Appendix A
Existing Conditions Report

I-70 Mountain Corridor Design Speed Study
Existing Conditions Report

Prepared for

COLORADO
Department of Transportation

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Acronyms

AASHTO	American Association of State Highway and Transportation Officials
CDOT	Colorado Department of Transportation
Corridor	I-70 Mountain Corridor
DSD	decision sight distance
EB	eastbound
EJMT	Eisenhower-Johnson Memorial Tunnels
FHWA	Federal Highway Administration
I-70	Interstate 70
LIZ	Linkage Interference Zone
MP	milepost
MUTCD	Manual on Uniform Traffic Control Devices
NEPA	National Environmental Policy Act
PEIS	I-70 Mountain Corridor Programmatic Environmental Impact Statement (CDOT, 2011b)
ROD	I-70 Mountain Corridor Record of Decision (CDOT, 2011a)
SH	state highway
VMS	variable message sign
WB	westbound
WHI	weighted hazard index
WT/HP	weight-to-horsepower

AASHTO	American Association of State Highway and Transportation Officials
CDOT	Colorado Department of Transportation
Corridor	I-70 Mountain Corridor
DSD	decision sight distance
EB	eastbound
EJMT	Eisenhower-Johnson Memorial Tunnels

1 Introduction

Current travel speeds in the Interstate (I) 70 Mountain Corridor (Corridor) are influenced by roadway geometry and context, such as the proximity of streams to the road, which may restrict the centerline geometry; canyon walls that influence drivers to adjust their speeds; or vertical grades that impact the operations of some vehicles. When selecting a design speed for a project or roadway segment, all of these factors must be considered, as well as continuity with adjoining roadway segments, length of the project, and distance between physical constraints. The I-70 Mountain Corridor Context Sensitive Solutions design guidelines aim to connect and integrate different projects within the Corridor, and the design speed and operations of the Corridor must be considered holistically when designing specific projects (CDOT, 2015a).

1.1 Project Background

In 2011, the Federal Highway Administration (FHWA) signed the *I-70 Mountain Corridor Record of Decision* (Colorado Department of Transportation [CDOT], 2011a) (ROD) approving the Preferred Alternative for the *I-70 Mountain Corridor Programmatic Environmental Impact Statement* (CDOT, 2011b) (PEIS). The decision approves a broad (Tier 1) program of transit, highway, safety, and other improvements on the 144-mile route between Glenwood Springs and the western edge of the Denver metropolitan area. The decision provides a framework for the CDOT to implement specific projects in the Corridor as funding allows. To carry out improvements that are outlined in the Tier 1 decision and have federal involvement, subsequent National Environmental Policy Act (NEPA) processes, referred to as Tier 2 NEPA processes, are required.

The ROD outlined several important decisions to be made in Tier 2 processes, including design speed for highway improvements. The ROD was specific about the decision to defer the design speed decision and provided two options for Tier 2 highway improvement projects: either design alternatives at both 55 mph and 65 mph or initiate another study to make a corridor design speed decision:

> "[D]ecisions regarding…highway design speed will affect future projects, regardless of whether the scope of the Tier 2 NEPA process that evaluates these decisions is Corridorwide or site-specific…Tier 2 projects must be designed to accommodate both a 55 and 65 mph design speed, or a Tier 2 NEPA process will need to make a design speed decision for the Corridor." (ROD, page 11)

CDOT is now considering potential interim and permanent improvements consistent with the Preferred Alternative identified in the Tier 1 ROD. Before moving forward with new Tier 2 NEPA processes and the design of improvements, CDOT and FHWA have determined that establishing a Corridor-wide interstate design speed would benefit future projects, both in terms of time and money invested in developing and evaluating multiple alternatives. Additionally, addressing design speed Corridor-wide will provide consistency in decision making and ensure that site-specific designs in areas where design speeds are constrained do not restrict or create impacts for future projects outside the geographic limits of the constrained areas.

This I-70 Mountain Corridor Design Speed Study encompassed a Corridorwide review of design speeds, identifying issues, and recommending decision-making criteria and a design speed vision for the Corridor. Although this study falls under a Programmatic Categorical Exclusion that does not require detailed documentation, the NEPA considerations in relation to the PEIS will be specifically addressed to satisfy the ROD Tier 2 NEPA process regarding a design speed decision for the Corridor. The objectives of the I-70 Mountain Corridor Design Speed Study project are to define:

- A design speed vision and recommendation for the entire Corridor
- Locations of speed concerns, such as areas of lower speeds or high speed differential

- A process and criteria by which future projects can assess tradeoffs of location-specific design speed decisions

1.2 Corridor Context

The I-70 Mountain Corridor includes 144 miles of I-70 between Glenwood Springs and the western edge of the Denver metropolitan. The corridor traverses the rugged terrain and outstanding scenery of Colorado's Rocky Mountains, including the steep grades leading up to the Continental Divide and Vail Pass, and the narrow, steep walled Clear Creek and Glenwood Canyons. Tight curves, steep grades, deficient interchanges, and the lack of climbing and passing lanes contribute to capacity limitations throughout the corridor.

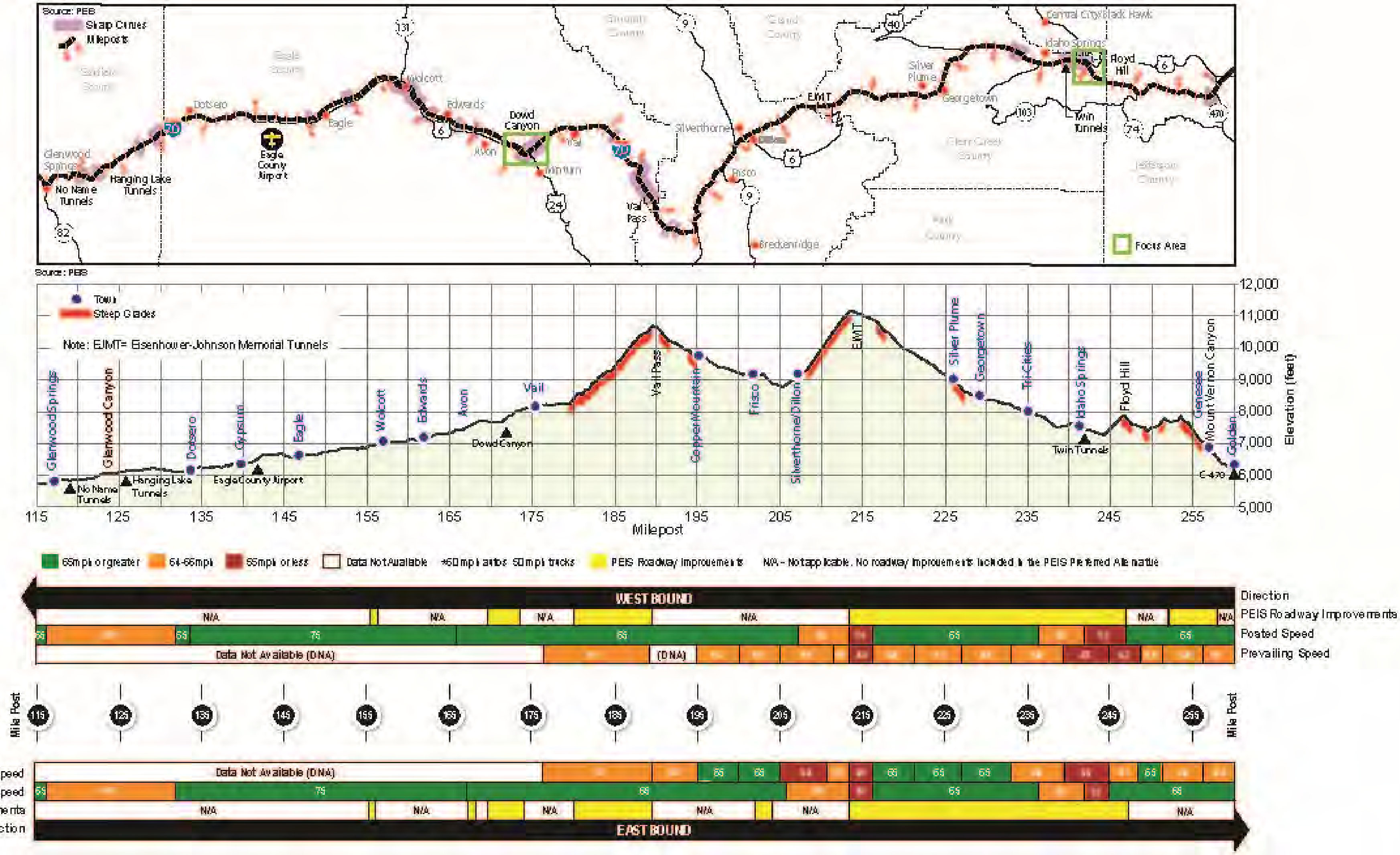
Interstate 70 is the major corridor for access to established communities and recreational areas that are important contributors to the quality of life and the economic base in the state. Recreational travel is the most predominant contributor to peak I-70 highway traffic, especially during summer and winter weekends and holidays. Existing traffic during peak travel times is characterized by congestion that noticeably affects local travel, suppresses the number of skier and other recreational visits, and affects the tourism economy. Travelers currently experience congestion, and in the future will experience substantial travel time delays, which restrict mobility and accessibility along the Corridor. Projected travel demands in this Corridor exceed the design capacity of the facility and will result in severe congestion for extended periods of time.

In addition to serving local community and recreational trips, I-70 is important to freight movement in Colorado. Heavy vehicles—trucks, buses, and recreational vehicles—represent about 10 percent of traffic along the Corridor, which will continue to rely on the Corridor for east-west intra- and inter-state travel as no alternate routes exist. The variation in speeds between these vehicles and faster moving automobiles, particularly on the steep grades, contributes to safety, mobility, and congestion in the Corridor.

The Preferred Alternative for the corridor approved in the ROD provides a broad (Tier 1) program of transit, highway, safety, and other improvements that will increase capacity, improve accessibility and mobility, and decrease congestion along the Corridor. The Preferred Alternative includes an adaptive management approach that provides a framework for implementing specific projects in the Corridor as funding allows.

A review of the traffic operations, roadway geometry, safety history, and environmental opportunities and constraints was completed for the entire 144-mile Corridor to provide an overall understanding of the measureable influences of these factors on design and posted speeds in the corridor. Figure 1 illustrates speed conditions by milepost in the corridor. The top two maps in Figure 1 were presented in the PEIS and illustrate geometric constraints influencing corridor speeds: horizontal curves and steep grades. The bottom graphic in Figure 1 was developed for this study and identify the areas of PEIS roadway improvements by milepost (yellow bars) along with data regarding posted and prevailing speeds within these areas. As shown in Figure 1, posted speeds within the corridor range from 50 to 75 mph, and prevailing speeds—the speed at which 85 percent of traffic travels— are generally at or less than the posted speeds. Speed ranges are characterized by green bars in areas where speeds are 65 mph or higher, orange bars in areas where speeds range from 64 to 56 mph, and red bars where speeds are 55 mph or lower. For the most part, PEIS improvements were planned for 65 mph. In two locations, referred to as areas of focus on Figure 1, two alternatives were considered for design speeds: 55 mph and 65 mph. These areas are at Dowd Canyon between Vail and Avon and Floyd Hill east of Idaho Springs and west of Genesee and are identified in Figure 1 by a green outlined box.

Figure 1. Speed Context Map



Source: CH2M HILL, 2015

Although the PEIS referred to two alternatives, 55 mph and 65 mph, the alternatives are the same through most of the improvements.

Roadway improvements are recommended only in XX miles of the 144-mile corridor. There are only a few locations where there are differences between the alternatives.

1.3 National Environmental Policy Act Compliance

Although this study falls under a Programmatic Categorical Exclusion that does not require detailed documentation, the NEPA considerations in relation to the PEIS are specifically addressed to satisfy the ROD Tier 2 NEPA process regarding a design speed decision for the Corridor.

1.4 I-70 Mountain Corridor Programmatic Environmental Impact Statement Preferred Alternative Highway Elements Summary

The PEIS Preferred Alternative includes a package of highway improvements comprising six-lane capacity, auxiliary lanes, curve safety modifications, interchange improvements, and truck operation improvements, such as pullouts, parking, and chain stations. Because the design speed study focuses on those locations in the Corridor where the PEIS Preferred Alternative proposes improvements, this section of the report summarizes why improvements are proposed in some locations in the Corridor and not others. The information in this memorandum is summarized directly from the *I-70 Mountain Corridor PEIS Alternatives Development and Screening Technical Report* (CDOT, 2011c), located in Volume 2 of the PEIS. Information on the interchange improvements is not included in this memorandum, but can also be found in the *I-70 Mountain Corridor PEIS Alternatives Development and Screening Technical Report* (CDOT, 2011c).

1.4.1 Six-lane Capacity

The PEIS identified the areas of the Corridor that warranted consideration for highway capacity improvements—problematic areas with existing mobility, safety, and maintenance concerns. The problematic areas were identified by a composite of congestion and safety concerns. Congestion is measured by the ratio of the volume of traffic to the roadway capacity; this measurement establishes the Level of Service condition of the roadway. Level of Service F indicates congestion, delays, and stop-and-go conditions. The threshold of 365 annual hours of Level of Service F congestion in either direction determines the congestion problematic areas. Current (as evaluated in the PEIS) congestion corresponds to just more than 6 hours of congestion a day occurring on 40 to 60 peak days over the course of the year.

The incidence of crashes along the I-70 highway is another defining indicator of problematic areas. Areas where the crash rate is higher than the average for mountainous roads are considered problematic. The crash rate in the PEIS was calculated using a weighted hazard index (WHI).

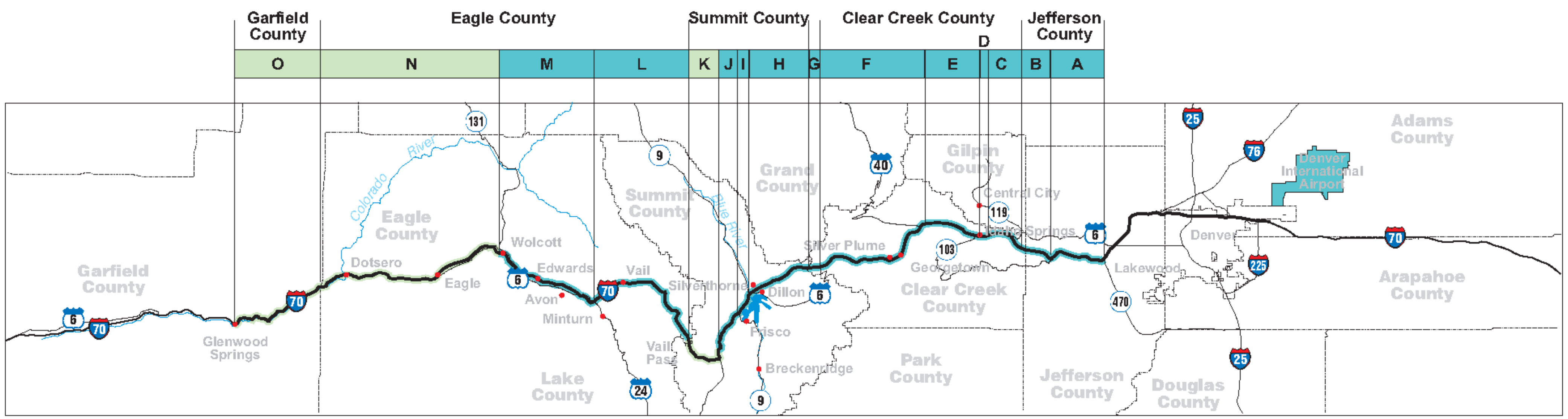
The composite problematic areas were determined by areas meeting any one of the following characteristics: poor Level of Service, sharp curves or “S” curves, safety concerns, lane drops, traffic bottlenecks, tunnels, high crash areas, steep grades, high rockfall incident areas, and/or areas prone to extreme ice or snow build-up. Based on the analysis, the resulting problematic areas are the Dowd Canyon area between Eagle-Vail and West Vail, and the 33-mile segment between the west portal of the Eisenhower-Johnson Memorial Tunnels (EJMT) and Floyd Hill. Figure 2 provides a summary of these areas. The PEIS Preferred Alternative includes six-lane highway capacity in these two sections of the Corridor.

In other areas of the Corridor, six-lane highway widening was eliminated from further consideration because the threshold was not met for congestion or safety problems.

Figure 2. PEIS Summary of Problematic Highway Areas

Figure 2. Summary of Problematic Highway Areas

	H	G	F	E	D	C	B	A
Section	Eisenhower Tunnel to SH 9 at Silverthorne MP 213 to MP 205.5	Eisenhower Tunnel MP 217 to MP 213	US 40 to Eisenhower Tunnel MP 232.5 to MP 217	Twin Tunnels to US 40 MP 241.5 to MP 232.5	Twin Tunnels MP 242.5 - 241.5	Floyd Hill to Twin Tunnels MP 246.5 to MP 242.5	Evergreen Exit to Floyd Hill MP 251 to MP 246.5	C470 to Evergreen Exit MP 260 to MP 251
Roadway Characteristics and Traffic Operations	•Grades greater than 6% (MP 207.5 - MP 213) •Slow moving truck traffic eastbound •High accident rate at Exit 205 and MP 210 Summer EB: D Summer WB: C Winter EB: D Winter WB: C	•Narrow shoulders •Limited capacity • Represents regional bottleneck in I-70 Mountain Corridor •Lane Drop - 6 lanes to 4 lanes at MP 213.25 •Lane reduction eastbound leaving Eisenhower Tunnel (accident rate high) Summer EB: E Summer WB: E Winter EB: E Winter WB: E	•Grades greater than 6% (Georgetown & MP 215 - 216.5) •Rock fall area •Inside shoulder •Curves near Silver Plume MP 227, 224 •Silver Plume interchange •Lane reduction eastbound leaving Eisenhower Tunnel at the merge of US 6 (accident rate high) •High accident rate density at base of hill Summer EB: E Summer WB: D Winter EB: E Winter WB: E	•Multiple interchanges in short distance •Tight horizontal curves - Fall River Road •Design Speed •Heavy eastbound merge at Empire/ US 40 Summer EB: F Summer WB: D-E Winter EB: F Winter WB: E-F	•Limited capacity •Posted speed - 50 mph • High accident rate • Lateral clearances 1ft. in Twin Tunnels Summer EB: F Summer WB: E Winter EB: F Winter WB: F	•Grades greater than 6% on Floyd Hill •Lane reduction at westbound MP 246 •Design speed - 50-55 mph at SH 6 and at 'S' curves MP 244.5 to 242.5 •Left-side merge at SH 6 •Short decel lanes at SH 6 •Accident area MP 244-242.5 Summer EB: D-F Summer WB: D-F Winter EB: D-F Winter WB: D-F	•Grades vary from 1% to 6% (Floyd Hill) Summer EB: D Summer WB: D Winter EB: D Winter WB: E	•Grades vary from 3% to 6.5% •Heavy merge eastbound at Evergreen Exit 251 •High accident rate at C470 and Morrison Exits (260 and 258.5) • Six lanes Summer EB: D-E Summer WB: D-F Winter EB: E Winter WB: C-F
Year 2000 Problematic Areas	MP 210, 206 - 205.5	MP 217 - 213	MP 228 - 226	MP 242 - 232.5	MP 241.5 - 242.5	MP 245 - 242	MP 248 - 246.5	MP 260 - 251



	O	N	M	L	K	J	I
Section	Eagle County to Glenwood Springs MP 130.5 to Glenwood Springs	Wolcott to Eagle County Line MP 156.5 to MP 130.5	US 24/Minturn to Wolcott MP 171 to MP 156.5	Vail Pass to Minturn (US 24) MP 189 to MP 171	Copper Mountain to Vail Pass MP 195.5 to MP 189	Frisco to Copper Mountain MP 202.5 to MP 195.5	Silverthorne to Frisco MP 205.5 to MP 202.5
Roadway Characteristics and Traffic Operations	Glenwood Canyon	•Grades rarely exceed 3% •High accident rate at Eagle interchange (MP 146.5) Summer EB: B Summer WB: D Winter EB: A Winter WB: B	•Grades less than 3% •Weekday winter commuter traffic is comparable to weekend traffic on I-70 •High incidence of accidents MP 160.5 - 166.5 Summer EB: C Summer WB: D Winter EB: B Winter WB: B	•Grades greater than 5% (MP 177.5 - 181) •Slow moving traffic on long grades •Heavy merging along Vail exits 180, 176, and 173 •Highest accident rate of study area at Minturn/US 24 Exit 171 •Potential weather concerns (ice build-up on Vail Pass and near Dowd Canyon) •US 24/Minturn interchange configuration •Summer and winter weekend traffic is predominant; however, weekday commuter traffic is becoming noticeable Summer EB: D Summer WB: C Winter EB: C Winter WB: B	•Grades greater than 5% •Slow moving traffic on long grades Summer EB: D Summer WB: C Winter EB: C Winter WB: B	•Grades of 5% and 6% •High accident rate at Frisco interchange (MP 202.5) Summer EB: D Summer WB: D Winter EB: D Winter WB: D	•Heavy merges at Silverthorne and Frisco exits (205 and 203) •Grades greater than 5% (MP 204 - 205) •Weekend summer and winter traffic is predominant; however, weekday commuter traffic is becoming noticeable Summer EB: D Summer WB: D Winter EB: D Winter WB: C
Year 2000 Problematic Areas			MP 171 - 170, 166.5 - 160.5	MP172 - 171		MP 202.5, 200 - 198	MP 205, 202.5

LEGEND

EB=eastbound
WB=westbound
LOS=Level of Service (LOS ratings vary from most desirable (LOS A) to forced break-down (LOS F))
(LOS calculated at mileposts with steep grades, lane changes or large traffic volumes)

A=free-flow operations
B=reasonably free-flow operations
C=noticeable traffic
D=speeds decline and congestion
E=maximum service flow (full capacity)
F=heavy congestion, significant delays, stop-and-go traffic

LOS:
Under Current Traffic Volumes

Problematic Areas Identified within Section for Year 2000: Areas would include at least one or a combination of the following conditions: LOS F, sharp curves or "S" curves, safety concerns at interchanges, lane drops, traffic bottlenecks, tunnels, high accident areas, steep grades, high rock fall incident areas, and areas prone to extreme ice and snow build-up

Not Considered Problematic Under Existing Conditions (Year 2000)

Source: CDOT, 2011c

1.4.2 Auxiliary Lanes

The need for auxiliary lanes was assessed on the basis of capacity, mobility, and safety. Capacity and mobility issues were determined based on substandard design. Substandard design issues include tight interchange spacing (less than 2 miles), steep grades, and inadequate acceleration or deceleration lanes. Volume-to-capacity ratios are not applicable to the auxiliary lane analysis.

Safety issues were identified for locations with high WHI values. A WHI compares the weighted crash rate, measured as weighted crashes (higher weight given to a higher severity crash) per million vehicle miles of travel, at a location in the Corridor compared to the statewide average weighted crash rate for similar roadways. This determines if the observed rate is higher than the statewide average. If a WHI is greater than 2.50, it signifies that the location in question has a higher weighted crash rate than the statewide average and is a potentially problematic area in terms of the number of crashes observed or their severity. A threshold of 2.5 was selected because merge and diverge areas are generally more prone to crashes and high WHI values are not uncommon.

Auxiliary lanes were analyzed and given a priority rating of A, B, or C based on the criteria below:

- A priority rating of “A” was given if an auxiliary lane location met **both** of the following criteria:
  - WHI greater than 2.50 and
  - Substandard geometry
- A priority rating of “B” was given if an auxiliary lane location met **either** of the following criteria:
  - WHI greater than 2.50 or
  - Substandard geometry
- A priority rating of “C” was given if an auxiliary lane location met **neither** of the following criteria:
  - WHI greater than 2.50 nor
  - Substandard geometry

Table 1 provides detail about WHI values, design issues, assigned priority ratings, and potential improvements for the 14 potential auxiliary lane locations. Two of the 14 locations were eliminated during the alternatives screening process—“Chief Hosa to Genesee, Flat” and “US 6 to Hyland Hills”—because they did not warrant any improvements. Five additional auxiliary lane locations were not carried into the PEIS Preferred Alternative because they are located within the Corridor section that is recommended for six-lane widening, and are therefore not needed. The remaining seven auxiliary lane locations are listed below and are included as components of the PEIS Preferred Alternative:

- Avon to Post Boulevard, Uphill (eastbound (EB)) (Milepost (MP) 167–168)
- West side of Vail Pass, Downhill (westbound (WB)) (MP 180–190)
- West side of Vail Pass, Uphill (EB) (MP 180–190)
- Frisco to Silverthorne (EB) (MP 202.7–205.1)
- EJMT to Herman Gulch, Downhill (EB) (MP 215–218) (currently under study)
- Bakerville to EJMT, Uphill (WB) (MP 215–221)
- Morrison to Chief Hosa, Uphill (WB) (MP 253–259)

Table 1. PEIS Analysis of I-70 Auxiliary Lanes

Name	WHI 2001 to 2005	Priority Rating	Description of Problem Areas and Proposed Improvements
Avon to Post Boulevard, Uphill (EB) (MP 167-168)	-0.45	B	**Problem:** The I-70 highway between Avon (MP 167) and Post Boulevard (MP 168) is uphill. Traffic merging from the Avon on-ramp has difficulty accelerating on the grade and finding sufficient gaps for merging. Traffic attempting to get from the I-70 highway to the Post Boulevard off-ramp creates a problematic weaving issue. The interchanges are only 1 mile apart. **Improvement:** An auxiliary lane between these two interchanges increases safety and improves merge capacity. It also allows local traffic to stay in the auxiliary lane and not affect the I-70 highway mainline.
West Side of Vail Pass, Uphill (EB) (MP 180-190)	4.78	A	**Problem:** Steep 7 percent grades limit the highway capacity. Demand is expected to exceed capacity occasionally in the future. **Improvement:** A new EB auxiliary lane provides additional capacity by allowing more space for fast-moving vehicles to pass slow-moving vehicles struggling with the steep grades.
West Side of Vail Pass, Downhill (WB) (MP 180-190)	1.34	B	**Problem:** There is a high amount of incident-related delay possible because of adverse weather conditions, steep grades and curves; not a major capacity issue. **Improvement:** Curve smoothing, more intensive winter maintenance practices with ice sensors and better signage helps to reduce the number of crashes. A WB auxiliary lane is primarily a safety improvement, reducing the likelihood of rear-end collisions with slow-moving vehicles and providing an increase in roadway capacity. Reducing the frequency of crashes also reduces the delay associated with clearing the disabled vehicles.
Frisco to Silverthorne (EB)[1] (MP 202.7-205.1)	0.23	B	**Problem:** Travel demand west of Silverthorne from local trips combined with through traffic results in Level of Service F for eastbound travel between Frisco and Silverthorne. **Improvement:** An EB auxiliary lane is added between Frisco and Silverthorne starting east of the recent EB on-ramp extension at the Silverthorne/State Highway (SH) 9 interchange. The addition of an EB auxiliary lane improves traffic operations and substantially reduces the number of hours of Level of Service F in the Frisco/Silverthorne area due to congestion.
EJMT to Herman Gulch, Downhill (EB) (MP 215–218) (currently under study)	2.56	A	**Problem:** The EB lanes from the EJMT east portal to Herman Gulch currently experience an above-average crash rate attributed to narrow shoulders, steep grades, and an unexpected left-lane drop before the Loveland Pass on-ramp merge. There is an unusual existing lane configuration, with two lanes expanding to three at the EJMT and then merging back to two lanes shortly before EB on-ramps merge. There is a highly substandard 2-foot shoulder between the Loveland Pass off- and on-ramps. The lack of shoulders and an atypical left lane merge are not expected by drivers. **Improvement:** This improvement provides three standard, continuous EB lanes to address the safety and congestion issues in this portion of the I-70 highway. Shoulders are improved to standard width throughout the section.

Table 1. PEIS Analysis of I-70 Auxiliary Lanes

Name	WHI 2001 to 2005	Priority Rating	Description of Problem Areas and Proposed Improvements
Bakerville to EJMT, Uphill (WB) (MP 215–221)	1.10	A	**Problem:** There is a high concentration of rear-end crashes around the Loveland Pass WB on-ramp and around the Bakerville interchange. Steep grades WB from the Bakerville interchange (MP 221) to the east portal of the EJMT (MP 215) cause large disparities in speed between vehicles in different weight classes. These differences in speed reduce capacity and make rear-end crashes more likely. **Improvement:** The addition of a climbing lane reduces the crashes, especially rear-end and sideswipe crashes. The additional lane also improves capacity in this area.
Georgetown to Silver Plume, Uphill (WB) (MP 226–228)	0.23	B	**Problem:** Steep 6 percent grades limit the highway capacity. Traffic demand is limited by two lanes east of Empire Junction. **Improvement:** A new WB auxiliary lane provides additional capacity by allowing more space for fast-moving vehicles to pass slow-moving vehicles struggling with the steep grades.
Silver Plume to Georgetown, Downhill (EB) (MP 226–228)	0.68	B	**Problem:** There is a high number of rear-end, sideswipe, and fixed-object crashes and a high amount of incident-related delay possible because of steep grades and curves. There are no major capacity issues. **Improvement:** An EB auxiliary lane is a safety improvement, reducing the likelihood of rear-end, sideswipe, and fixed-object crashes and also providing an increase in roadway capacity. Reducing the frequency of crashes also reduces the delay associated with clearing disabled vehicles.
Empire to Downieville, Downhill (EB) (MP 232–234)	0.64	B	**Problem:** Rear-end crashes occur due to vehicles slowing, stopping in traffic, or changing lanes. There is a high amount of incident-related delay possible. There are no major capacity issues. **Improvement:** An EB auxiliary lane is a safety improvement reducing the likelihood of rear-end crashes and providing an increase in roadway capacity. Reducing the frequency of crashes also reduces the delay associated with clearing disabled vehicles.
US 6 Off-ramp to Hidden Valley Off-ramp, Uphill (WB) (MP 243–244)	0.03	B	**Problem:** Through traffic and traffic heading to the Central City Parkway combine to substantially exceed the capacity of this section. **Improvement:** An additional auxiliary lane is added to provide increased capacity for traffic.
US 6 to Hyland Hills, Uphill (EB) (MP 244–247)	-0.81	C	**Problem:** There is an uphill capacity issue. **Improvement:** Based on criteria, improvement is not warranted.
Chief Hosa to Genesee, Flat (EB) (MP 252–253)	-0.89	C	Based on criteria, improvement is not warranted. While an auxiliary lane allows local traffic to stay in a separate lane from Evergreen to Genesee, there is insufficient demand to warrant improvement.
Morrison to Chief Hosa, Uphill (WB) (MP 253–259)	3.01	A	**Problem:** Steep 7 percent grades limit the highway capacity. Increased demand in the future will turn this section into a substantial bottleneck. **Improvement:** An additional WB auxiliary lane provides additional capacity up this steep section with the highest traffic volumes in the Corridor.

Table 1. PEIS Analysis of I-70 Auxiliary Lanes

Name	WHI 2001 to 2005	Priority Rating	Description of Problem Areas and Proposed Improvements

Source: CDOT, 2011c

[1]Frisco to Silverthorne was identified during the Collaborative Effort process as a problematic area warranting an auxiliary lane.

1.4.3 Curve Safety Modifications

The need for the curve safety modifications in the Corridor is based on safety—as determined by WHI—and curve design—as determined by the design speed of the curve. A WHI threshold of 2.00 was selected because curves are generally more prone to crashes and high WHI values are not uncommon. Substandard design corresponds to locations where the highway design speed on the curves is less than the posted speed limit as well as adjacent portions of the highway. Volume-to-capacity ratio information is not applicable to the curve safety analysis.

Curves were given a priority rating of A, B, or C depending on the following criteria:

- An "A" rating was given if the curve met **both** of the following criteria:
  - WHI greater than 2.00 and
  - Design speed less than 65 miles per hour (mph)
- A "B" rating was given if the curve met either of the following criteria
  - WHI greater than 2.00 or
  - Design speed less than 65 mph
- A "C" rating was given if the curve met **neither** of the following criteria:
  - WHI greater than 2.00 nor
  - Design speed less than 65 mph

Of the five curves identified for potential safety modifications, one—the "East of Wolcott Interchange" curve—was eliminated during the alternatives screening process because it did not warrant any improvements based on the criteria. The remaining curve safety improvements are listed below and are included as components of the Preferred Alternative:

- West of Wolcott Interchange (MP 155–156)
- Dowd Canyon (MP 170–173)
- Fall River Road (MP 237–238)
- East of Twin Tunnels to US 6 (MP 242–245)

Table 2 provides details on each of the curve safety modifications. The *I-70 Mountain Corridor PEIS Safety Technical Report* (CDOT, 2010) also provides details about the proposed curve safety modifications.

Table 2. PEIS Analysis of I-70 Curve Safety

Name	WHI 2001 to 2005	Design Speed (mph)	2035 Priority Rating	Description of Problem Areas and Proposed Improvements
East of Wolcott Interchange (MP 158-159)	1.38	65	C	Based on criteria, improvements are not warranted.

Table 2. PEIS Analysis of I-70 Curve Safety

Name	WHI 2001 to 2005	Design Speed (mph)	2035 Priority Rating	Description of Problem Areas and Proposed Improvements
West of Wolcott Interchange (MP 155-156)	2.01	55	A	**Problem:** The design speed of the curve is less than that for surrounding portions of the highway. There is a critical safety issues in an area with relatively less demand. **Improvement:** Curve safety modifications improve safety.
Dowd Canyon (MP 170-173)	1.89	50	B	**Problem:** The design speed of the curve is less than that for surrounding portions of the highway. There is a critical safety issues in an area with very high demand. **Improvement:** Curve safety modifications improve safety.
Fall River Road (MP 237-238)	1.43	55	B	**Problem:** The design speed of the curve is less than that for surrounding portions of the highway. There is a high amount of incident-related delay; but not a major capacity issue. **Improvement:** Curve safety modifications improve safety.
East of Twin Tunnels to US 6 (MP 242-245)	1.16	45	B	**Problem:** The design speed of the curve is less than that for surrounding portions of the highway. There is a critical safety issues in an area with very high demand. **Improvement:** Curve safety modifications improve safety.

Source: CDOT, 2011c

Appendix A contains Corridor maps that present the existing design speed constraints within the corridor. The maps depict only the infrastructure improvement areas proposed in the PEIS, which include curve safety modification projects, auxiliary lanes, and capacity improvement projects discussed in Sections 1.4.2 and 1.4.3. The maps show the proposed 55- and 65 mph proposed infrastructure improvements presented in the PEIS. A side-by-side comparison of the existing and proposed conditions aids in identifying areas where providing a higher design speed will require additional improvements to meet minimum criteria. The maps also include the Advanced Guideway System hybrid alignment; for some of the maps, the alignment is so far away from the I-70 alignment that it will not show in the map area.

2 Roadway Design

Roadway design geometry is largely controlled by the desired design speed, based on a tiered level of national and state policy recommendations. The Corridor is unique compared to other interstates nationwide. Because of its age and distinctive setting, a wide range of physical, geometric, and operational conditions exist. This section lists the design standards that apply to the Corridor, evaluates existing geometric conditions of I-70 in locations of PEIS Preferred Alternative improvements, and identifies areas where providing a higher design speed will require additional improvements to meet minimum criteria.

FHWA defines design speed as follows (FHWA, 2007):

> *Design speed is a selected speed used to determine the various geometric features of the roadway. The assumed design speed should be a logical one with respect to the topography, anticipated operating speed, the adjacent land use, and the functional classification of the highway*.

This discussion assumes the design speed is equal to the posted speed limit. Desirably, the speed at which drivers are operating comfortably will be close to this same speed.

2.1 Design Standards Applicable to the I-70 Mountain Corridor

The 2011 AASHTO *Policy on Geometric Design of Highways and Streets* (2011), nicknamed "the Green Book," is the principal source for highway and roadway design criteria. This publication and AASHTO's *A Policy on Design Standards, Interstate System* (2005) have been adopted by FHWA to guide interstate design. States also publish their own design manuals that may be more stringent than AASHTO requirements. The 2005 *CDOT Design Guide* has been adopted by CDOT for Colorado interstates (CDOT, 2005).

As part of CDOT's commitment to Context Sensitive Design in the Corridor, Corridor-specific Engineering Design Criteria have been developed and adopted because they represent an approach that enhances safety, mobility, and sustainability while reducing maintenance through design and engineering.

Each of these publications provide direction on considerations related to establishing a design speed.

2.1.1 FHWA Standards

In addition to the adoption of AASHTO policies for interstate design, FHWA identifies 13 controlling criteria as having substantial importance to the operational and safety performance of any highway (FWHA, 2007). One of these criteria is Design Speed. Unlike specific elements of roadway design, such as lane width or horizontal curvature, Design Speed is a design control used to establish values for the other design elements. The selected design speed should be high enough so that the posted speed limit will be less than or equal to it.

Travel speeds cannot be reduced by simply changing the posted speed limit. Geometric and cross-sectional elements, in combination with the context, establish a driving environment in which drivers choose speeds that feel reasonable and comfortable.

2.1.2 CDOT Standards

The 2005 *CDOT Design Guide* stresses that the roadway alignment should provide for safe and continuous operation of vehicles at a uniform design speed for a substantial length of highway. The design speed should be consistent with driver expectations. In mountainous terrain, the *CDOT Design Guide* allows design speeds as low as 50 mph to 60 mph on interstates.

Specific criteria from the *CDOT Design Guide* to be considered in design speed decisions include:

- Sight distance, compatible with the selected design speed. Horizontal alignment must afford at least the minimum stopping sight distance for the design speed at all points on the highway.
- Every effort should be made to exceed the minimum curve radii. Minimum curve radii should be used only when the cost of realizing a higher standard is not consistent with the benefits. The final considerations for the safety of any curve should be the combination of the factors of radius, sight distance, and superelevation.
- To avoid the appearance of inconsistent distribution, the horizontal alignment should be coordinated carefully with the profile design.

2.1.3 I-70 Mountain Corridor Standards and Areas of Special Attention

Table 3 lists the seven required Engineering Design Criteria that have been developed and adopted by the CDOT to address the unique characteristics of the Corridor.

Table 3. I-70 Mountain Corridor Design Criteria

	Design Criteria	Remarks	Impact to Corridor Design Speed
Design speed	65 mph design speed.	1) Posted speed of 55 mph on I-70. 2) FHWA 13 controlling criteria and CDOT Design Criteria apply.	Yes
Alignment	EB highway lanes, WB highway lanes, and the Advanced Guideway Systems will be designed as separate, independent alignments. The three alignments will maintain no less than the existing median width or create a clear zone that does not require a guard rail or barrier. No loss of existing vertical separation of highway lanes will occur in any section.	1) Provides a recovery zone. 2) Median required for snow removal and maintenance. 3) Separation prevents headlight glare, improving safety and maintenance conditions. 4) Separate alignments will adapt to topographic conditions.	Yes
Slope cut and fill	Limits of physical disturbance shall be less than 40 vertical feet from the top of the pavement or rail platform to the farthest edge of cut or fill. Cut and fill embankment will not exceed a slope of 2.5:1 (H:V). All roadway retaining walls over 12 feet in height will be installed below the elevation of the roadway.	1) Planting, re-vegetation, and restoration of slopes will be successful with flatter slope embankment. 2) Slopes will be more easily maintained and erosion and sediment transport will be manageable.	No
Disturbance	Construction will be fully contained with areas of historic or current disturbance if no centerline change occurs. New alignments must be consistent with Design Criteria for slope cut and fill.	1) Existing maintenance problems will be resolved or improved by staying within the existing limits of disturbance. 2) Construct without increasing the disturbance zone.	Yes
Rock cut	A geotechnical analysis report will be completed and reviewed prior to any proposal to create rock cuts for an alignment. If rock cuts are required, naturalized custom cuts methods are required. Rock cuts shall be constructed using scatter blasting techniques and provide for adequate rockfall area at the base.	1) Allows for understanding of rock formations at an early planning stage to potentially avoid rock cuts. 2) Avoids rockfall mesh and reduces maintenance. 3) Scatter blasting techniques provide a naturalized cut and allows safety from rockfall to be incorporated in the design.	No
Bridge structures	Bridge structures will not utilize slope paving techniques and will require a closed-end abutment design with a minimum vertical height of 8 feet, measured below the bridge girder. Bridge embankments shall be 2.5:1 maximum.	1) Avoids the maintenance of slope paving. 2) Provides a method of incorporating re-vegetation and landscape into bridge slopes. 3) A clear span over streams and drainages avoids water quality construction impacts and reduces maintenance and pier scour. 4) Provides benefits below bridges for vehicle clearance, wildlife crossing, solar access, and re-vegetation success.	No
Sound attenuation	Sound buffering and attenuation will be designed in conjunction with the horizontal and vertical alignment to eliminate the need for noise mitigation. Mitigation, if required, will integrate landforms, landscape planting buffers, and walls.	Design can minimize or eliminate additional noise mitigation.	No

Source: CDOT, 2012c.

Corridor stakeholders also identified 19 Areas of Special Attention throughout the Corridor. These areas are locations or stretches that have been identified as having multiple or unique issues. Addressing the various issues and integrating them into design solutions requires further understanding of stakeholder concerns, issues, and suggested solutions. Table 4 summarizes these 19 Areas of Special Attention.

Table 4. I-70 Mountain Corridor Areas of Special Attention and Associated Issues

	Areas of Special Attention	*Major Issues*	*Impact to Corridor Design Speed?*
Mountain Mineral Belt	Floyd Hill*	Design speed; steep gradient; tight curves	Yes
	Central City	Unsightly cut and fill slopes	No
	Twin Tunnels*	Slowing traffic that creates congestion; wildlife; land bridge	Yes
	Idaho Springs*	Narrow canyon; potential conflict between I-70, Idaho Springs, and Clear Creek	Yes
	Downieville-Lawson-Dumont*	Narrow canyon; potential conflict between I-70, Idaho Springs, and Clear Creek	No
	Empire Junction*	Most open and flat part of the county; potential conflict between I-70 and Clear Creek, and efficient land uses	No
	Georgetown/Silver Plume*	Steep grades that create congestion; cut and fill slopes; I-70 bisects Silver Plume	No
Crest of the Rockies	Herman Gulch*	Narrow forested canyon; potential conflicts between I-70, Clear Creek, wildlife, and forest	No
	EJMT Approach*	Slowing traffic that creates congestion; aesthetics of the approaches to the tunnel	No
	Silverthorne*	Congestion on I-70 between Frisco and Silverthorne; heavy traffic volume on US 6 and SH 9 closely spaced intersection contribute to vehicle incidents	No
	Officers Gulch	Weather conditions, tight curve, and interchange geometry all contribute to higher accident rates	No
	Top of Vail Pass*	Potential maintenance facility relocations	No
	West of Vail Pass	Truck traffic and traffic volumes contribute to congestion — Level of Service "E" on weekends by 2025	No
	Town of Vail*	Narrow canyon; dense development; multiple interchanges; major regional destination	No
Western Slope	Dowd Junction*	Landslide; tight curves; 4 percent grades; interchange geometry	Yes
	Wolcott Curves*	Tight curves	No
	Eagle Airport Interchange	Regional destination; new development	No
	Dotsero	Truck parking; rest area; new development	No
	East Entrance Glenwood Springs*	Slope stabilization; revegetation; aesthetics; transition from urban geometry in Glenwood Springs to rural geometry of canyon	No

* Reports must be prepared for these Areas of Special Attention.

Source: CDOT, 2015b.

2.2 Geometric Element Evaluation Methodology

The existing horizontal and vertical alignments of the I-70 Mountain Corridor were evaluated by comparing them to the aforementioned policies and guidelines for freeways. The purpose of this comparison was to identify locations along the Corridor that are not currently in compliance with national and state guidance. This section discusses the methodology followed to perform the comparison for this initial assessment. Subsequent work conducted or information gathered for this study may suggest the need to revise this methodology.

2.2.1 Horizontal Alignment

Mainline horizontal alignment is based on the adherence of the horizontal alignment to current AASHTO design policy for all mainlines and maximum superelevation (e_{max}) = 0.06. The centerline is used as the control line geometry. If the two directions of travel are on an independent alignment, each direction was evaluated separately. Table 5 shows the relationship between curve radii and design speed.

Table 5. Minimum Horizontal Curve Radius per Design Speed

Design Speed	Curve Radius
Above 65 mph	Radius of Curve is ≥1,660 ft.
55 to 64 mph	Radius of Curve is ≥1,060 ft. and < 1,660 ft.
Less than 55 mph	Radius of curve is < 1,060 ft.

Source: CDOT, 2015c

2.2.2 Vertical Alignment

The vertical alignment analysis compares mainline centerline grades to maximum recommended values per AASHTO. For evaluation purposes, the entire study area was considered mountainous terrain. Table 6 shows the relationship between vertical grade and design speed.

Table 6. Maximum Vertical Grades in Mountainous Terrain per Design Speed

Design Speed	Vertical Grade
Above 65 mph	≤6.4%
55 to 64 mph	6.5 – 8.4%
Less than 55 mph	≥ 8.5%

Source: OTIS CDOT; http://dtdapps.coloradodot.info/otis

2.2.3 Other Geometric Elements Not Considered in this Existing Conditions Evaluation

Several other geometric elements are typically considered when evaluating the existing conditions of a corridor in terms of design speed. These elements are not considered in this existing conditions evaluation because data were not readily available:

- **Critical Length of Grade**. This element encompasses the operational effects of long and/or steep grades. The AASHTO policy for combinations of percent and length of grade is based on avoiding designs that can result in significant speed reductions by trucks with high weight-to-horsepower (WT/HP) ratios. The AASHTO policy recommends the use of a 10 mph speed reduction for typical heavy trucks (WT/HP of 200) as a desirable maximum. The AASHTO policy includes curves that combine length and grade to enable this analysis. For percent and length combinations of upgrades, Highway Capacity Software includes a simple module that enables testing of vertical alignment effects on speed.

- **Vertical Curvature.** Vertical alignment also includes sag and crest vertical curvature. Design for these geometric features is based on the design requirements for stopping sight distance. Detailed existing vertical information is not available.
- **Cross Section.** The cross section of the existing roadway such as number of lanes, lateral clearances to obstructions, and the superelevation can affect the operating speed of the roadway. However, it is difficult to identify from published research the isolated effect of speed on each specific element.
- **Ramp Terminal Design.** The design of each ramp is based on two elements—the ramp taper angle in the vicinity of the point of physical merge or diverge, and the length of acceleration or deceleration taper available to the driver. The acceleration/deceleration length required is dependent on the operating speed of the mainline. Detailed existing ramp information is not available.
- **Stopping Sight Distance**. Both vertical and horizontal stopping sight distance are dictated by the design speed control. Research on risk analysis suggests that marginal deficiencies in available stopping sight distance may not pose serious problems.
- **Decision Sight Distance (DSD)**. The concept of DSD addresses the desirability of providing additional time for driver decision-making. DSD is an increment of sight distance above stopping sight distance and should be provided in advance of exits, major forks, and lane drops. As DSD is not a requirement per AASHTO policies, lack of DSD should not be a distinguishing factor in the decision making.

2.3 Summary of Existing Design Speed Conditions

A comprehensive review of the existing freeway geometric conditions was conducted for the entire corridor using the methodology described in Section 2.2 of this report. Table 7 summarizes this review based on the evaluation criteria for the project areas identified in the PEIS, as discussed in Sections 1.4.2 and 1.4.3. For each improvement area, the table shows the number of horizontal curves by design speed and the length of vertical grades by design speed. As the table shows, the posted speed limit is higher than the design speed for the horizontal curvature at most of these locations.

Table 7. Summary of Geometric Element Evaluation

Improvement Area MP	Posted Speed Limit (mph)	Number of Horizontal Curves by Design Speed		Length of Vertical Grade by Design Speed (mi)	
		< 55 mph	55 to 64 mph	< 55 mph	55 to 64 mph
155 – 156	75	-	1	-	-
167 – 168	65	-	1	-	-
170 – 173	65	-	4	-	-
180 – 190	65	-	4	-	0.9
202 – 205	65	-	-	-	0.5
215 – 218	50/65	-	-	-	0.2
218 - 221	65	-	-	-	-
242 - 247	65/55	7	2	-	-
253 - 259	65	-	3	-	-

3 Speed

Speed is often used as a measure of mobility because higher speeds typically result in shorter travel times. Many previous studies within the Corridor have focused on improving mobility during the peak travel times when congestion is high and speeds are low. In order to meet this study's objective to define a design speed vision and recommendation for the Corridor, off-peak speeds were evaluated and compared to posted speeds. Off-peak speeds are a good indicator of free flow speeds, upon which posted speed limits are based. Peak-hour speeds are not relevant for making a decision between a 55- or 65-mph design speed because the peak hour speeds are typically well below either of these speeds. This section presents summaries of existing speed limits and prevailing speeds within the Corridor, and CDOT's efforts toward implementation of variable speed limits.

3.1 Existing Corridor Posted Speeds

Statutory requirements define how speed limits are set and charge departments of transportation (DOTs) with determining and posting speed limits on state highways. CDOT determines and declares reasonable and safe speed limits on the basis of a traffic investigation, survey, and/or design standards. The guidance in the AASHTO 2005 *A Policy on Geometric Design of Highways and Streets* and FHWA *Manual on Uniform Traffic Control Devices* (FHWA, 2009a) manuals recommend determining the prevailing 85th percentile speed to establish reasonable speed limits.

The prevailing speed or 85th percentile speed is one of the primary factors used by CDOT, and most DOTs, to determine an appropriate speed limit. The 85th percentile speed is defined as the speed at or below which 85 percent of vehicles travel in free flow conditions. Other factors considered when setting speed limits include roadside development, crash experience, road characteristics, and pace speed. These factors all contribute to the context in which drivers make their individual vehicle operating speed decisions.

Posted speeds in the Corridor range from 50 mph to 75 mph. Geometric constraints such as steep grades, sharp curves, and tunnels play a role in both the posted and 85th percentile speeds. As shown in Figure 1, the majority of the corridor is posted at or above 65 mph. The stretch of I-70 from Avon to Dotsero is posted at 75 mph. There are posted speeds below 65 mph in both directions at the following locations:

- Floyd Hill to the Twin Tunnels (55 mph)
- Twin Tunnels to Idaho Springs (60 mph)
- EJMT (west portal) to Silverthorne (60 mph)

Within the EJMT and Glenwood Canyon the posted speed limits are currently 50 mph. CDOT recently completed a speed study in Glenwood Canyon and has approved a 60 mph speed limit for automobiles and maintenance of the 50 mph speed limit for trucks. Variable speed limit signs will be installed to adjust the posted speeds according to conditions.

3.2 Prevailing Speeds

It is not the intent of this study to complete detailed speed studies along I-70. Rather, readily available prevailing speeds were compiled to understand the corridor context. Prevailing speeds were obtained from CDOT's Cognos system, which uses Automatic Vehicle Identification or toll tag readers, Doppler radar, and Remote Traffic Microwave Sensors (RTMS) placed throughout the Corridor. The data used to compute the average prevailing speeds were recorded during the first two weeks of June, 2014 for weekdays between the hours of 10 a.m. and 2 p.m. As shown in Figure 1, the prevailing speeds are primarily less than or equal to the posted speed limits.

3.3 Variable Speed Limits

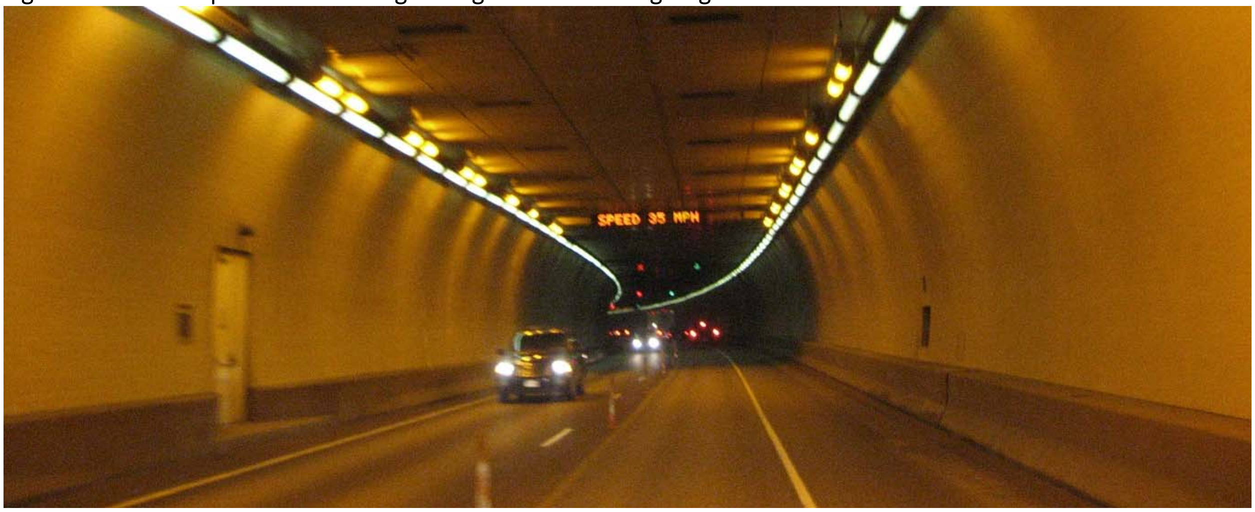
CDOT also uses variable speed limit signs to adapt the speed limit to adverse weather conditions. When the chain law is in effect, speed limits may be reduced by remotely illuminating an otherwise blank speed limit sign to lower the posted speed limit. CDOT is one of the most active DOTs in the nation with regard to managing speed limits in real time. In addition to posting regulatory speed limits on variable message signs, the Department also selectively uses “speed feedback” warnings, such as the one in Figure 3, to warn of excessive speed entering a horizontal curve with a lower design speed than the adjacent tangent segments.

Figure 3. CDOT Speed Warning Sign

Source: Daniel Baxter, CH2M HILL, 2009

Figure 4 shows an example of a reduced regulatory speed limit used by CDOT for operational purposes when two-way traffic flow is established in one of the two bores in the Hanging Lakes tunnel for maintenance reasons.

Figure 4. Reduced Speed Limit Message Using Variable Message Signs



Source: Daniel Baxter, CH2M HILL, 2009

In Figure 5, a variable message sign (VMS) warns motorists of the two way traffic operation, and the revised speed limit is posted on smaller variable signs on the end posts of the larger VMS.

Figure 5. Warning and Regulatory Variable Speed Limit Messages Combined

Source: Daniel Baxter, CH2M HILL, 2009

4 Traffic Safety

This section presents a summary of applicable research about the state of the practice for setting speed limits and the current knowledge base about the relationship between speed and safety. Following this discussion is a presentation of the recent crash history for three segments within the Mountain Corridor and a discussion about the limitations to establishing one Corridor-wide speed limit.

4.1 Current State of the Practice and Knowledge Base

From a safety perspective, an appropriate speed limit is an essential element of highway safety and the avoidance of crashes and mitigation of crash outcomes is the most important reason for imposing speed limits. An appropriate speed limit is safe, considered reasonable by most drivers, fair in the context of traffic law, and enforceable with available resources. Motorists tend to comply voluntarily with speed limits that are appropriate. Speed limits that are not considered reasonable typically result in greater speed differentials among motorists, as some comply with the regulation and others drive at the speed they consider appropriate for the conditions.

Although speed contributes to the occurrence and severity of crashes, the range in speeds is thought to contribute more to crashes than speed itself. Irrespective of the average speed on the highway, a greater deviation from average traffic speeds increases crash probability and the risk of a severe crash. Initial research into setting speed limits indicated that crash risk increases rapidly for motorists traveling two standard deviations or more above or below the mean operating speed (FHWA, 2012a). Thus, a smaller speed differential promoted by a reasonable speed limit can enhance safety and reduce the frequency and severity of crashes.

4.1.1 Methods for Setting Speed Limits

The most common methodology used to set speed limits is the 85th percentile speed. The mean speed plus one standard deviation approximates the 85th percentile speed for a normally distributed sample of speeds. Initial research into setting speed limits indicated that traveling at or around one standard deviation above the mean operating speed (which is approximately the 85th percentile speed) yields the lowest crash risk for drivers (FHWA, 2012a). Therefore, the 85th percentile speed is thought to separate acceptable speed behavior from unsafe speed behavior that disproportionately contributes to crash risk. The Manual on Uniform Traffic Control Devices (FHWA, 2009a) indicates that posted speeds “should be within 5 mph of the 85th-percentile speed of free-flowing traffic.”

Another methodology used to set speed limits is the engineering approach. This method sets the speed limit based on a study of context. The context of a roadway includes the following: review of the road’s environment, features, and condition and traffic characteristics; observation and measurement of vehicle speeds at one or more representative spots along the road in ideal weather and under free-flowing traffic conditions; analysis of vehicle speeds to determine 85th percentile speed and other characteristics; review of the road’s crash history; and review of any unusual conditions not readily apparent.

The USLIMITS2 expert system is another approach for setting speed limits that uses either a geometric and volume-based methodology or a safety-based methodology which compares the average and critical crash rates for the particular roadway segment to the rates for similar roadway segments.

4.1.2 Heavy Vehicle Considerations

An engineering study considering factors such as magnitude and length of roadway grades and horizontal curvature is typically conducted when there is a need to determine if a lower speed limit should be set for trucks than for automobiles. The safety effectiveness of differential speed limits for trucks is inconclusive based on most studies and there is no compelling proof that a lower speed limit for trucks reduces truck-involved crash rates. Policies requiring slower vehicles to keep to the right on rural interstate highways are one method that assists with reducing dispersion in operating speeds.

4.1.3 Nighttime Speed Limits

Lower speed limits are typically implemented for nighttime driving conditions because illumination limitations of headlamps restrict the distance ahead that a driver can see. However, there is little evidence to suggest that motorists decrease driving speeds at night when lower nighttime speed limits are in effect.

4.1.4 Variable Speed Limit Systems

Variable speed limit systems are a type of Intelligent Transportation System that use traffic speed and volume detection, weather information, and road surface condition technology to determine appropriate speeds at which drivers should be traveling given current roadway and traffic conditions. The algorithms used to determine the applicable speed limit for a given set of conditions reflect some of the same factors a prudent driver would consider when selecting an operating speed. Reducing the speed limit during conditions in which the roadway surface is wet or icy, visibility is reduced to due to weather (fog, blizzard, sand), or is congested or an active work zone can enhance safety by promoting uniformity in operating speeds. When the operating speed exceeds the design speed, such as when drivers travel through a curve at a speed that exceeds the design speed or at locations where there is a change in alignment, variable speed limits can be beneficial.

4.1.5 Minimum Length of Speed Zones

A speed zone is a location along which the speed limit is lowered because of a change in roadway characteristics, such as school zones, adjacent development, or terrain/geographic impacts to vehicle operating characteristics. Minimum lengths for speed zones are desirable to prevent frequent changes in speed limit. These changes can cause turbulence in the traffic stream if drivers begin their acceleration/ deceleration at different locations or accelerate/decelerate at different rates due to personal preference or vehicle operating characteristics. Some drivers may choose to ignore a reduced speed limit while others comply. All of these factors can decrease the uniformity of the operating speeds of vehicles in a traffic stream. Various agencies have established their own guidelines for minimum speed zone lengths. Although published guidelines for agencies in the U.S. tend to focus on highway speed transitions between urban and rural areas, guidelines in effect in Australia and New Zealand for rural roadways (that are equivalent to rural interstates in the U.S.) suggest a minimum speed zone length of 1.3 miles for a 55 mph speed limit and 2.0 miles for a 60 mph speed limit.

4.2 Considerations Specific to the I-70 Mountain Corridor

4.2.1 Crash Data Review

To provide input into setting speed limits for the areas in which infrastructure improvements will likely occur in the near future, recent crash data were reviewed to determine if there are locations with concentrations of crashes for which circumstances suggest speed or speed dispersion may have contributed to the crashes. This information could help to determine if the current speed is set too high or too low. Crash data for the Jan. 1, 2009 through June 30, 2014 time period were reviewed for select locations that provide a representative sample of the locations along the Corridor where speed limits are currently posted below 65 mph and/or the PEIS notes safety concerns related to roadway curvature: MP 168-172 (Minturn), MP 213-215 (EJMT), and 221-247 (Floyd Hill to Silver Plume).

4.2.1.1 General Summary of Crash Data

The crash data provided by CDOT included 2,538 crashes for this 5.5-year time period. Figure 6 shows the number of crashes by severity for each of the three locations. At all three locations, the proportion of severe crashes (fatal plus injury) is similar (between 20 and 22 percent). This proportion is slightly less than that for all interstates in Colorado during the 2009 to 2012 time period. Although the Corridor reflects a higher degree of difficulty for drivers than the typical Colorado freeway, this finding indicates that the more complex driving environment results in lower operating speeds, which tend to reduce crash severity.

Figure 6. Number of Crashes by Crash Severity

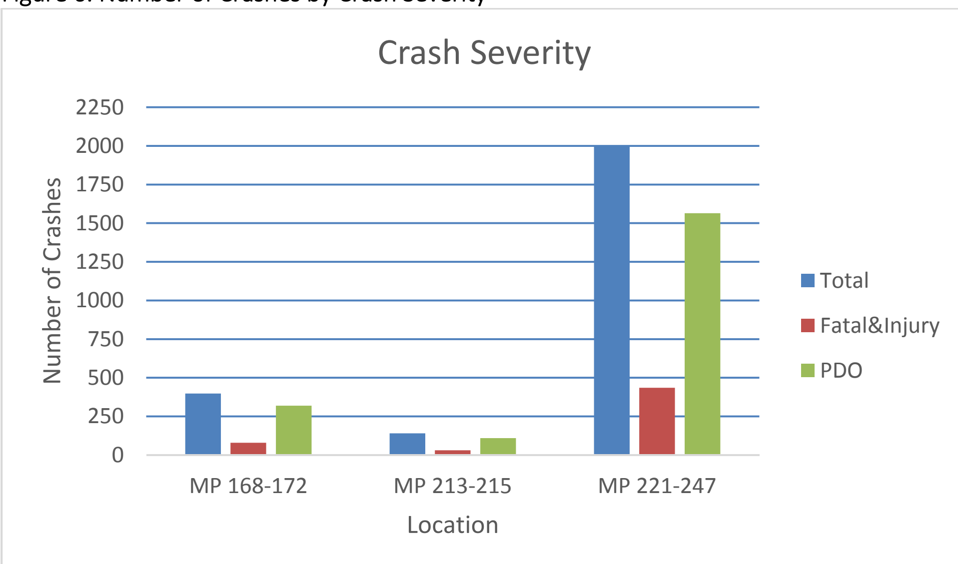


Figure 7 shows the number of crashes by collision type. The predominant crash type is collision with a fixed object, which includes elements such as concrete barrier, guardrail, embankment, and signs. Fixed-object collisions occur when a vehicle has departed the roadway, which can occur on curves if the operating speed is too high for the geometric or roadway surface conditions. The other collision types in the Minturn area occurred in a similar proportion to each other. In the higher-volume segments between EJMT and Floyd Hill, rear-end and sideswipe same-direction collisions occurred in a higher proportion than the other collision types. Rear-end crashes can be indicative of operating at a speed that is too fast for congested conditions. Because grades and roadway curvature along the Corridor cause limited visibility, there is an increased probability of vehicles leaving the road and striking objects or unexpected slow or stopped vehicles. Travelling at or below the posted speed limits does not ensure a safe commute when drivers encounter intermittent congestion on I-70.

Figure 7. Number of Crashes by Crash Type

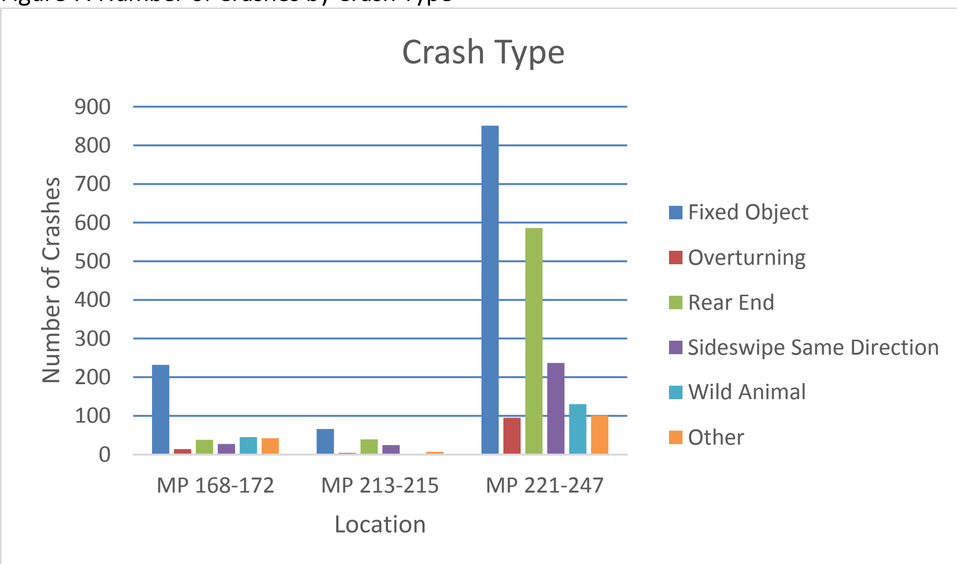


Figure 8 compares the number of crashes by operating speed compared to posted speed. Data was compiled from law enforcement's vehicle speed estimate entered into crash investigation reports "before difficult is encountered" and compared to the posted speed limit. This comparison would be useful as a surrogate for exceeding posted speed limit as a contributing factor to crashes if the estimates were accurate. Unfortunately the prevailing practice of investigating officers not citing excessive speed without direct evidence explains the preponderance of reports to be at or slightly below the posted speed limit as seen in Figure 10. Anecdotal evidence in consultation with experienced officers in the Corridor, such as those employed by the Colorado State Patrol, reveals a consistent observation that most Mountain Corridor crashes occur due to motorists travelling too fast for the prevailing conditions. None of the post-crash records reviewed included speed as a contributing factor to the crash, which is likely due to the prevailing reporting practices. As a result, this comparison does not adequately provide information about speed in terms of drivers operating their vehicles at a speed that is too fast for conditions (such as, icy or wet road surface conditions or high volume density). At all three locations, the majority of crashes occurred when the reported pre-crash operating speed was at or below the posted speed limit. The fact that between MP 221 and 247 less than 15 percent of the crashes were reported to have occurred at speeds starting above the posted limit is counterintuitive and points to the reality of reporting practices and not a reflection of the likely contribution of excessive speed to driver difficulty and crashes.

The PEIS noted a few locations where the design speed on the curves is less than the posted speed limit (MP 170-172, MP 237-238, and MP 242-245), so some of these crashes may have occurred when the operating speed was higher than the design speed.

Figure 8. Number of Crashes by Operating Speed Compared to Posted Speed

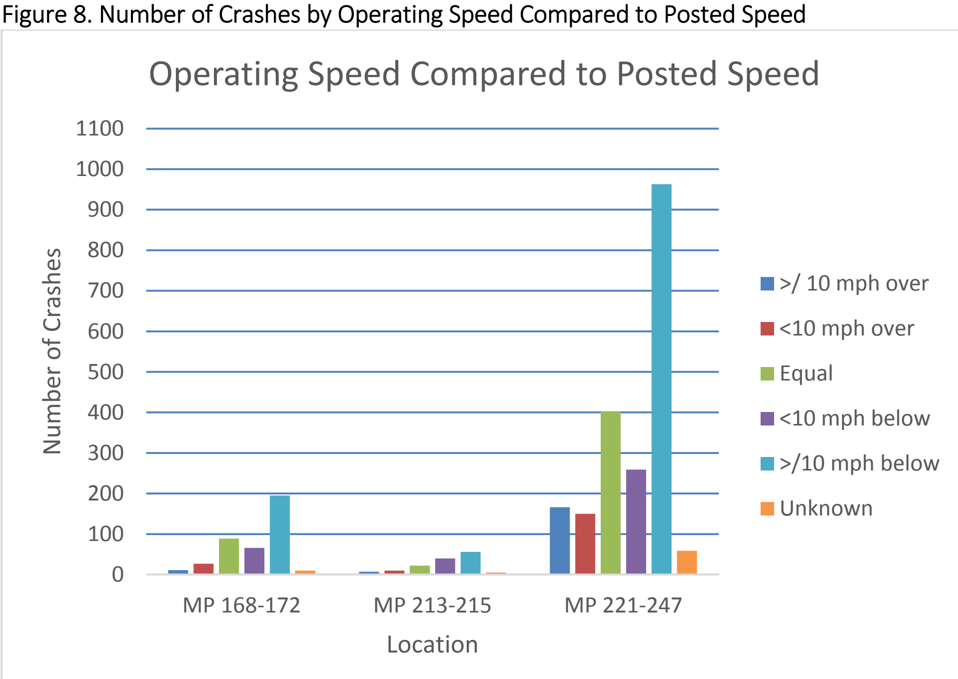


Figure 9 shows the number of crashes by roadway surface condition. At the Minturn and EJMT locations, the proportion of crashes on wet surfaces exceeds that for dry surface conditions. The proportions are nearly equal between Silver Plume and Floyd Hill. Typical crash patterns show that a majority of crashes occur on dry roadway surfaces, suggesting that roadway conditions are a contributing factor to crashes in these areas. The significant proportion of crashes that occur during reduced friction and visibility conditions, when the operating speed often falls below the posted speed limit, and the proportion of crashes on wet surface conditions suggest drivers are slowing down, but perhaps not enough for inclement conditions.

Figure 9. Number of Crashes by Road Surface Conditions

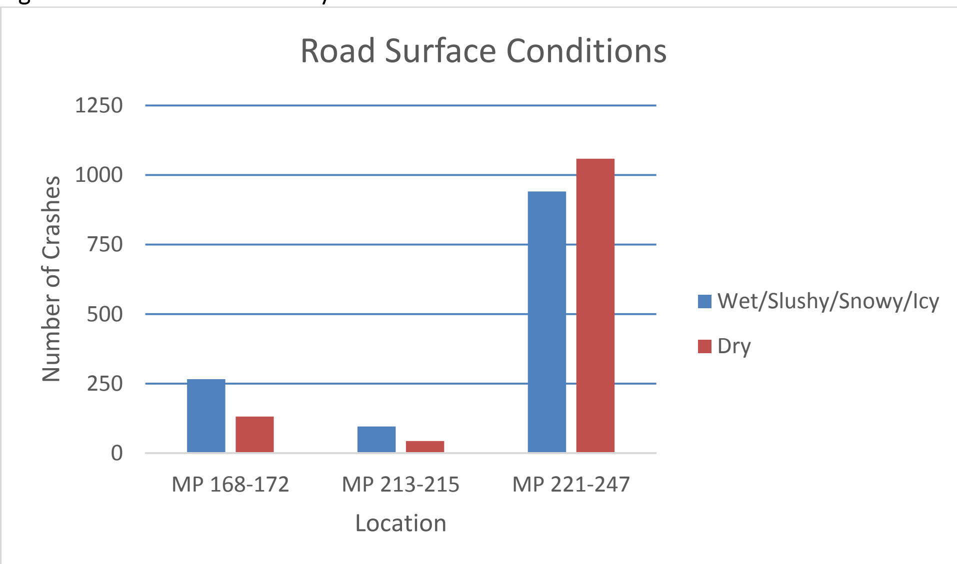


Figure 10 shows the number of crashes by roadway alignment. Overall, nearly half of the crashes (47 percent) occurred on a curved section of I-70. The high proportion of curve crashes (75 percent) in the Minturn area is to be expected given the alignment along this stretch of I-70. However, this location is noted in the PEIS for the posted speed limit exceeding the design speed at curves.

Figure 10. Number of Crashes by Road Alignment

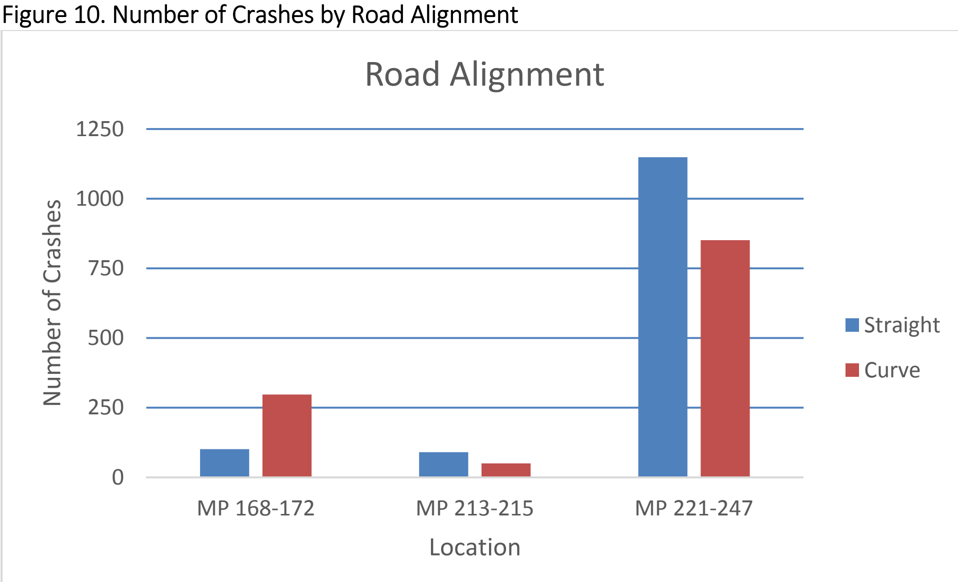
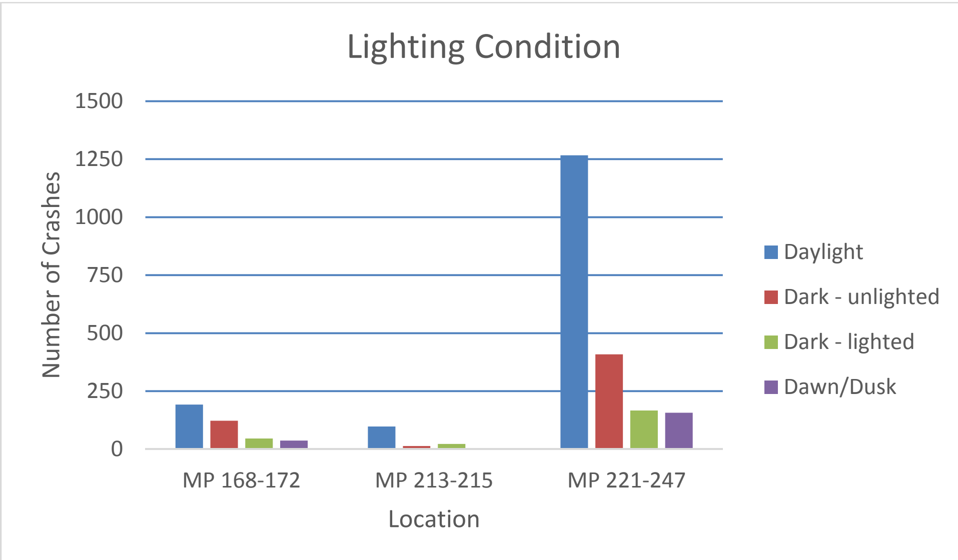


Figure 11 shows the number of crashes by lighting condition. As is typical for crash patterns, a significant proportion of the crashes occurred during daylight. Dark-unlighted conditions represented the highest proportion of the crashes that occurred in low-light conditions, which is to be expected given that in general only the interchange areas are lighted.

Figure 11. Crashes by Lighting Condition



4.2.1.2 Data Analysis by Location

After assembling general summary statistics, the data analysis was refined for each location to determine if speed could have been a contributing factor to crashes along the length of the segments or at specific locations within the segments. Typical speed-related contributing factors reported by police are "too fast for conditions" and "exceeding posted speed limit." Since none of the crash records included either of these contributing factors for reasons explained, other data fields in the crash records were used to assess this issue such as operating speed, posted speed limit, roadway surface condition, and crash type. The refinement process began by filtering out collision types and contributing factors that were likely not attributable to speed. The collision types filtered out include wild animal, same direction sideswipe, avoiding an object in the road, and vehicle cargo/debris in the road. Contributing factors filtered out include alcohol/drug impairment, asleep at the wheel, and driver fatigue/illness. To focus on the mainline segments, crashes that occurred along interchange ramps or at ramp terminal intersections were filtered out. Of the initial set of 2,538 crash records, 789 were filtered out (31 percent) to obtain the dataset for the refined analysis. The subsequent discussion is based on this set of 1,749 crash records.

MP 168-172 Analysis. The posted speed limit is 65 mph along this segment. The crash data shows the MP location to the nearest tenth of a mile. The road surface conditions for all of the crashes that occurred on straight alignment were wet/snowy/slushy/icy. One of these included an operating speed recorded above the posted speed limit. The analysis indicates that exceeding the posted speed limit was less likely to contribute to these crashes than adverse weather conditions.

Of the 22 curve crashes that occurred on dry pavement, less than 22 percent occurred when the reported operating speed was 5 mph above the posted speed limit. The majority of dry-surface curve crashes were road departures that occurred when the operating speed was reported at or within 5 mph below the posted speed limit, which, if accurately reported, would indicate the posted speed limit is too high along this segment of I-70, especially during compromised travel conditions. These crashes were located along the length of this segment, with no obvious clusters of crashes at a specific milepost.

The curve crashes that occurred on wet/snowy/slushy/icy roadway surfaces were located at every tenth of a mile point along the whole length of this 5-mile stretch, with no obvious clusters of crashes at a specific MP.

The typical crash pattern is similar to that for the dry-surface curve crashes—a single vehicle road departure that resulted in a collision with a fixed object or the vehicle overturning with an operating speed at or below the posted speed limit (98 percent of the curve crashes on wet/snowy/slushy/icy roadway surface). This data suggests an operating speed too fast for the roadway surface conditions could be a contributing factor to these crashes.

MP 213-215 Analysis. The posted speed limit varies from 50 to 60 mph along this segment. There were no obvious clusters of crashes at particular MPs along this segment. Nearly 70 percent of the crashes along this segment occurred on a straight alignment. Most of these straight-alignment crashes occurred on wet/snowy/slushy/icy pavement when a single vehicle departed the roadway. An operating speed for more than half of these that was reported to be at least 15 mph below the posted speed limit, which may confirm observations that drivers typically reduce speed for the roadway surface conditions and/or congestion. This pattern suggests that exceeding the posted speed limit is not a contributing factor to the majority of crashes on the straight alignment in this segment, but driving too fast for conditions could be a contributing factor. On dry pavement, nearly two-thirds of the crashes were rear-end collisions that occurred when the operating speed was reported below the posted speed limit. This pattern suggests congestion is a contributing factor to these crashes.

All but one of the curve crashes occurred on wet/snowy/slushy/icy roadway surfaces; only three occurred at an operating speed of 5 mph above the posted speed limit. Half of the wet-surface curve crashes occurred when the operating speed was at least 15 mph below the posted speed limit, indicating that drivers were slowing down for the roadway surface conditions and/or congestion. This pattern suggests that exceeding the posted speed limit is not a contributing factor to the curve crashes in this segment, but driving too fast for conditions could be a contributing factor in some of these crashes.

MP 221-247 Analysis. The posted speed limit varies from 55 to 65 mph along this segment. The curve-related crashes that occurred when the operating speed was 10 or more mph above the posted speed limit were primarily single-vehicle lane departures on dry pavement, indicating exceeding the posted speed limit was a contributing factor to these crashes. The operating speed could have been much higher than the design speed for the crashes that occurred within the 5 miles of this segment that were identified in the PEIS as locations at which the posted speed limit is higher than the design speed. Furthermore, driving too fast for conditions was another contributing factor to the curve crashes that occurred on wet/snowy/slushy/icy roadway surfaces. Although there were fewer of them, the crashes that occurred on straight alignment followed a similar pattern as the curve crashes when the operating speed was 10 or more mph above the posted speed limit. Driving too fast for conditions was likely a contributing factor to the straight-alignment crashes that occurred on wet/snowy/slushy/icy roadway surfaces.

The curve-related crashes when the operating speed was 5 mph above the posted speed occurred nearly equally on dry and wet/snowy/slushy/icy roadway surfaces. Nearly all were roadway departure crashes that resulted in collisions with a fixed object or overturning. A majority of these curve crashes (84 percent) occurred at locations that were identified in the PEIS as locations at which the posted speed limit is higher than the design speed, indicating excessive speed could have been a contributing factor in these crashes. The straight-alignment crashes when the operating speed was 5 mph above the posted speed (which totaled about half the number of curve crashes) followed a similar pattern as the curve crashes. Driving too fast for conditions could have been a contributing factor to these crashes that occurred on wet/snowy/slushy/icy roadway surfaces.

For the crashes that occurred when the operating speed was at or below the posted speed limit, 75 percent of the straight alignment and 60 percent of the curve crashes on dry surfaces were rear-end collisions - indicating congestion is likely a primary contributing factor to these crashes. Speed dispersion between faster moving vehicles approaching the congested area and slower-moving vehicles in the congested area likely contributes to this crash pattern. On wet/snowy/slushy/icy roadway surfaces, 69 percent of the crashes that occurred along a straight alignment and 83 percent along a curve were single-vehicle lane departures that resulted in collisions with a fixed object or overturning. The roadway surface conditions were a primary contributing factor to these crashes and driving too fast for conditions was likely a contributing factor in many of them.

Crash Data Review Conclusions

This crash data analysis for the three locations at which infrastructure improvements are likely to commence in the near future led to the following conclusions:

- Operating the vehicle at a speed that is too fast for conditions is the most predominant contributing factor to the crashes in these locations, although crashes while exceeding the posted speed limit may have been underreported.
- The combined circumstances of road surface conditions and operating versus posted speed suggests that variable speed limits could be effective at reducing the potential for crashes to occur on non-dry roadway surface conditions and during inclement weather events.
- Rear-end crashes on dry pavement suggest that variable speed limits and/or queue warning systems could be effective for incrementally reducing operating speed as the traffic stream approaches a congested area.
- The crash patterns near Minturn suggest the posted speed limit should align more closely to the design speed of the infrastructure improvements.
- There is no compelling evidence to suggest that the few heavy vehicle-involved crashes can be attributed to speed-related issues.

Analysis of Approximated Free-Flow Conditions

As discussed previously, most of the crashes along these three segments of I-70 occurred while operating speeds were below the posted speed limit and on wet or snowy roadway surfaces. These crash characteristics suggest most crashes do not occur during free-flow conditions when drivers are operating their vehicles at their chosen speed and the weather is fair. To assist with determining if speed was a contributing factor to crashes during free-flow conditions, a subset of the dataset was analyzed. This subset defines free-flow conditions as dry road surfaces on a Tuesday, Wednesday or Thursday during the five-year analysis period. The resultant free-flow conditions crash dataset includes 237 crashes for these three locations, which is 14 percent of the 1,749 crash dataset analyzed for the three locations. The following details the results of this free-flow conditions analysis. These results do not change the conclusions drawn from the larger dataset nor suggest any other conclusions can be drawn from this five-year crash history.

MP 168-172 Analysis. All seven of the free-flow condition crashes along this segment occurred at or below the posted speed limit on a curve. Most of these were lane departure crashes, which suggests the posted speed limit may be too high for the curve alignment or lower advisory speeds would be appropriate. Caution should be exercised when drawing conclusions from this small sample size that equates to approximately one crash per year.

MP 213-215 Analysis. Five of the seven crashes along this segment occurred at or below the posted speed limit on a straight alignment. These crash types were both lane departures and rear-ends that occurred during lane-changing maneuvers. The crash characteristics do not suggest speed was a contributing factor in this subset of crashes. Caution should be exercised when drawing conclusions from this small sample size that equates to approximately one crash per year.

MP 221-247 Analysis. This data subset, which includes 223 crashes, suggests similar conclusions to the larger dataset that includes all seven days of the week and all types of road surface conditions (contributing factors to crashes were congestion and driving too fast for the curve alignment). More than half of the crashes in this free-flow conditions dataset (56 percent) occurred at an operating speed that was at or below the posted speed limit on a straight alignment. Approximately 83 percent of these were rear-end crashes, for which the operating speed for the majority was well below the posted speed limit. This pattern suggests congestion due to volume or at spot-specific locations due to slow-moving vehicles. Further analysis indicates these crashes that appear to be congestion-related occur throughout the day from 7 a.m. until midnight.

One-fourth of the crashes along this segment occurred with an operating speed that was above the posted speed limit. These predominately lane departure crashes occurred along both curved and straight alignments, suggesting an operating speed too fast for the curve alignment or driver error.

4.2.2 Limitations to Establishing One Corridor-wide Speed Limit

As noted in the PEIS, the variation in speeds between heavy vehicles (bus, truck, recreational vehicles) and faster moving passenger vehicles (particularly on steep grades) contributes to safety, mobility, and congestion problems in the Corridor. The information presented about the current knowledge base suggests that more uniform operating speeds within a traffic stream enhance safety. Because of the continually fluctuating horizontal and vertical curvature along the Corridor that is required by the varying terrain, one Corridor-wide speed limit cannot promote a minimal operating speed dispersion. Speeds tend to become more diverse along sections of extreme geographical terrain due to vehicle operating characteristics and driver preferences. To promote more consistent operating speeds among all vehicles within a given roadway segment, the speed limit should vary as the terrain varies. Likewise, one Corridor-wide speed limit cannot convey a reasonable operating speed when some locations may be experiencing inclement weather and roadway surface conditions or congested operating conditions while other locations are experiencing typical operating conditions.

5 Environmental Existing Conditions

A variety of environmental and social resources are present within the areas of PEIS Preferred Alternative improvements. Table 8 summarizes the resources present in each of the PEIS Preferred Alternative improvement locations, and Figure 12 illustrates the locations of the resources.

Table 8. Resources Present in PEIS Preferred Alternative Areas of Improvement

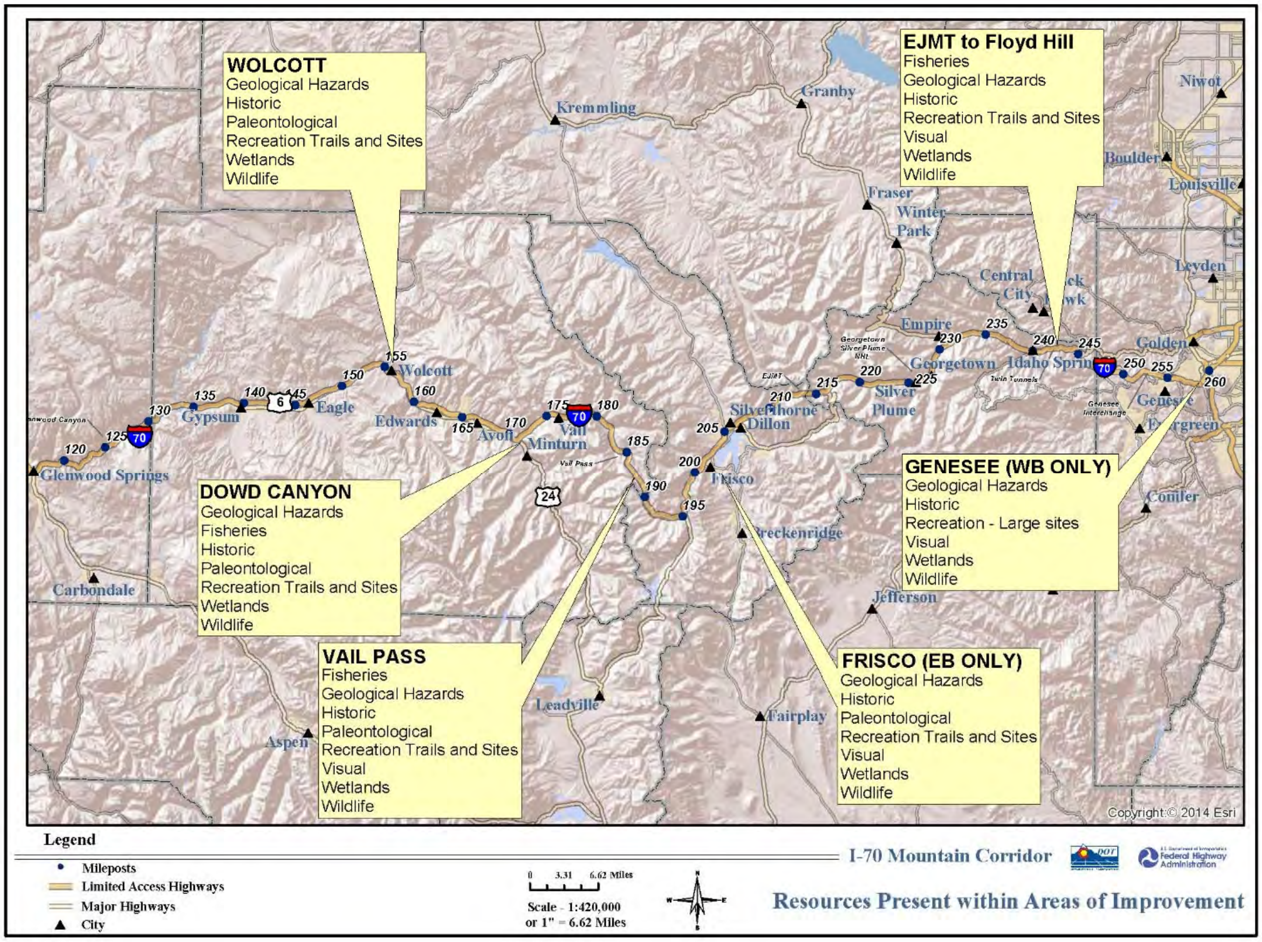
Resource	**PEIS Preferred Alternative Areas of Improvement**						
	Wolcott (MP 155-156)	Avon **(MP** 167-168**)**	**Dowd Canyon (MP 170-173)**	**Vail Pass (MP 180-190)**	**Frisco (EB only) (MP 202-205)**	**EJMT to Floyd Hill (MP 213-247)**	**Genesee (WB only) (MP 253-259)**
Wildlife and sensitive species	Mule deer, elk, bald eagle, river otter habitat; Linkage Interference Zone	Elk, deer, lynx, sheep	Lynx, boreal toad, songbird habitat; LIZ	Lynx, bighorn sheep, boreal toad, ptarmigan, songbird habitat; LIZ	Lynx, bald eagle, boreal toad, songbird habitat	Lynx, mule deer, bighorn sheep, elk, Preble's, bald eagle, boreal toad, ptarmigan habitat; LIZ	Mule deer habitat; LIZ
Wetlands	Wetlands present	Wetlands present	Wetlands present	Wetlands present	Wetlands present	Wetlands present	Wetlands present
Visual Resources	None	None	Representative views	Gateway Views	Gateway view	Gateway views, focal views, and representative views	Gateway views

Table 8. Resources Present in PEIS Preferred Alternative Areas of Improvement

Resource	PEIS Preferred Alternative Areas of Improvement						
	Wolcott (MP 155-156)	Avon **(MP** 167-168**)**	**Dowd Canyon (MP 170-173)**	**Vail Pass (MP 180-190)**	**Frisco (EB only) (MP 202-205)**	**EJMT to Floyd Hill (MP 213-247)**	**Genesee (WB only) (MP 253-259)**
Fisheries	None	Eagle River High Value Fishery	Gore Creek Gold Medal Fishery	Black Gore Creek (parallel to I-70) and other intersecting creek High Value Fisheries	None	Clear Creek High Value Fishery	None
Recreation Sites	Trails and recreation sites	Trails and recreation sites	Trails and recreation sites	Trails and recreation sites	Trails and recreation sites	Trails and recreation sites	Large recreation sites
Historic Resources (note: surveys not comprehensive)	Two nearby eligible bridges (5EA.198.1, 5EA.1614)	None	None	Two eligible bridges (5EA.727, 5EA.728)	None	Many eligible resources throughout alignment	One eligible bridge (5JF.398) and many eligible adjacent resources
Paleontological Resources	High sensitivity	High sensitivity	High sensitivity	High sensitivity	High sensitivity	Low sensitivity	Low sensitivity
Geological Hazards	Debris flow and landslide areas	Debris flow and landslide areas	Rockfall and landslide areas	Rockfall, landslide, and avalanche areas	Avalanche area	Rockfall, landslide, debris flow, mine subsidence, and avalanche areas	Rockfall areas

Source: Assembled from PEIS documentation

Figure 12. Resources Present Within PEIS Preferred Alternative Areas of Improvement



Source: Assembled from PEIS documentation

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Definitions

Advisory speed[i] – a speed below the speed limit that is recommended for a section of highway. The advisory speed is normally determined through an engineering study that considers highway design, operating characteristics, and conditions. Advisory speeds are displayed on warning signs in speed values that are multiples of 5 mph. Advisory speeds cannot be enforced.

Design speed[ii] – a selected speed used to determine the various geometric features of the roadway. The assumed design speed should be a logical one with respect to the topography, anticipated operating speed, the adjacent land use, and the functional classification of the highway. Design speed is different from the other controlling criteria in that it is a design control, rather than a specific design element. In other words, the selected design speed establishes the range of design values for many of the other geometric elements of the highway. Because of its effect on so much of a highway's design, the design speed is a fundamental and very important choice that a designer makes. The selected design speed should be high enough so that an appropriate regulatory speed limit will be less than or equal to it. Desirably, the speed at which drivers are operating comfortably will be close to the posted speed limit.

Horizontal alignment[ii] – … horizontal alignment refers only to the horizontal curvature of the roadway. The adopted design criteria specify a minimum radius for the selected design speed… Horizontal alignment influences another primary controlling criterion, stopping sight distance.

Inferred speed[i] – the maximum speed for which all critical design-speed-related criteria are met at a particular location.

Operating speed[i] – the speeds at which vehicles are observed operating during free flow conditions. Free flow speeds are those observed from vehicles whose operations are unimpeded by traffic control devices (e.g., traffic signals) or by other vehicles in the traffic stream. The 85th percentile of the distribution of observed speeds is the most frequently used measure of the operating speed.

Pace speed[iv] – the 10 mph range encompassing the greatest percentage of all the measured speeds in a spot speed study.

Posted speed[i] – one of two speed limit types (statutory speed is other type); the maximum lawful vehicle speed for a particular location as displayed on a regulatory sign. Posted speeds are displayed on regulatory signs in speed values that are multiples of 5 mph.

Prevailing speed[iii] – or 85th-Percentile Speed—the speed at or below which 85 percent of the motor vehicles travel.

Sight distance[ii] – the length along a roadway over which a driver has uninterrupted visibility – this is known as available sight distance. Different minimum sight distance design criteria exist for various operations and maneuvers, including stopping sight distance, passing sight distance and intersection sight distance.

Stopping sight distance[ii] – the distance needed for drivers to see an object on the roadway ahead and bring their vehicles to a safe stop before colliding with the object.

Variable speed limits – an intelligent transportation system strategy where by posted speed limits are changed in response to weather, congestion, or other conditions.

Vertical alignment[ii] – includes grade as well as vertical curvature (both crest and sag).

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[ii] FWHA. 2007. *Mitigation Strategies for Design Exceptions*. FHWA Office of Safety. FHWA-SA-07-011 William J. Stein, P.E., and Timothy R. Neuman, P.E. July.

[iii] FWHA. 2009a. *Manual on Uniform Traffic Control Devices for Streets and Highways.* FHWA Office of Safety.

[iv] FWHA. 2012b. *Methods and Practices for Setting Speed Limits: An Informational Report*. FHWA Office of Safety. FHWA-SA-12-004. Gerald J. Forbes, P.Eng., Teresa Gardner, P.E., Hugh McGee, P.E., Ph.D., Raghavan Srinivasan, Ph.D., April.

Appendix
Existing Design Speed Constraint Maps

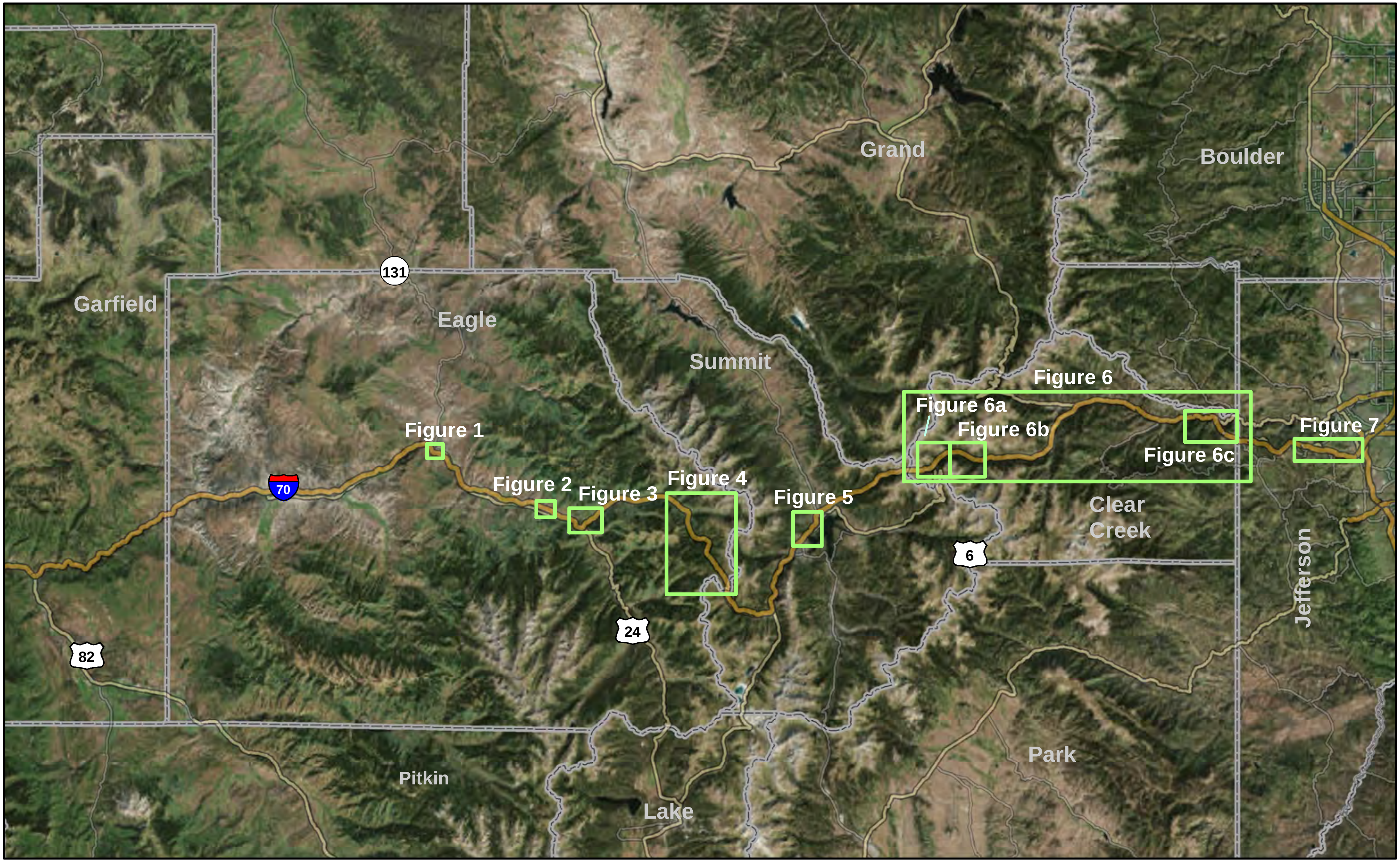


Figure 1 - West of Wolcott
Figure 2 - Avon
Figure 3 - Dowd Canyon
Figure 4 - West Side of Vail Pass
Figure 5 - Frisco to Silverthorne

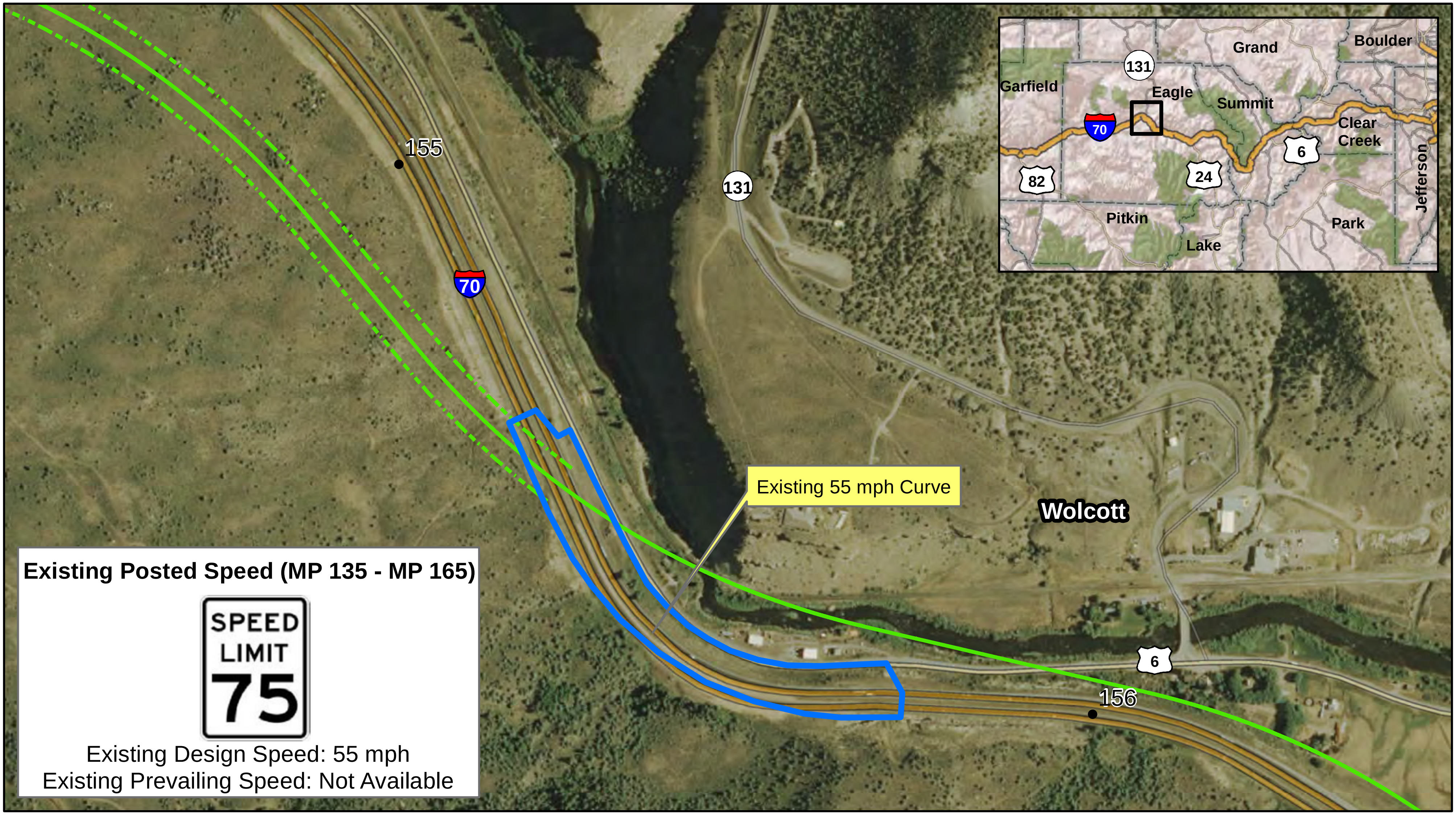
Figure 6 - MM 213 to 247
Figure 6a - EJMT to Herman Gulch
Figure 6b - Herman Gulch
Figure 6c - East of Twin Tunnels
Figure 7 - Morrison to Chief Hosa

N

0 7.5 15 22.5 30
Miles

Key Map

I-70 Design Speed Study



Legend

- 55 and 65 mph PEIS Alternative Footprints
- Existing Alignment
- AGS Hybrid Alignment
- AGS Tunnel Locations
- Mile Posts

Conditions

- Proposed curve safety modifications
- No distinguishing difference between PEIS alternatives
- Design speed of the curve less than surrounding highway

Figure 1
West of Wolcott
MM 155 to 156

I-70 Design Speed Study

DRAFT

N

0 500 1,000 1,500 2,000
Feet

Legend

- 55 and 65 mph PEIS Alternative Footprints
- Existing Alignment
- AGS Hybrid Alignment
- AGS Tunnel Locations
- Mile Posts

Conditions

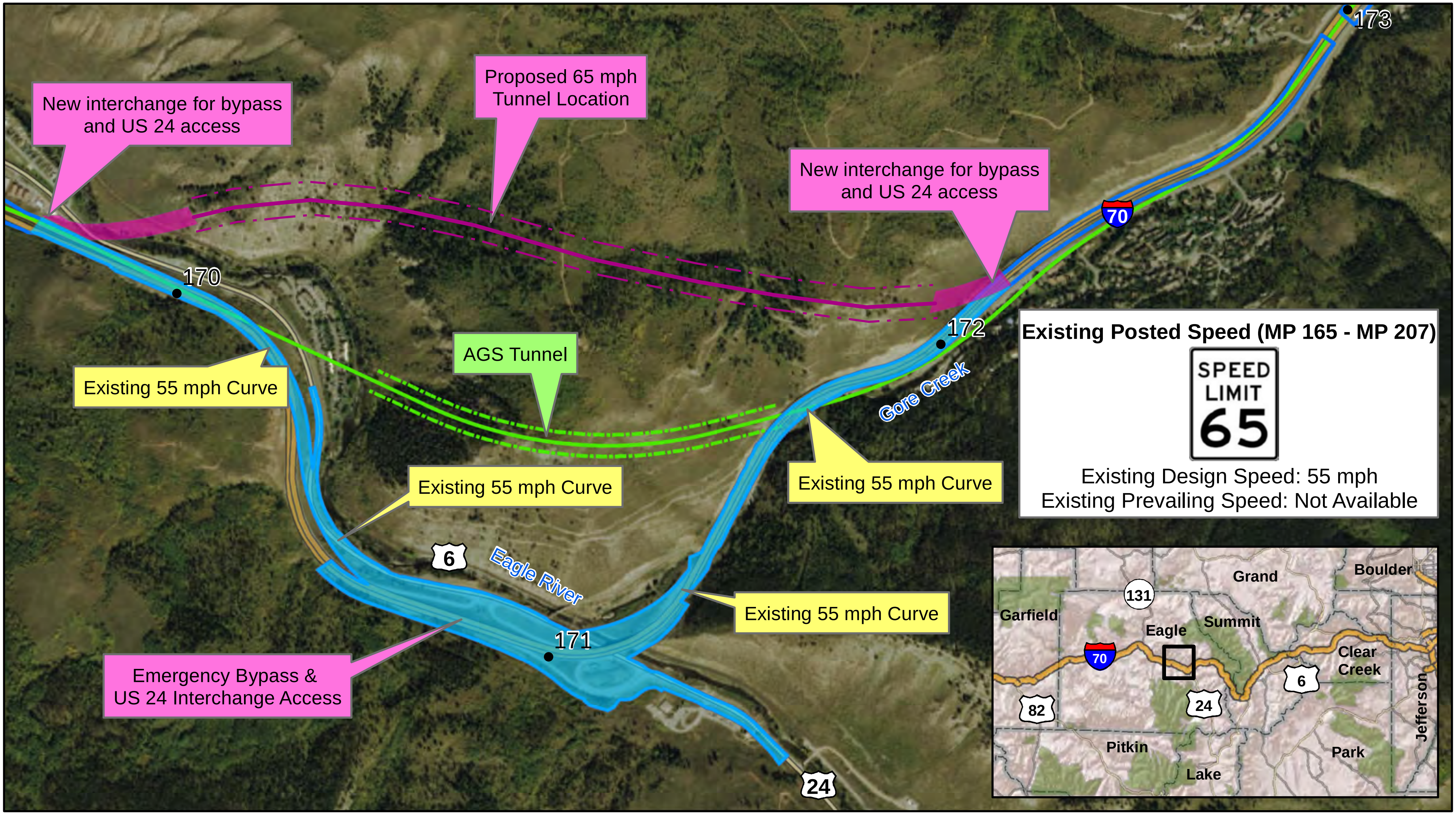
- Proposed EB (uphill) auxiliary lanes
- No distinguishing difference between PEIS alternatives

Figure 2
Avon
MM 167 to 168

N

I-70 Design Speed Study

0 500 1,000 1,500 2,000
Feet



Legend

- 55 and 65 mph PEIS Alternative Footprints
- Existing Alignment
- AGS Hybrid Alignment
- AGS Tunnel Locations
- Mile Posts
- 55 mph PEIS Alternative Footprint
- 65 mph PEIS Alignment Footprint
- 65 mph PEIS Alignment Tunnel

Conditions

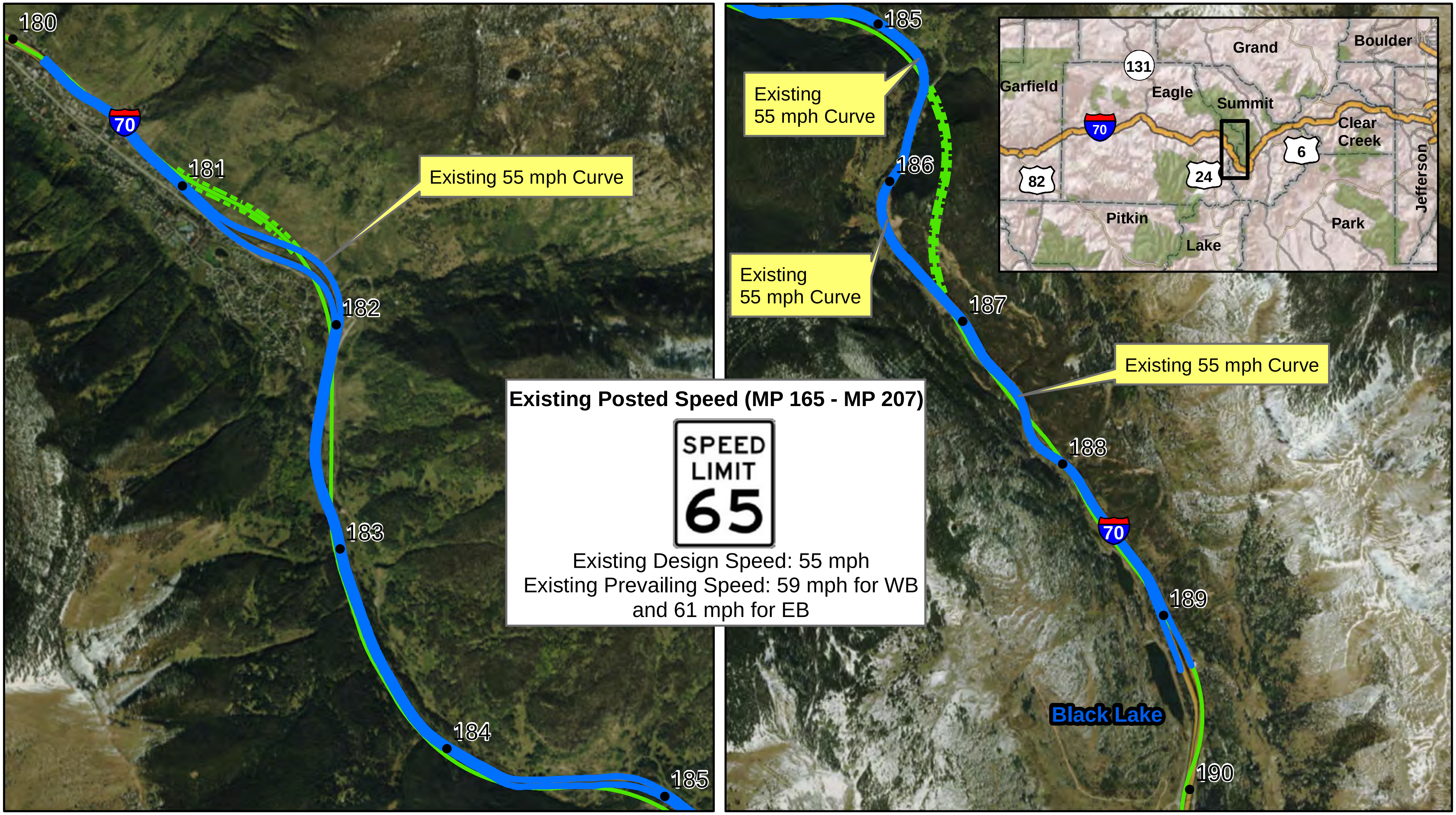
- Proposed Curve Safety Modifications
- Proposed Six Lane Highway Capacity
- 65 mph Proposed Tunnel Location
- Existing I-70 roadway to be used for emergency bypass and US 24 interchange access
- Design speed of the curve less than surrounding highway
- Additional footprint needed for interchanges, staging areas and tunnel waste disposal
- Assume the new bypass access is likely to be a split interchange

Dowd Canyon MM 170 to 173

N

I-70 Design Speed Study

0 750 1,500 2,250 3,000
Feet



Legend

- 55 and 65 mph PEIS Alternative Footprint
- Existing Alignment
- AGS Hybrid Alignment
- AGS Tunnel Locations
- Mile Posts

Conditions

- Steep grades MP 180 - MP 185
- Proposed EB (uphill) auxiliary lanes
- Proposed WB (downhill) auxiliary lanes
- No distinginguishable difference between PEIS alternatives

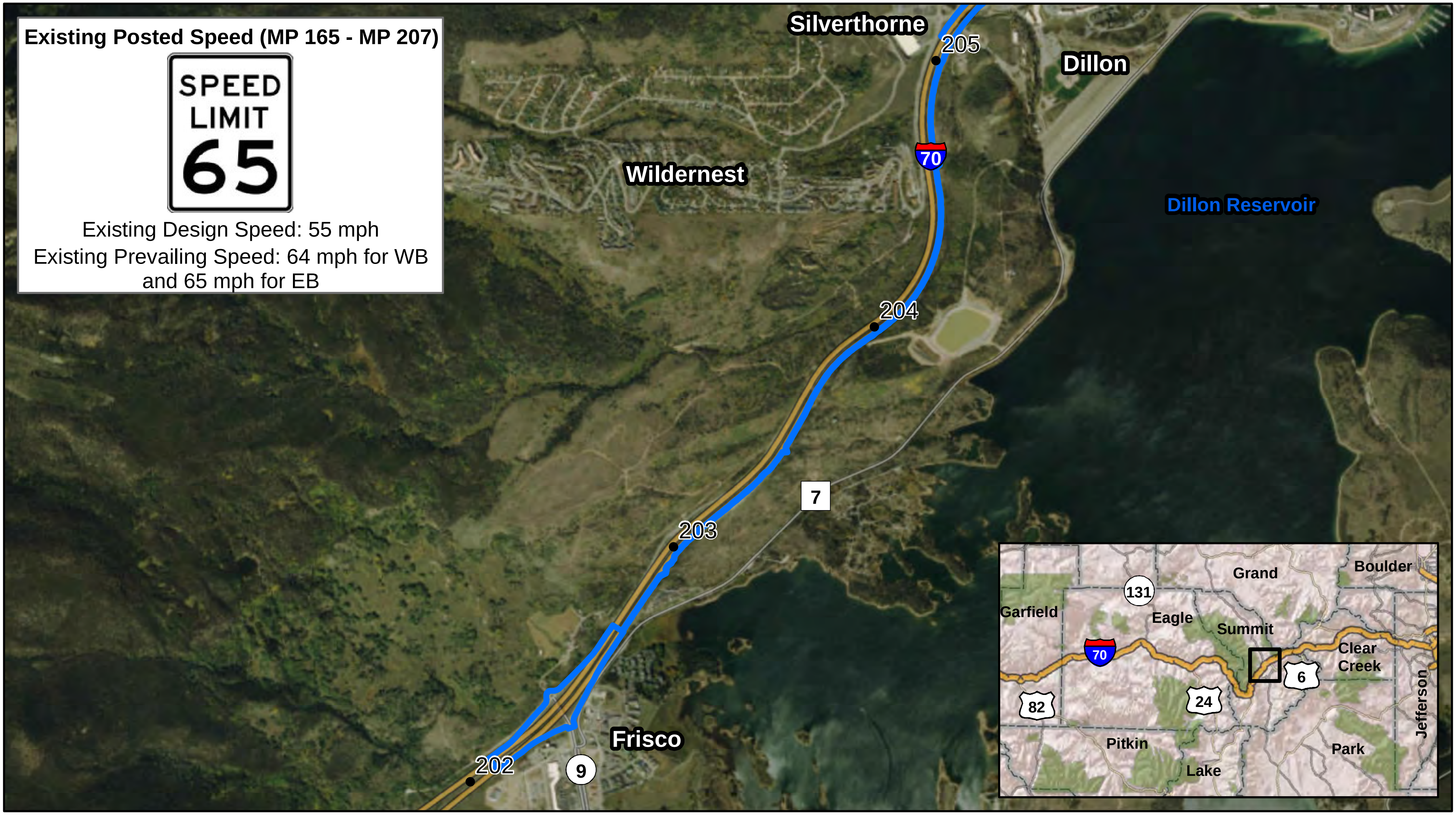
Figure 4
West Side of Vail Pass
MM 180 to 190

N

I-70 Design Speed Study

DRAFT

0 0.5 1 1.5 2
Miles



Legend

- 55 and 65 mph PEIS Alternative Footprint
- Existing Alignment
- Mile Posts

Conditions

- Steep Grade - MP 203 - MP 205
- EB auxiliary lanes
- No distinguishable difference between PEIS alternatives

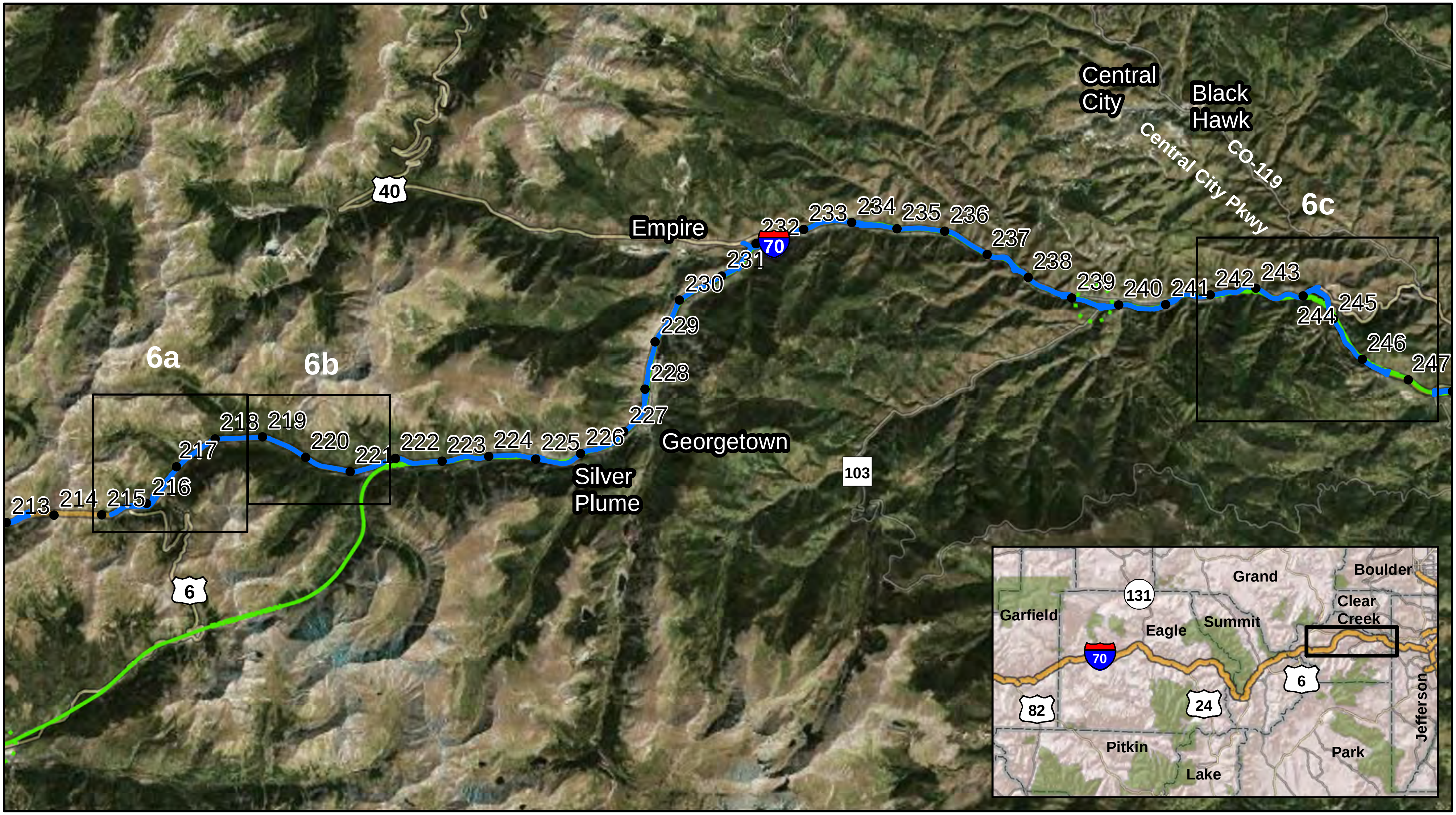
Figure 5
Frisco to Silverthorne MM 202 to 205

N

I-70 Design Speed Study

DRAFT

0 0.25 0.5 0.75 1
Miles



Legend

- 55 and 65 mph PEIS Alternative Footprints
- Existing Alignment
- AGS Hybrid Alignment
- AGS Station Location
- Mile Posts

Conditions

Mitigation/Design Exceptions

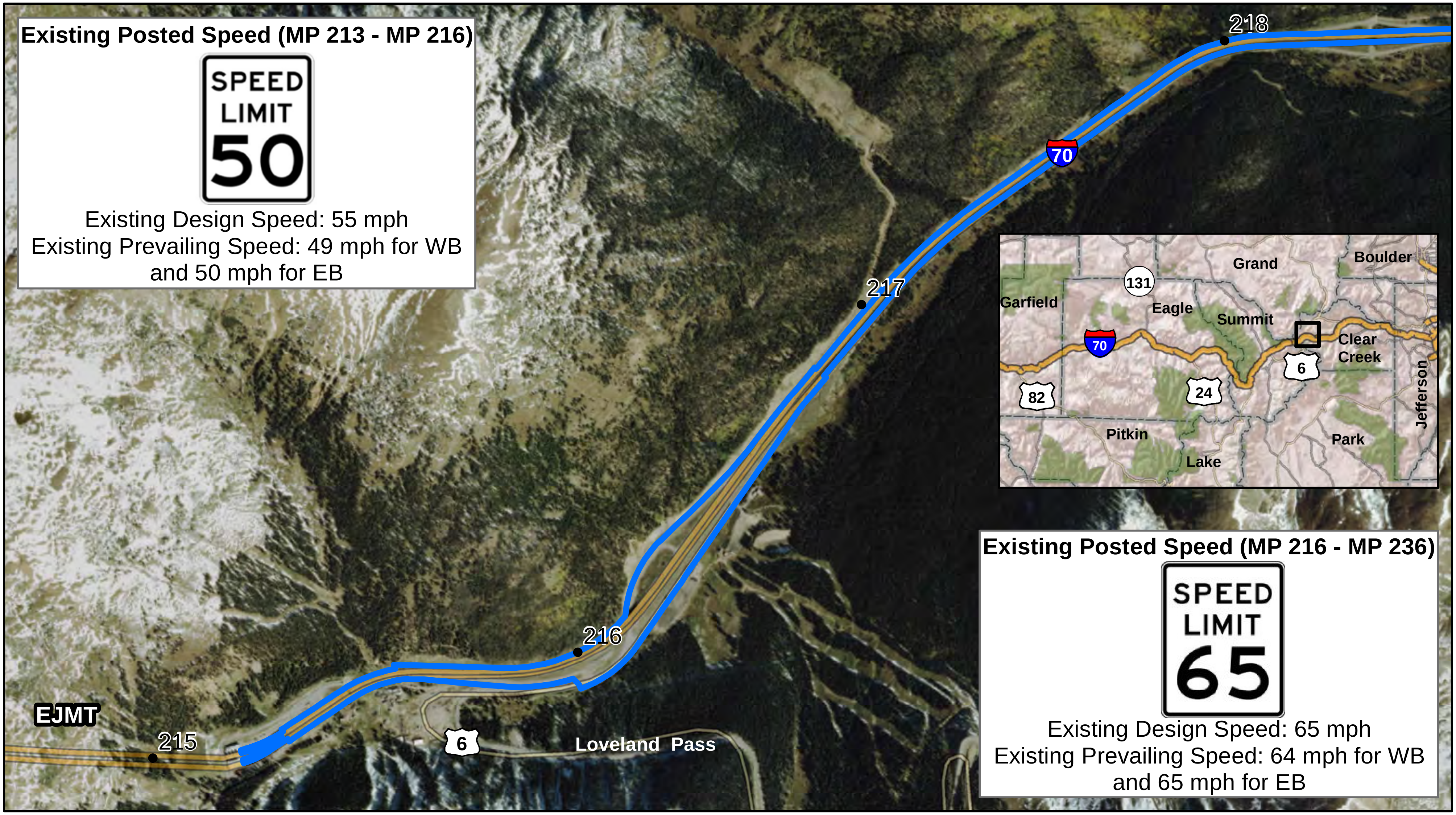
Figure 6
MM 213 to 247

I-70 Design Speed Study

DRAFT

N

0 2 4 6 8
Miles



Legend

- 55 and 65 mph PEIS Alternative Footprint
- Existing Alignment
- Mile Posts

Conditions

- Steep grade MP 215 - MP 216
- Proposed EJMT third bore
- Proposed EB and WB auxiliary lanes
- No distinguishable difference between PEIS alternatives

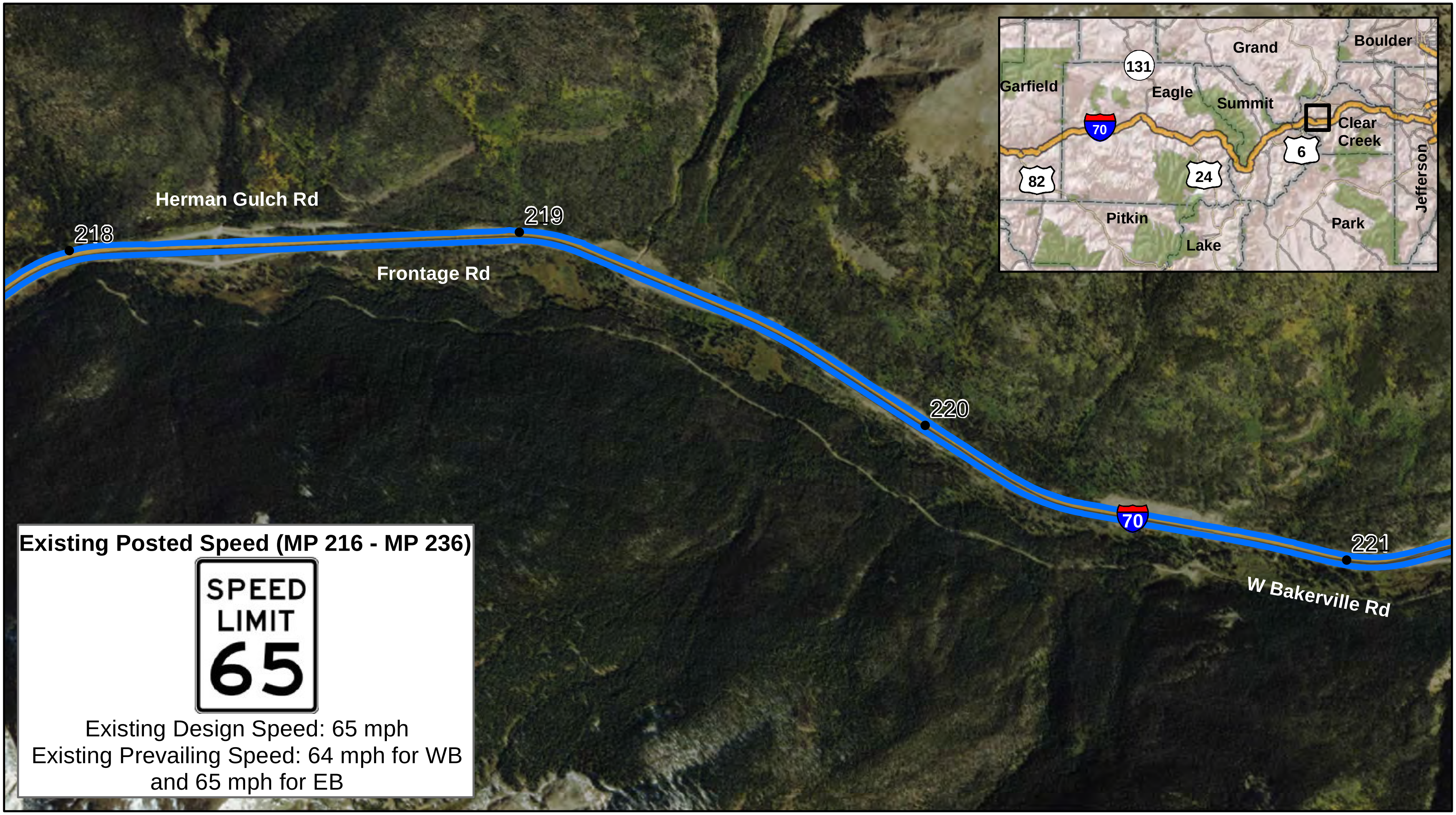
Figure 6a
EJMT to Herman Gulch
MM 215 to 218

N

I-70 Design Speed Study

DRAFT

0 1,000 2,000 3,000 4,000
Feet



Legend

- 55 and 65 mph PEIS Alternative Footprint
- Existing Alignment
- Mile Posts

Conditions

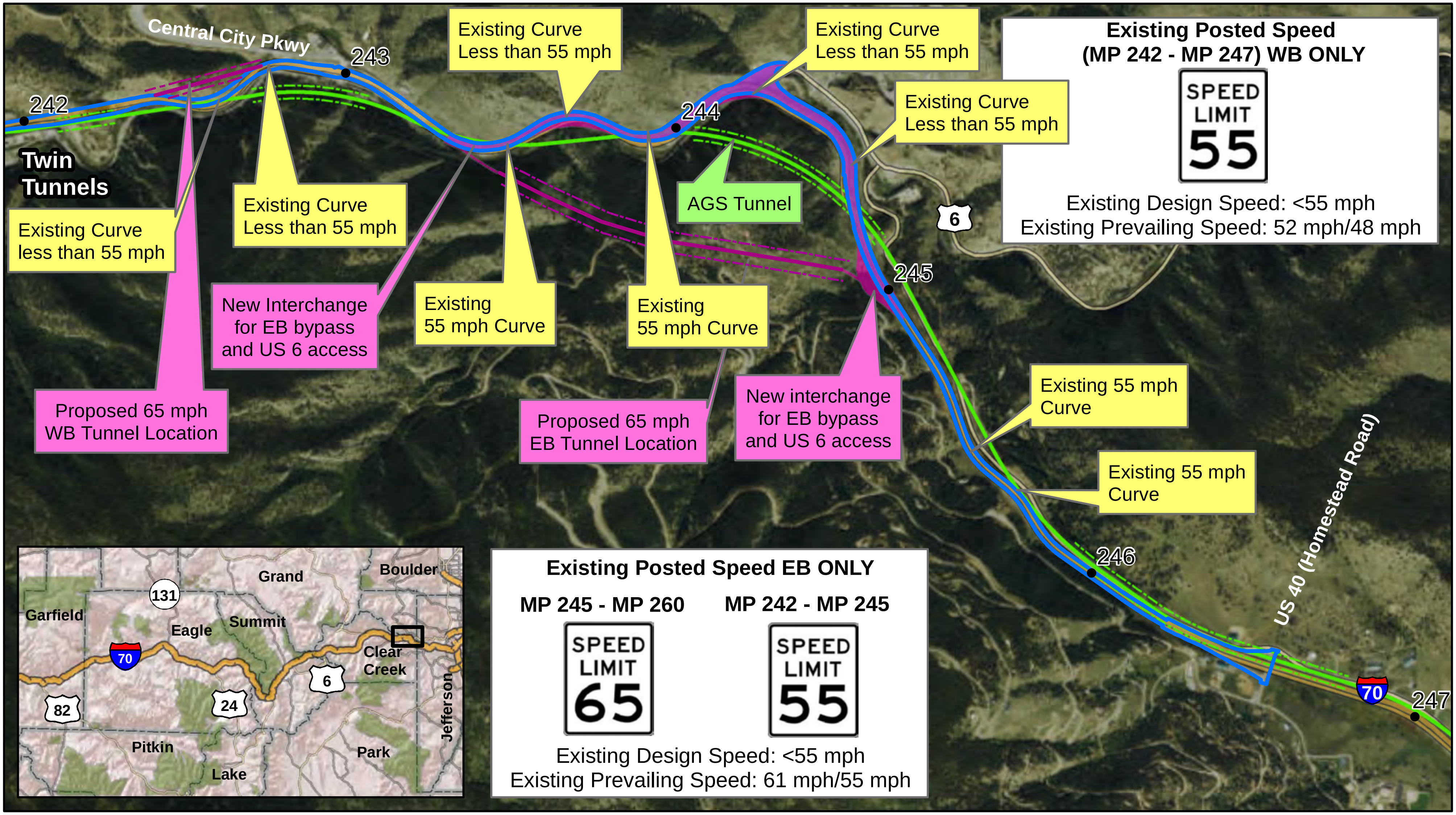
- Proposed WB auxiliary lane
- No distinguishable difference between PEIS alternatives

Figure 6b
Herman Gulch to Bakerville MM 218 to 221

I-70 Design Speed Study

N

0 1,000 2,000 3,000 4,000
Feet



Legend

- 55 and 65 mph PEIS Alternative Footprints
- Existing Alignment
- AGS Hybrid Alignment
- AGS Tunnel Locations
- Mile Posts
- 55 mph PEIS Alternative Footprint
- 65 mph PEIS Alignment Footprint
- 65 mph PEIS Alignment Tunnel

Conditions

- Proposed six-lane highway with bike trail and frontage roads
- Proposed curve safety modifications
- 65 mph Proposed Floyd Hill Tunnel (EB only)
- Existing I-70 roadway to be used for EB emergency bypass and US 6 interchange access
- Design speed of some curves less than the surrounding highway
- Additional footprint needed for interchanges, staging areas and tunnel waste disposal
- Assume the new bypass access is likely to be a split interchange

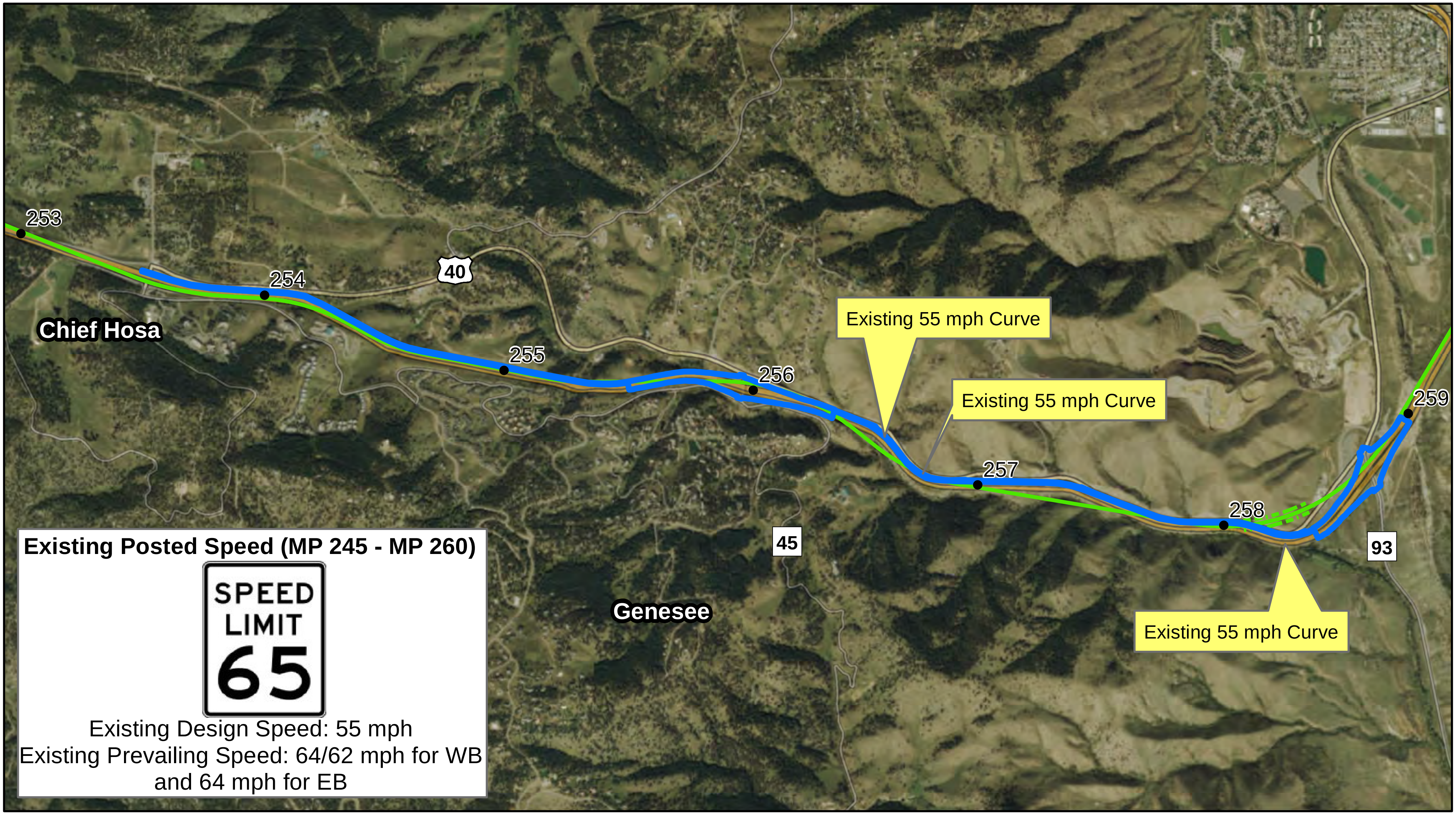
East of Twin Tunnels MM 242 to 247

N

I-70 Design Speed Study

DRAFT

0 0.25 0.5 0.75 1
Miles



Legend

- 55 and 65 mph PEIS Alternative Footprint
- Existing Alignment
- AGS Hybrid Alignment
- AGS Tunnel Locations
- Mile Posts

Conditions

- Steep grade MP 252 - MP 254
- Proposed WB (uphill) auxiliary lanes
- No distinguishable difference between PEIS alternatives

Figure 7
Morrison to Chief Hosa
MM 253 to 259

N

I-70 Design Speed Study

DRAFT

0 0.25 0.5 0.75 1
Miles