	Winter Weekend	45,400	74	5,030	52	F	13	3,420
	Summer Weekend	60,360	46	5,785	70	F	13	3,430
Westbound	Weekday	45,655	75	5,925	186	F	7	3,570
	Winter Weekend	53,990	74	5,110	31	F	3	3,420
	Summer Weekend	51,170	48	5,520	83	F	2	3,430

Focal point: Twin Tunnels (milepost 242)

The **baseline annual peak-day hours of congestion** (out of a possible 17,520 hours per year for both directions or 8,760 daytime hours) is 3,282.

Baseline Peak-Hour Travel Time

In this gently sloping Downieville to Hidden Valley segment, eastbound and westbound free-flow travel times are approximately equal, **8** minutes at **66** mph. Baseline peak-day, peak-hour travel times for the 8.8-mile Segment 8 are projected to be:

Winter westbound: **29** minutes at **18** mph

Summer westbound: **42** minutes at **12** mph

Winter eastbound: **64** minutes at **8** mph

Summer eastbound: **52** minutes at **10** mph

Current and Future Mainline Capacity Constraints

Eastbound and westbound weekend traffic at the tunnel already exceeds capacity on peak hours, as shown on **Table E-24**.Weekday trips are projected to saturate the westbound tunnel in 2015, and the eastbound tunnel by about 2025.

E.5.9 Segment 9, Hidden Valley to Beaver Brook

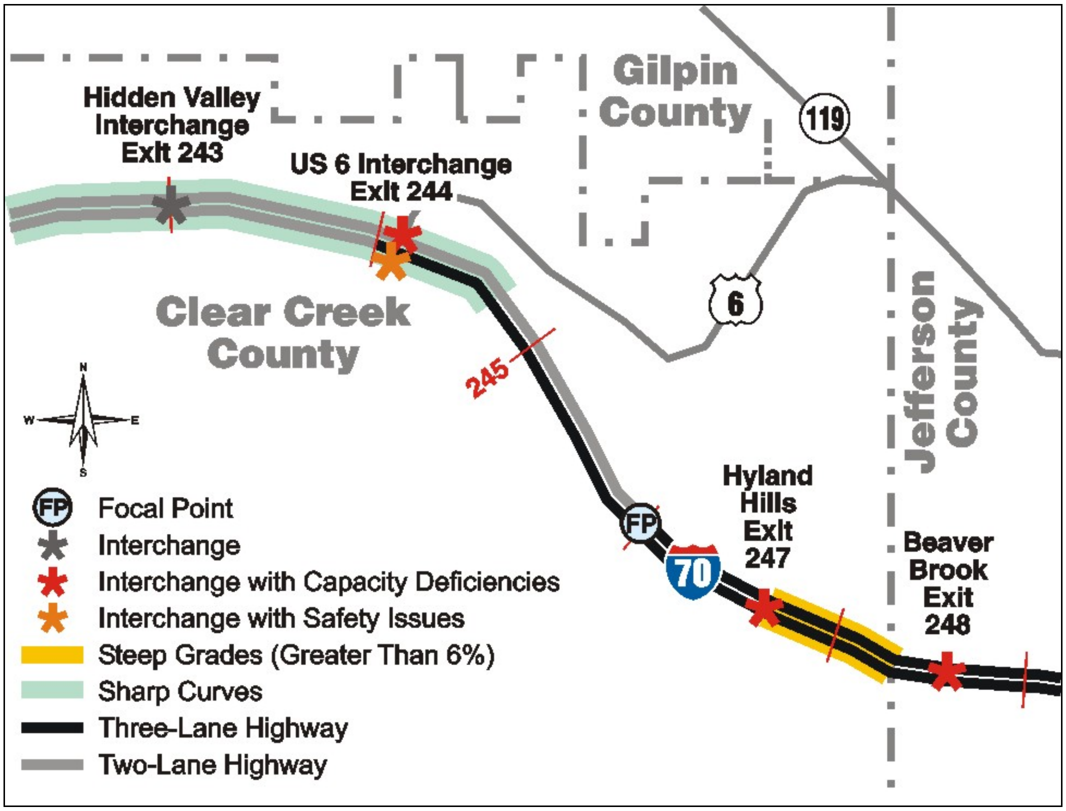
Segment Description

Study Segment 9 (mileposts 243 to 248) is located primarily within the eastern portion of Clear Creek County and extends less than 1 mile into Jefferson County (see **Figure E-9**). I-70 through this segment extends a total distance of 4.6 miles between Hidden Valley (milepost 243) and Beaver Brook (milepost 248). This segment is characterized by steep slopes and sharp curves and includes lane drops and interchange deficiencies. I-70 follows Clear Creek from Hidden Valley to US 6, where I-70 heads to the south toward Denver, and US 6 paralleling Clear Creek branches off to the north toward SH 119 or Golden.

Initial construction of I-70 exposed a landslide at the bottom of Floyd Hill—now called the Floyd Hill slide—during removal of material at the base of the slope. The Floyd Hill slide remains active; major movements can follow extended periods of heavy precipitation.

Both the Hidden Valley and US 6 interchanges are slated to provide new accesses to the gaming communities of Central City and Black Hawk within this segment. The Central City Parkway (CCP) serving Central City is being built to connect at Hidden Valley. In addition, a new tunnel connection from the base of Floyd Hill and US 6 is proposed for quicker access to SH 119 and Black Hawk. Both facilities are proposed to provide two lanes in each direction to the gaming areas of Gilpin County.

Figure E-9. Hidden Valley to Beaver Brook Study Segment



Roadway Deficiencies

Table E-26 shows the roadway deficiencies in Segment 9.

Table E-26. Roadway Deficiencies and Safety Assessment, Hidden Valley to Beaver Brook

Location	Milepost	Deficiencies	Length (miles)	Safety Issues (Measured by WHI)	
				Below Average Accident Rate	Above Average Accident Rate
Twin Tunnels to base of Floyd Hill (eastbound and westbound)	242.3–244.7	Safety: Sharp curves; design speed is lower than surrounding portions of I-70	2.4		2.66
US 6 interchange	244	Capacity and safety: Heavy mainline volumes; left on and off-ramps; inadequate sight distance	N/A		0.96
Hyland Hills interchange	247	Capacity: Future eastbound traffic is expected to back up onto the I-70 mainline	N/A	-2.57	
Floyd Hill (eastbound and westbound)	246.7–247.6	Safety: Steep grades	0.9		0.16

Note: Positive WHI values indicate an above average accident rate.
WHI data 1996 to 2001

Steep Grades

Floyd Hill is one of the steepest sections of I-70, where it goes from its lowest point in Clear Creek County to the highest point in the Mount Vernon Canyon (mileposts 244 to 247). The Jefferson County line is near the split diamond interchanges of Beaver Brook (milepost 248), which provides the eastern movements, and Hyland Hills (milepost 247), which provides the western movements.

Sharp Curves

I-70 passes through a series of sharp curves on either side of the Hidden Valley interchange (milepost 243) from the Twin Tunnels to US 6. The curves on the westbound descent into Clear Creek Canyon and the particularly sharp left at the intersection with US 6 result in a significant bottleneck with a speed limit reduction to 50 mph. These sharp curves along with inadequate clearances cause a high number of fixed object accidents.

Lane Drops

Along this stretch of I-70, eastbound lanes widen from two to three lanes all the way into the Denver metropolitan area, and westbound lanes transition from three lanes to two. West of milepost 244, I-70 essentially becomes a four-lane interstate through the Corridor.

Interchange Deficiencies

Two interchanges along I-70 in this study segment are considered to have capacity deficiencies: US 6 (milepost 244) and Hyland Hills (milepost 247). In addition to capacity deficiencies, the US 6 interchange also has safety issues. Most accidents at the bottom of Floyd Hill (US 6 interchange, milepost 244) occur in the westbound direction (74 percent; 83 of 112). This can be attributed to the steep grade and problematic left-hand on-ramp. The westbound on-ramp is at the base of a steep hill, is on a sharp curve, has a sight distance problem, and feeds into high traffic volumes on the mainline highway that is often near capacity during peak hours.

Segment Focal Point: Top of Floyd Hill (milepost 246)

The stretch of I-70 along Floyd Hill between mileposts 244.5 and 247 represents the most severe constraints within this study segment. Due to these constraints, the focal point for this segment falls within this stretch of I-70. Note that with the planned third westbound lane continuing to the base of Floyd Hill for the planned US 6 and Black Hawk Tunnel interchange, the westbound bottleneck would then be the three-lane ascent from Beaver Brook to Hyland Hills.

Existing LOS

Currently, the most severe congestion in this segment occurs westbound where I-70 drops from three to two lanes, west of the Hyland Hills interchange. Severe queues form westbound due to this lane drop, especially on winter weekends with 3 hours of LOS F, and summer weekends with 2 hours of LOS F. Eastbound on a summer weekend, the steep grades along Floyd Hill result in a peak-hour LOS of D for about 9 hours. On winter weekends, eastbound travel is at LOS D for 2 hours. Weekday travel in this area is at LOS D or better in either direction. **Table E-27** shows the existing capacity and travel performance of this segment, as represented by the year 2000.

Table E-27. 2000 Capacity and Travel Performance, Hidden Valley to Beaver Brook

Direction and Time		Average Daily Traffic (ADT)	Peak-Hour Volume (PHV)	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	20,700	2,480	D	0	4,200
	Winter Weekend	22,200	3,007	D	0	4,680
	Summer Weekend	36,700	3,067	D	0	4,480
Westbound	Weekday	26,200	2,697	D	0	3,720
	Winter Weekend	27,200	3,889	F	3	3,510
	Summer Weekend	27,500	3,459	F	2	3,580

Focal point: Top of Floyd Hill

2035 Baseline LOS

With the Central City Parkway route to Central City at the Hidden Valley interchange, I-70 is expected to provide an attractive option to Denver metropolitan area residents bound for the gaming area. The projected increase in traffic on I-70 associated with this new gaming access – from about 69 to 80 percent of existing westbound volumes – are anticipated to result in 17 hours of congestion westbound on winter weekends and 15 hours on summer weekends (see **Table E-28**). Additionally, 11 hours of congestion are expected on weekdays.

In the eastbound direction a 67 to 98 percent increase is in traffic volumes results in LOS F conditions on weekdays and weekends, with 4 hours of congestion expected on summer weekends and 6 hours on winter weekends. This eastbound congestion would be exacerbated by traffic backing up from lower-capacity sections to the east, before the Evergreen exit (shown in Segment 10).

Table E-28. 2035 Baseline Capacity and Travel Performance, Hidden Valley to Beaver Brook

Direction and Time		Average Daily Traffic (ADT)	Percent Increase in ADT from 2000	Peak-Hour Volume (PHV)	Percent Increase in PHV from 2000	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	57,520	91	5,115	102	F	0	4,200
	Winter Weekend	69,620	98	6,745	72	F	6	4,680
	Summer Weekend	85,500	67	5,575	44	F	4	4,480
Westbound	Weekday	61,455	79	7,495	184	F	11	3,720
	Winter Weekend	76,710	80	5,540	28	F	17	3,510
	Summer Weekend	79,030	69	7,475	95	F	15	3,580

Focal point: Top of Floyd Hill

The **baseline annual peak-day hours of congestion** (out of a possible 17,520 hours per year for both directions or 8,760 daytime hours) is 5,403.

Baseline Peak-Hour Travel Times

For this short 4.6-mile segment, eastbound and westbound free-flow travel times and speeds are both **5** minutes at **60** mph. Baseline peak-hour travel times in Segment 9 are projected to be:

Winter westbound: **31** minutes at **9** mph Winter eastbound: **6** minutes at **46** mph

Summer westbound: **22** minutes at **13** mph Summer eastbound: **7** minutes at **39** mph

Current and Future Mainline Capacity Constraints

I-70 westbound (2-lane) currently experiences LOS F during both winter and summer weekends. On weekends eastbound, demand exceeds capacity in 2010. The three lanes uphill should accommodate eastbound weekday demand through 2020.

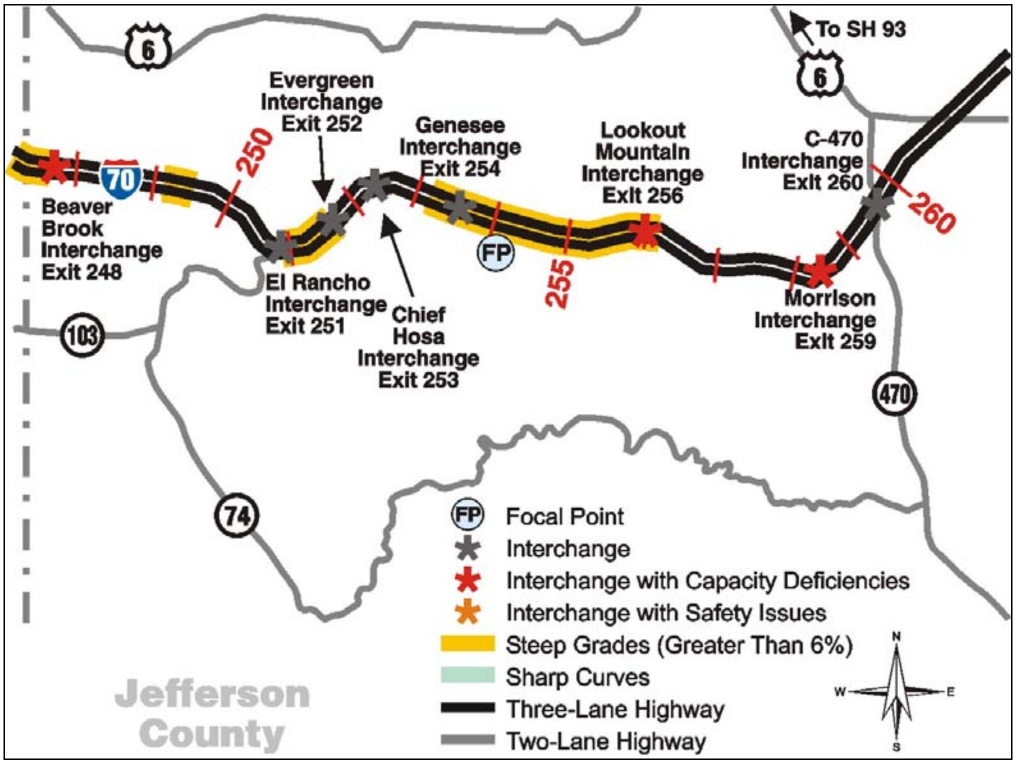
E.5.10 Segment 10, Beaver Brook to C-470

Segment Description

Study Segment 10 (mileposts 248 to 260) is located within Jefferson County and extends a total distance of 12.2 miles between the Beaver Brook interchange and C-470 (see **Figure E-10**). This segment is characterized by steep grades and includes interchange deficiencies. Eastbound, I-70 passes half-diamond interchanges for El Rancho (milepost 251) and the Evergreen Parkway (milepost 252) before crossing a crest at Genesee (milepost 254), a focal point area.

The Genesee interchange is another peak of I-70 in Mount Vernon Canyon. The Genesee Bridge over I-70 is a clear span bridge, which is locally known as the "picture bridge" because of the westbound framed views under the bridge of the Continental Divide, and the eastbound framed views of the Denver area.

Figure E-10. Beaver Brook to C-470 Study Segment



Roadway Deficiencies

Table E-29 describes the following roadway deficiencies in Segment 10:

Table E-29. Roadway Deficiencies and Safety Assessment, Beaver Brook to C-470

Location	Milepost	Deficiencies	Length (miles)	Safety Issues (Measured by WHI) Below Average Accident Rate	Safety Issues (Measured by WHI) Above Average Accident Rate
Beaver Brook interchange	248	Capacity: Inadequate westbound off-ramps intersection capacity; future traffic expected to back onto I-70	N/A	-2.40	
Lookout Mountain interchange	256	Capacity: Unsignalized ramp intersection has insufficient capacity; future traffic expected to back up onto I-70	N/A	-1.08	
Chief Hosa to Lookout Mountain interchange (Hogback) (eastbound)	253.2–256.1	Safety: Steep (6%) grades limit highway capacity	3.0	-0.42	
Morrison (Hogback) interchange	259	Capacity: US 40 to I-70 eastbound on-ramps turn capacity is inadequate for future demand	N/A	-0.72	

Note: Positive WHI values indicate an above average accident rate.
WHI data 1996 to 2001

Steep Grades

Trucks are restricted to lower gears, and an eastbound runaway ramp is provided between Genesee and Lookout Mountain. Because a large number of trucks travel on this section—which also has several curves to conform to the terrain—the effect of heavy vehicles on capacity is considerable. It is assumed that the quick transition between flat and steep grades encourages drivers to switch lanes and reduce speed, contributing to the high percentage of sideswipe and rear-end accidents observed in the steep section between Chief Hosa and Lookout Mountain. Two fatalities were also recorded in this section.

Interchange Deficiencies

Future traffic volumes at the Beaver Brook, Lookout Mountain, and Morrison interchanges are expected to exceed capacity.

Segment Focal Point: Genesee (milepost 254)

I-70 traverses rolling terrain eastbound from Beaver Brook to the Evergreen Parkway interchange. Auxiliary lanes between the Evergreen Parkway interchange and the Chief Hosa interchange provide a momentary increase in capacity (and accompanying demand). The roadway curves east of Chief Hosa and gradually ascends to the picturesque view under the Genesee overpass, before beginning the steep, winding descent to the Denver metropolitan area.

In proximity to the Denver metropolitan area, US 40 diverges from I-70 (at milepost 259) and heads north through the town of Golden. The interchange at milepost 259 is also the location of the Hogback parking facility, which offers Corridor travelers a free place to park when carpooling. SH 93 to the Boulder area can be accessed from Golden. From the junction with US 40, I-70 then travels less than a mile to reach the project area's eastern terminus, the junction with highway C-470 (milepost 260).

Existing LOS

Currently, the worst traffic in this study segment is seen on summer weekends eastbound (4 hours of LOS E). Westbound traffic operates at LOS D during weekdays and winter weekends. On weekdays and winter weekends, eastbound I-70 experiences LOS C or better. **Table E-30** shows the existing capacity and travel performance for Segment 10, represented by year-2000 data.

Table E-30. 2000 Capacity and Travel Performance, Beaver Brook to C-470

Direction and Time		Average Daily Traffic (ADT)	Peak-Hour Volume (PHV)	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	33,200	2,750	C	0	4,450
	Winter Weekend	29,800	3,030	C	0	4,900
	Summer Weekend	48,000	4,060	E	0	4,690
Westbound	Weekday	36,200	2,850	D	0	4,200
	Winter Weekend	32,500	3,300	D	0	4,720
	Summer Weekend	44,700	3,860	E	0	4,490

Focal point: Genesee (milepost 254)

2035 Baseline LOS

By 2035, both directions of I-70 are projected to operate at LOS F during the peak periods of all model days, as shown on **Table E-31**. Winter weekends would experience the worst congestion: 16 hours westbound and 8 hours eastbound. Westbound summer weekend and weekday travel is expected to experience LOS F for 14 hours and 9 hours respectively.

Table E-31. 2035 Baseline Capacity and Travel Performance, Beaver Brook to C-470

Direction and Time		Average Daily Traffic (ADT)	Percent Increase in ADT from 2000	Peak-Hour Volume (PHV)	Percent Increase in PHV from 2000	Peak-Hour LOS	Hours of Congestion	Hourly Capacity at LOS E
Eastbound	Weekday	62,705	89	5,110	86	F	0	4,450
	Winter Weekend	71,850	141	6,080	101	F	8	4,900
	Summer Weekend	98,590	105	6,795	67	F	0	4,690
Westbound	Weekday	65,905	82	6,510	128	F	9	4,200
	Winter Weekend	78,350	141	4,160	26	F	16	4,720
	Summer Weekend	90,925	103	5,910	53	F	14	4,490

Focal point: Genesee (milepost 254)

The **baseline annual peak-day hours of congestion** (out of a possible 17,520 hours per year for both directions or 8,760 daytime hours) is 2,878.

Baseline Peak-Hour Travel Times

For the 12.2-mile Beaver Brook to C-470 segment, free-flow times and speeds are:

Westbound: **12** minutes at **62** mph

Eastbound: **11** minutes at **66** mph

Baseline peak-hour travel times for Segment 10 are projected to be:

Winter westbound: **131** minutes at **5** mph

Summer westbound: **123** minutes at **6** mph

Winter eastbound: **21** minutes at **35** mph

Summer eastbound: **18** minutes at **40** mph

Westbound peak-day, peak-hour travel during both the winter and summer seasons involves queued conditions for much of the length of this study segment.

Current and Future Mainline Capacity Constraints

Summer weekend demand is projected to exceed capacity in 2015 eastbound and 2010 westbound. Westbound weekday demands are projected to outgrow capacity around 2010. The existing roadway should accommodate eastbound weekday and winter weekend demands until 2035 and 2025 respectively.

E.6 Summary of Corridor Segment Issues

The following summarizes Corridor study segment issues under the 2035 Baseline demand. Note that the travel model predicts that transit use on I-70 under the 2035 Baseline scenario is an insignificant mode share percentage (0 to 3 percent of total person trips on I-70).

- Even with suppression of travel in the Corridor, traffic congestion has become a fact of life for motorists on I-70 during ski season and summer weekends. Congestion on I-70, the main artery into and out of the mountains, is increasing as Colorado's population grows. The average number of vehicles that pass through the Eisenhower Tunnel daily has jumped from about 26,000 in 1998 to roughly 30,000 in 2004, an increase of 4,000 vehicles per day.
- It is anticipated that such continued congestion would be a further negative influence on economic growth in the Corridor communities. Unless improvements are made to mobility in the Corridor, the congestion is anticipated to worsen, and this would have a dampening effect on growth in demand for tourism services.
- Through Glenwood Canyon, traffic is expected to flow smoothly throughout the year, with the possibility of isolated incidents of parking on the shoulder at certain locations during peak summer weekends.
- From Dotsero to Edwards, the interchanges are projected to experience a demand higher than intersection capacity at the ramps. Mainline I-70 demand between Glenwood Springs and the Eagle Airport interchange should generally flow freely throughout the year.
- The major portion of growth in Eagle County is expected to occur in the area from Gypsum to Vail. Vail and Avon would continue to act as a major recreational anchor for visitors staying overnight. Residences also would be densely developed in this area. Summer overnight traffic from the Denver metropolitan area going to the Roaring Fork Valley, western Colorado, and Utah are projected to combine with the urban-type weekday traffic and cause congestion westbound on I-70. This congestion would be most severe at the tight curves within Dowd Canyon during Friday afternoons.
- Traffic over Vail Pass is expected to be sluggish on summer Sunday afternoons eastbound as weekend visitors head back to the Denver metropolitan area and to DIA, and slow-moving trucks reduce the capacity of I-70 because of the 7 percent grades.
- Between Frisco and Silverthorne, westbound traffic during peak hours of winter and summer weekends is projected to be heavy. Westbound traffic would not be as severe as eastbound traffic, which is projected to encounter LOS F conditions for 2,093 hours annually, spread throughout the week. (Note that this is in the context of a possible 17,520 hours per year for both directions or 8,760 hours in one direction.) Eastbound congestion in this part of Summit County is projected to be exacerbated by long-distance travelers queuing before entering the west portal of the EJMT.
- The areas of greatest traffic congestion on the Corridor are expected to occur between the EJMT and C-470. Eastbound I-70 changes from two lanes to three lanes at the US 6 interchange, and westbound I-70 changes from three lanes to two west of Hyland Hills. During the summer, westbound overnight and day traffic on I-70 would cause heavy delays for motorists from the Denver metropolitan area as they travel to the mountains. Westbound traffic peak periods would spread over both Friday evening and Saturday morning to access the mountain communities and forests. However, most of these Corridor visitors would return eastbound on Sunday afternoon, causing the months of July and August to have the highest directional volumes of the year.
- Compounding the congestion problem near Denver would be gaming traffic headed to and from Black Hawk and Central City, using the Central City Parkway to Central City at the Hidden Valley interchange. Two percent of the future population of the Denver metropolitan area is

expected to travel to the gaming area and back each day of each summer weekend, compared to under 2 percent in 2000.

- Given the large increase in travel demand between 2000 and 2035, without significant transportation improvements, travel times may reach levels never seen before, particularly from C-470 to the EJMT. Some travelers may then choose not to make a Corridor trip; they may instead choose to do something else to avoid being stuck in I-70 traffic. This is known as "trip suppression." Suppressed trips in 2035 are those trips compared to the Baseline that would have been made, but the transportation system was less convenient, slower, or more costly than the current system. (Some observers believe that current traffic on I-70 appears to be suppressed from historical levels.) This suppression of demand would have economic consequences to the Corridor-area residents and businesses, and to the state as a whole, especially if out-of-state trips are suppressed.
- If a major improvement is made that expands capacity and allows traffic to move faster because of highway widening or diversion of highway trips to transit (or both), variations of "induced" trips over the volumes shown in the 10 segment descriptions would be expected. Induced trips are those extra trips compared to the Baseline that are made solely because the improvements make trips more convenient, faster, or less costly. Likewise, these extra, induced trips would also have economic consequences to the Corridor-area residents, businesses, and the state (especially if more out-of-state trips are induced).