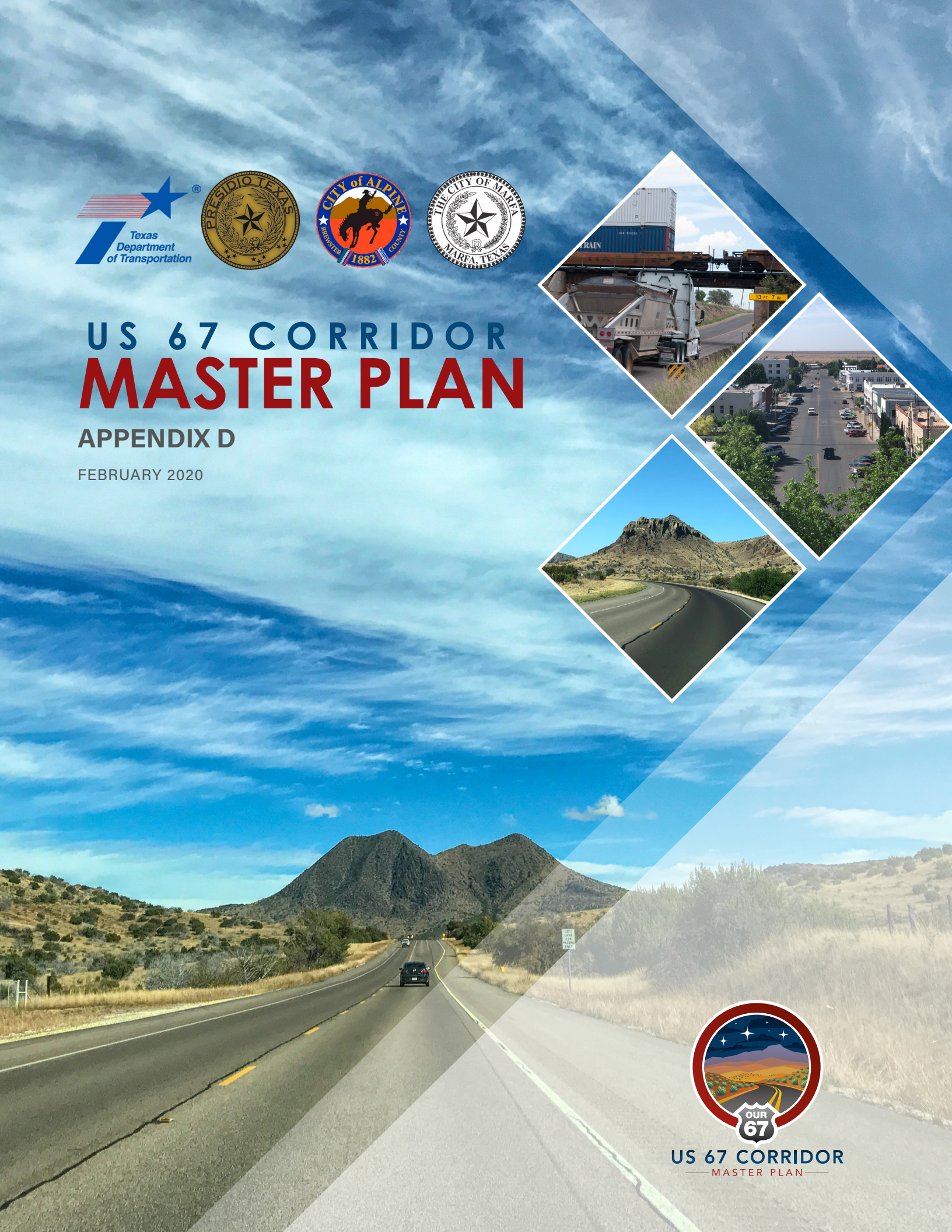
US 67 CORRIDOR MASTER PLAN

APPENDIX D

FEBRUARY 2020



US 67 CORRIDOR
MASTER PLAN

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Memorandum

To: *Rebecca Reyes, TxDOT Project Manager*
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From: *CDM Smith*

Date: *February 2020*

Subject: *US 67 Corridor Master Plan Safety Analysis Technical Memorandum*

Table of Contents

1.0 Introduction 1

2.0 Literature Review and Data Sources 2

2.1 TxDOT Crash Records Information System Database 2
2.2 Federal Highway Administration Highway Safety Improvement Program 3
2.3 2017-2022 Texas Strategic Highway Safety Plan 3
2.4 Federal Highway Administration Systemic Approach to Safety 3

3.0 Methodology 4

4.0 Traditional Safety Analysis 5

4.1 Crash Types 8
4.2 Crashes by Severity 8
4.3 Crash Type by Severity 9
4.4 Crashes by Location 11
4.5 Bicycle and Pedestrian Crashes 12
4.6 Other Crashes: Animal-on-Road, Commercial Motor Vehicle, Train, and Unrestrained Driver/Passenger 13
4.7 Comparison of US 67 Study Corridor to Texas Crash Data 16
4.8 Key Conclusions of Traditional Safety Analysis 18

5.0 Federal Highway Administration Systemic Approach to Safety 18

5.1 Step 1: Identify Focus Crash Types and Risk Factors 19
5.1.1 Identify focus crash types 19
5.1.2 Disaggregate focus crash types by facility 21
5.1.3 Identify potential risk factors 22
5.2 Step 2: Evaluate Risk Factors and Prioritize Candidate Locations 24
5.2.1 Segments outside the communities 25
5.2.2 Horizontal curves outside the communities 31
5.2.3 Intersections and interchanges outside the communities 34
5.2.4 Intersections within communities 36

5.3 Step 3: Select Potential Countermeasures....39
5.4 Step 4: Develop Projects....45
5.4.1 Projects approved by TxDOT....45
5.4.2 Safety analysis recommendations....46
6.0 Predictive Safety Analysis 51
6.1 HSM Analysis Tools....52
6.2 IHSDM Analysis on Freeway Segments....52
6.2.1 Modeling input....52
6.2.2 Available countermeasures....53
6.2.3 Results....53
6.3 ISATe Analysis on US 67 and I-10 Interchange....56
7.0 Benefit-Cost Analysis 57
7.1 Methodology and Assumptions....57
7.1.1 Methodology....57
7.1.2 Scenario Assumptions....58
7.1.3 Cost Assumptions....60
7.1.4 Benefit Assumptions....61
7.2 Results....63
8.0 Conclusion 64

List of Tables

Table 1: Crash Types 8
Table 2: Crash Types by Severity 9
Table 3: Crashes by Location 12
Table 4: Pedestrian and Bicycle Crashes 12
Table 5: Other Crashes 16
Table 6: US 67 Rural and Texas Statewide Rural Crash Rates 16
Table 7: Fatal and Severe Injury Crashes by Emphasis Area 20
Table 8: Sample of Potential Risk Factors for Focus Crash Types 22
Table 9: Potential Risk Factors for Roadway Departure and On-Curve Crashes 23
Table 10: Roadway Departure Crash Density 25
Table 11: Severe Roadway Departure Crash Rate vs. Clear Zone 28
Table 12: Severe Roadway Departure Crash Rate vs. Pavement Condition 30
Table 13: Severe Roadway Departure Crash Rate vs. In-the-Dark Crashes 30
Table 14: Prioritization of Segments Outside the Communities 31
Table 15: Intersection/Interchange outside of the Communities Risk Factor Score Summary 34
Table 16: Severe Crashes by Community 36
Table 17: Driver Behavior Factors by Urban Area 36
Table 18: Intersections Within Communities Score Summary 37
Table 19: Countermeasures-Advantages and Disadvantages to prevent roadway departure 40
Table 20: Horizontal Curve Countermeasures Criteria 48
Table 21: At-Risk Intersections and Type of Improvement 50
Table 22: Countermeasures Applied to Respective Sections 55
Table 23: Roadway Characteristics 59
Table 24: Safety Improvement Types by Segment 59
Table 25: Unit Cost Assumptions 60
Table 26: Total Cost Assumptions (millions) 61
Table 27: Baseline Crashes 2010-2018 62
Table 28: IHDSM Crash Reduction Estimates 62
Table 29: FHWA Cost per Crash Assumptions 63
Table 30: Crash Benefits Summary (2020-2045 Total) 63
Table 31: BCR Results Summary 64

List of Figures

Figure 1: US 67 Corridor Master Plan Study Corridor 2
Figure 2: Total Crashes by Year 6
Figure 3: Crash Density Map for All Crashes 7
Figure 4: Crashes by Severity 9
Figure 5: Crash Types vs. Crash Severity 10
Figure 6: US 67 Study Corridor Control Sections 11
Figure 7: Pedestrian and Bicycle Crashes in Marfa and Alpine 13
Figure 8: Animal Crashes 14
Figure 9: Commercial Motor Vehicle Crashes 15
Figure 10: Comparison of Average Crash Rate by Control Section 17
Figure 11: Crash Tree of Severe Crashes 21
Figure 12: Roadway Departure Crashes and Roadway Mileage vs. AADT 26
Figure 13: Roadway Departure Crashes on Curves and Straight Segments 27
Figure 14: Roadway Departure Crashes on Curves with Radius Less and Greater than 1,800 Feet 27
Figure 15: Rural Severe Crashes by Truck Volume Percentage 29
Figure 16: Curves with Superelevation Deficiency (emax of 8 Percent methodology) 33
Figure 17: Intersections and interchanges outside of the communities 35
Figure 18: At Risk Intersections 51
Figure 19: Observed versus Predicted Crashes Per Mile for Years 2010 to 2017 54
Figure 20: Predicted Crashes for No-build and Build Scenarios for years 2020-2045 55
Figure 21: US 67 and I-10 Interchange Components 56

1.0 Introduction

The purpose of this technical memorandum is to present the results of the safety analysis of the US 67 study corridor. This safety analysis includes a review of the state and national plans and policies that guided this process, the methodologies used to conduct multiple types of safety analysis and predictive safety analysis, the development of an implementation plan for identified safety projects, and a benefit-cost analysis.

The US 67 study corridor stretches 142 miles from Interstate 10 (I-10) west of Fort Stockton to the Presidio/Ojinaga Port of Entry (POE) on the United States/Mexico border. US 67 provides access to the towns of Alpine, Marfa, Presidio, and surrounding communities, as well as Big Bend National Park, Sul Ross State University, the Marfa Lights, Big Bend Ranch State Park, Fort Leaton State Park, and Fort Davis attractions. This rural area has experienced traffic growth in recent years driven by many factors, including tourism growth, international commerce, and Permian Basin oil field development. TxDOT, in consultation with local communities, is developing the US 67 Corridor Master Plan in response to these trends to help determine the current and future transportation needs along US 67. **Figure 1** shows the study corridor.

The safety analysis includes Business Route US 67 in Presidio. The study corridor is within two TxDOT Districts (Odessa and El Paso), three counties (Pecos, Brewster, and Presidio), and passes through three communities – Alpine, Marfa, and Presidio. Traffic data for the study corridor was collected in October 2017 and November 2017, and the data showed that outside of the three communities, the US 67 study corridor served 1,700 to 4,000 vehicles daily during the average weekday based on volume and classification counts with trucks accounting for between 6.2 and 8.4 percent of the total daily volume. However, within Presidio near the POE, the daily volume was 4,200 vehicles with commercial trucks accounting for 2.8 percent of the total traffic.

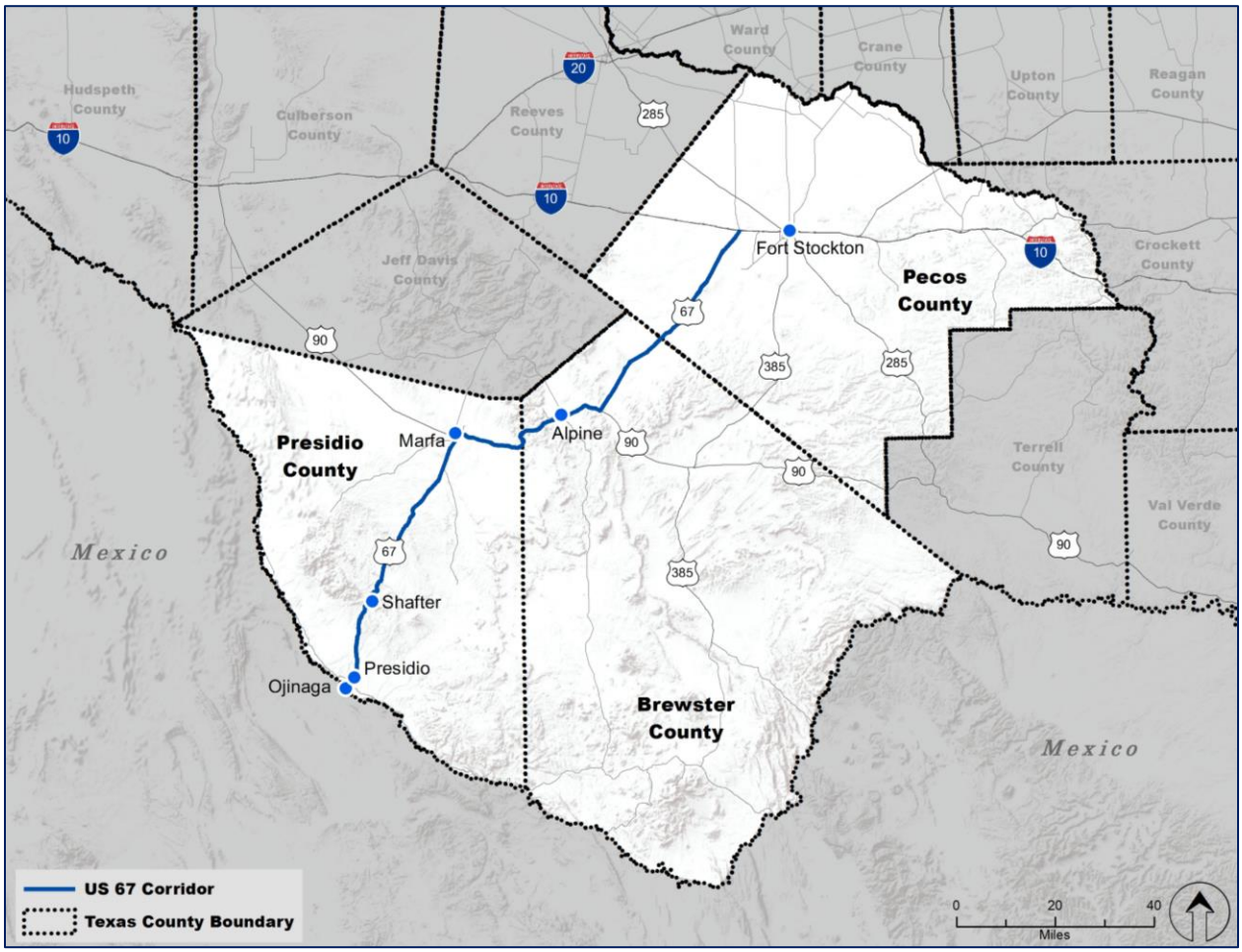


Figure 1: US 67 Corridor Master Plan Study Corridor

2.0 Literature Review and Data Sources

2.1 TxDOT Crash Records Information System Database

This safety analysis relied on TxDOT Crash Records Information System (CRIS)[1] data to understand safety trends and safety concerns along US 67. The CRIS Database contains nine years of crash records from 2010 to 2018 with various tables that include parameters such as crash types, number of vehicles, driver information, and vehicle characteristics. These individual crash tables were combined into a master crash database for the corridor safety analysis.

[1] Crash Records Information System: https://cris.dot.state.tx.us/public/Query/app/welcome

2.2 Federal Highway Administration Highway Safety Improvement Program

The Federal Highway Administration (FHWA) Highway Safety Improvement Program (HSIP) aims to achieve a significant reduction in traffic fatalities and serious injuries on all public roads and is built on a data-driven, strategic approach to improving highway safety. The HSIP is legislated under Section 148 of Title 23, *United States Code* (23 U.S.C. 148) and regulated under Part 924 of Title 23, Code of Federal Regulations (23 CFR Part 924). This program has three main components:

- Strategic Highway Safety Plan (SHSP): This is a statewide safety plan that provides a comprehensive framework for reducing highway fatalities and serious injuries on all public roads.
- State Highway Safety Improvement Program: This is the program of projects, activities, and reports. TxDOT has developed its State SHSP under this program in accordance with FHWA guidance.
- Railway-Highway Crossing Program: This provides funds for the elimination of hazards at rail-highway crossings.

2.3 2017-2022 Texas Strategic Highway Safety Plan

The 2017-2022 Texas SHSP provides insight on crash types and crash factors throughout the safety analysis process. The SHSP has a vision of zero deaths on the state's roadways and focuses on seven emphasis areas proven to have the greatest potential to reduce highway fatalities and serious injuries:

- Distracted Driving
- Impaired Driving
- Intersection Safety
- Older Road Users
- Pedestrian Safety
- Roadway and Lane Departures
- Speeding

VISION

TEXAS ENVISIONS A FUTURE WITH ZERO TRAFFIC FATALITIES AND SERIOUS INJURIES

2017-2022 Texas Strategic Highway Safety Plan

Additional details and evaluation of the Texas SHSP emphasis areas are discussed in **Section 5.1.1**.

2.4 Federal Highway Administration Systemic Approach to Safety

Traditional highway safety studies identify countermeasures for specific hot spot crash locations. FHWA also provides guidance to states wishing to conduct systemic safety analyses. In the systemic approach, the decision-making process does not only identify countermeasures for hot spot crash locations but also considers multiple locations with similar risk characteristics, selecting the

preferred countermeasures for widespread implementation. The FHWA Office of Safety website[2] provides the most up-to-date information on the systemic safety process, application suggestions, and case studies of the process being implemented.

The FHWA Office of Safety website lists several states and counties that are using the systemic approach to safety and achieving positive results which include: Illinois, Kentucky, Louisiana, Minnesota, Missouri, Nebraska, New York, Ohio, and Thurston County, Washington. The Minnesota Department of Transportation's Application of the Systemic Safety Planning Process was used as a reference for the US 67 safety analysis.

The Minnesota DOT County Road Safety Plans case study provided a sample methodology for risk factor identification using the available corridor crash data and the prioritization of locations for safety investment. In addition, the case study provided examples of ways to display the complex analysis results in the form of tables, charts, and graphics.

3.0 Methodology

The study team downloaded data from the TxDOT CRIS Database. These data tables provided information about crashes and their associated conditions, as well as vehicle characteristics and driver information. This data was used as the foundation of the safety analysis which is divided into the following five sections:

Section 4.0, Traditional Safety Analysis, includes the evaluation of all the crash data for a number of crashes, crash types, crash severity, crash rates, crash locations, lighting condition, and crashes involving animals, bicycles, pedestrians and other crash characteristics. This analysis provides a corridor level review for all crashes for nine years (2010–2018) of data.

Section 5.0, FHWA Systemic Approach to Safety, focuses on the most severe crashes (non-incapacitating, incapacitating, and fatal). This approach only evaluates the most severe crashes and focuses on the data in an effort to address the root cause of each severe crash and then apply appropriate countermeasures. There are four steps to the systemic approach to safety:

- **Step 1: Identify Focus Crash Types and Risk Factors** – The study team analyzed the data using the seven Texas SHSP emphasis areas and input from the local TxDOT experts. The analysis identified the most severe crash types in the corridor and their location. Next, the risk factors were identified based on the observed roadway and traffic characteristics associated with the crash locations.
- **Step 2: Evaluate Risk Factors and Prioritize Candidate Locations** – The analysis identified the US 67 study corridor at-risk segments based on the total number of risk factors present.

[2] FHWA Office of Safety website: https://safety.fhwa.dot.gov/

- **Step 3: Select Potential Countermeasures** – In coordination with TxDOT staff, the study team selected countermeasures that are specific to the crash type and risk factors from the previous steps.
- **Step 4: Develop Projects** – The study team developed a list of short-, mid-, and long-term projects to implement the countermeasures selected in Step 3 above.

Section 6.0, Predictive Safety Analysis, assesses the safety improvements for selected geometric countermeasures using Highway Safety Manual (HSM) based Interactive Highway Safety Design Model (IHSDM) and Enhanced Interchange Safety Analysis Tool (ISATe) for high-risk locations. The purpose of this predictive analysis is to forecast the number of crashes by severity and type for existing scenarios and future No-build and Build scenarios.

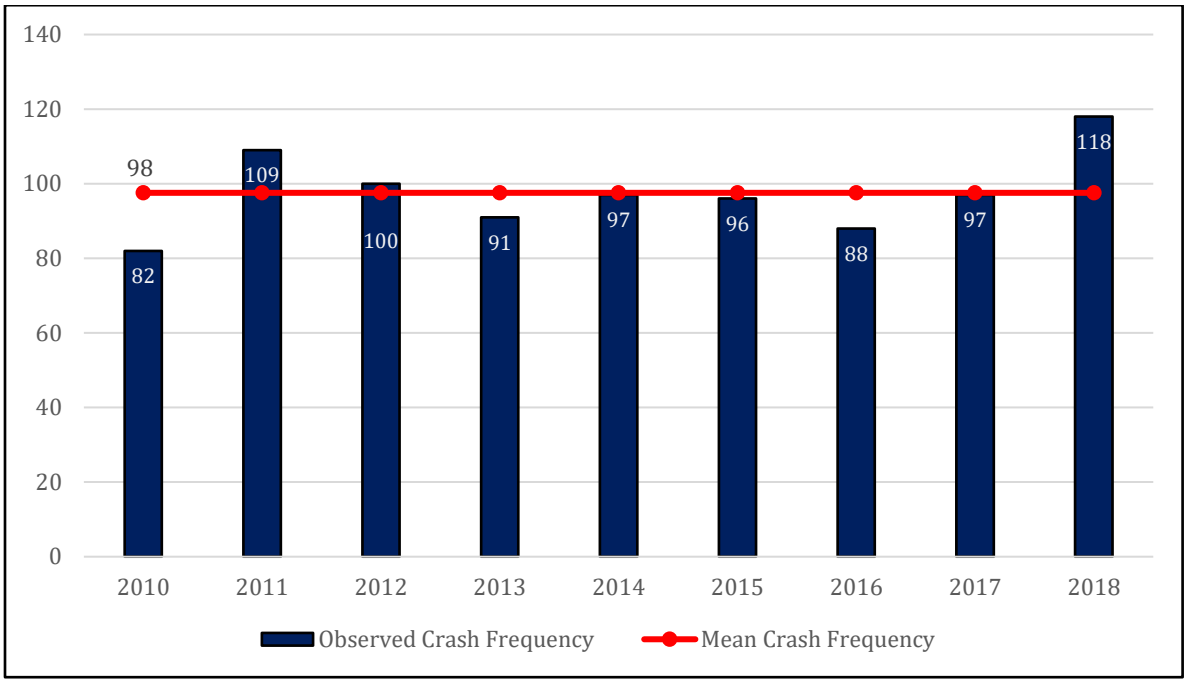
Section 7.0, Benefit-Cost Analysis, evaluates the safety benefits and costs of the geometric countermeasures for high-risk segments.

Section 8.0, Conclusions, provides a summary of the key findings of this technical memorandum.

4.0 Traditional Safety Analysis

The study team also conducted a traditional safety analysis that focused on identifying specific locations with a history of crash clusters, often known as hotspots. The analysis evaluated all crashes by time, location, type, and severity.

Over the nine years of crash data, there were 878 crashes with the most crashes (118) occurring in 2018. The year-by-year crashes on the US 67 study corridor are shown in **Figure 2**.

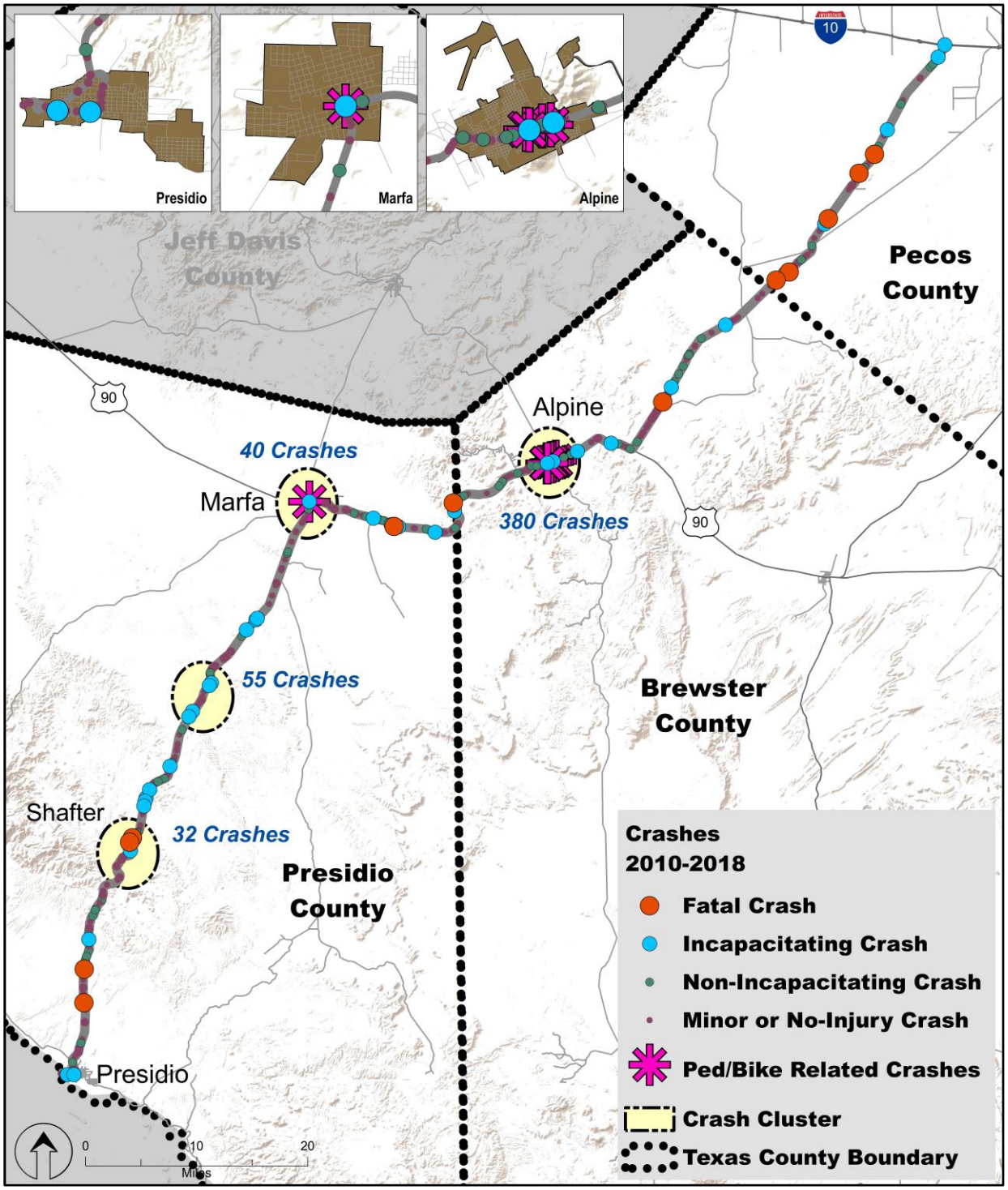


Source: TxDOT Crash Records Information System, 2010-2018

Figure 2: Total Crashes by Year

The data revealed that over 88 percent of the crashes occurred in clear or cloudy weather conditions. In addition, the roadway surface was dry during 86 percent of the crashes. Sixty-five percent of the crashes happened during daylight. Nearly 59 percent of the crashes were non-intersection crashes.

Figure 3 shows a density map of all US 67 study corridor crashes. Crashes within the Alpine, Marfa, and Presidio communities account for 49 percent of the crashes. There are also crash clusters in areas between the communities, mainly between Presidio and Marfa.



Source: TxDOT Crash Records Information System, 2010-2018

Figure 3: Crash Density Map for All Crashes

4.1 Crash Types

The top crash types are noted in **Table 1**. More than half of the crashes involved a single motor vehicle leaving the roadway.

Table 1: Crash Types

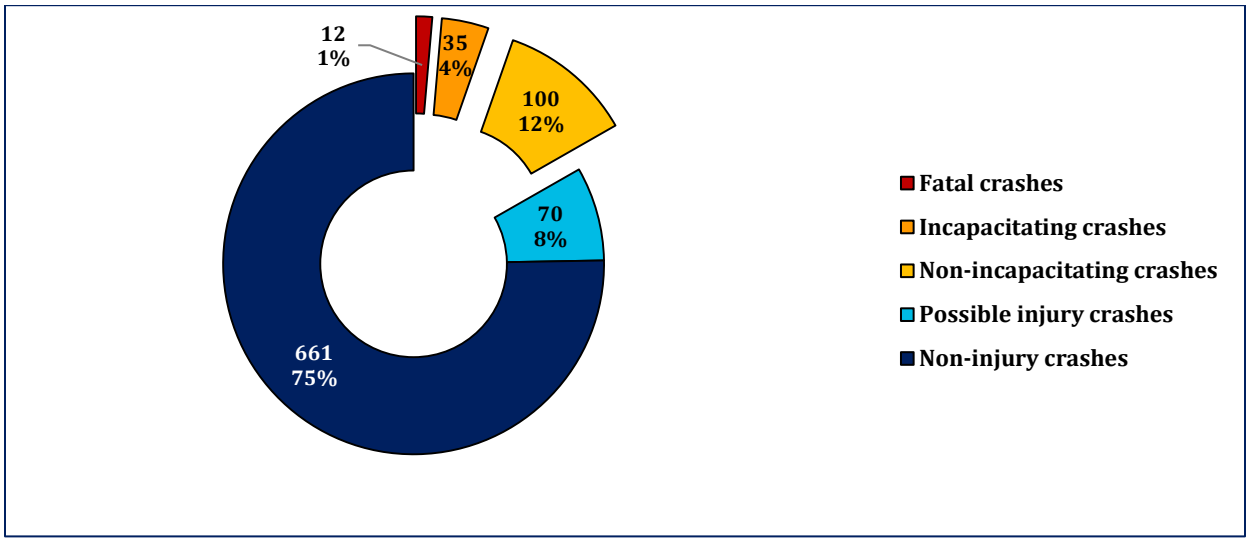
Crash Type	Number of Crashes	Percent
One Motor Vehicle – Roadway Departure	478	55%
Same Direction - One Straight-One Left Turn	102	12%
Angle – Both Going Straight	78	9%
Same Direction - Both Going Straight - Sideswipe	56	6%
Same Direction - One Straight - One Stopped	38	4%
Angle - One Straight-One Left Turn	27	3%
Opposite Direction - One Straight-One Left Turn	25	3%
Opposite Direction - Head-on	20	2%
Same Direction - Both Going Straight -Rear End	20	2%
All Other Types	34	4%
Total	878	100%

Source: TxDOT Crash Records Information System, 2010-2018

4.2 Crashes by Severity

Crash severity is categorized as non-injury, possible injury, non-incapacitating injury, incapacitating injury, and fatal crashes. Non-incapacitating injuries are injuries that are evident to observers at the crash scene; however, the person is able to return to his or her normal activities. An example of a non-incapacitating injury is a broken bone. Incapacitating injuries are severe injuries that prevent the person from walking, driving, or continuing the normal activities he or she was capable of prior to the injury.

For this analysis, no injury and possible injury crashes are termed “non-severe crashes”. The other injury type crashes are termed “severe crashes”. During the 9 years of crash data, there were 731 (83 percent) non-severe crashes and 147 (17 percent) severe crashes along the study corridor. Of the severe crashes, 100 were non-incapacitating injury crashes, 35 were incapacitating injury crashes, and 12 were fatal crashes. The non-incapacitating and incapacitating crashes resulted in 343 people with injuries and the 12 fatal crashes resulted in 15 fatalities. The crash severities are displayed in **Figure 4**.



Source: TxDOT Crash Records Information System, 2010-2018

Figure 4: Crashes by Severity

4.3 Crash Type by Severity

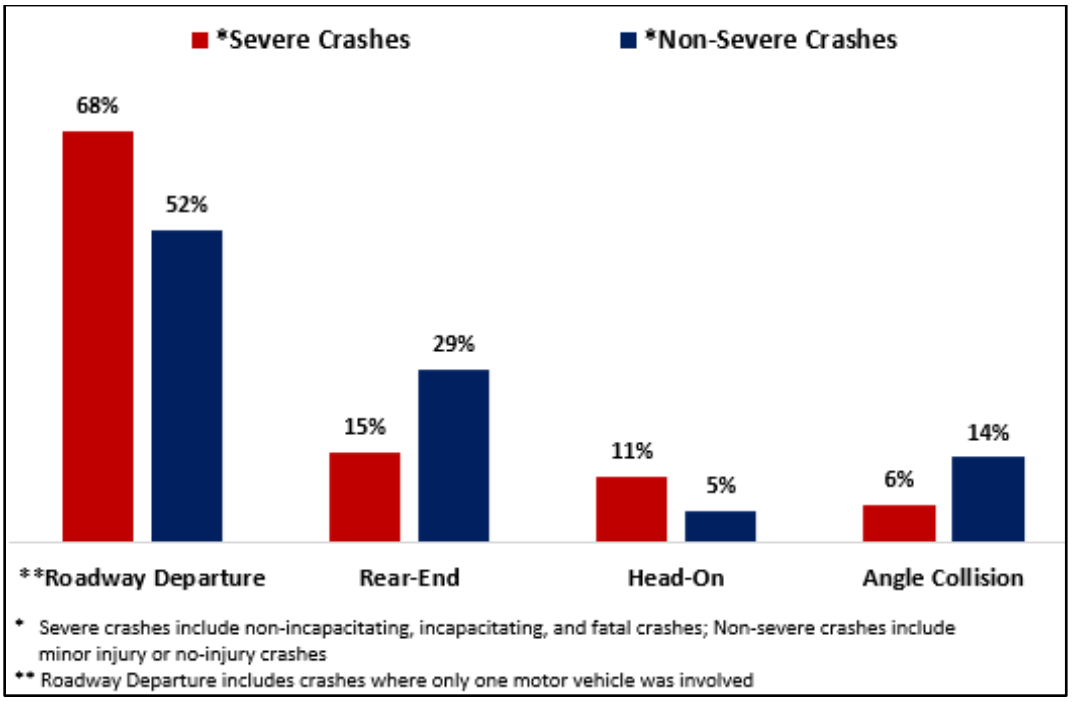
As seen in **Table 2**, from 2010 to 2018, all fatal crashes on the US 67 study corridor were roadway departure and head-on crashes. Roadway departure is the leading crash type accounting for 68 percent of the severe crashes (non-incapacitating, incapacitating, and fatal crashes).

Table 2: Crash Types by Severity

Crash Type	Number of Crashes	Non-incapacitating Crashes	Incapacitating Crashes	Fatal Crashes
One Motor Vehicle – Roadway Departure	478	64	28	8
Same Direction - One Straight-One Left Turn	102	9	0	0
Angle – Both Going Straight	78	6	1	0
Same Direction - Both Going Straight - Sideswipe	56	2	0	0
Same Direction - One Straight - One Stopped	38	7	0	0
Angle - One Straight-One Left Turn	27	1	1	0
Opposite Direction - One Straight-One Left Turn	25	1	2	0
Opposite Direction - Head-on	20	7	2	4
Same Direction - Both Going Straight -Rear End	20	2	1	0
All Other Types	34	1	0	0
Total	878 (100%)	100 (11.4%)	35 (4.0%)	12 (1.4%)

Source: TxDOT Crash Records Information System, 2010-2018

Figure 5 combines the crash types into four categories: roadway departure, rear-end, head-on, and angle collisions. The four crash categories are summarized to demonstrate their percentage relative to the total number of severe (non-incapacitating, incapacitating, and fatal) and non-severe crashes (non-injury and possible injury). Roadway departure crashes account for 52 percent of the non-severe crashes but account for 68 percent of the severe crashes. Similarly, head-on crashes account for 5 percent of the non-severe crashes, but they account for 11 percent of the severe crashes. Thus, roadway departure and head-on crash types tend to have higher severities when they occur.



Source: TxDOT Crash Records Information System, 2010-2018

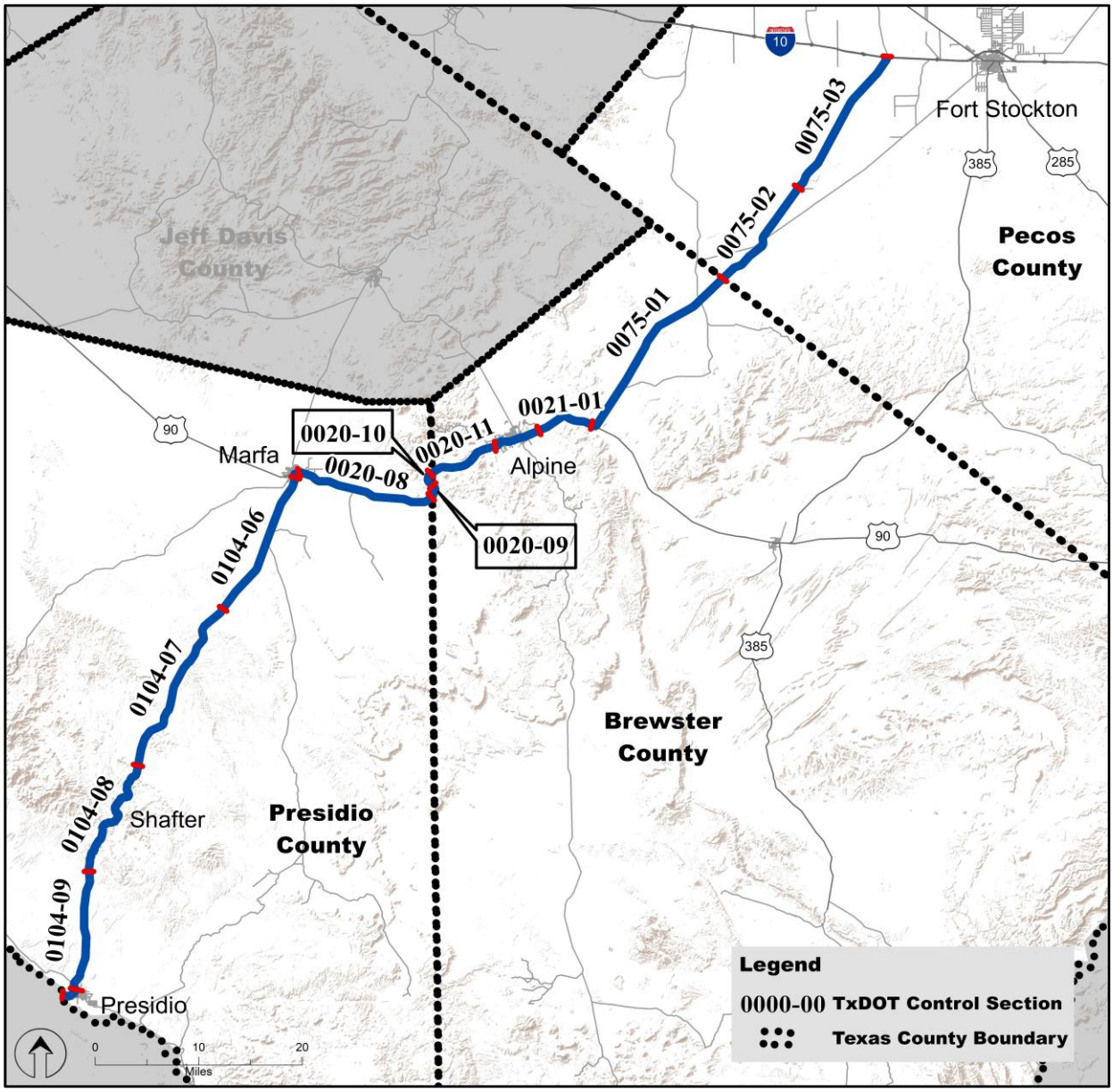
Figure 5: Crash Types vs. Crash Severity

Per the National Highway Traffic Safety Administration (NHTSA), a new Federal motor vehicle safety standard requires electronic stability control (ESC) on passenger cars, multipurpose passenger vehicles, trucks, and buses with a gross vehicle weight of 10,000 pounds or less. ESC systems use automatic computer-controlled braking of individual wheels to assist the driver in maintaining vehicle control in critical driving situations. NHTSA estimates that once all light vehicles in the fleet have ESC, the overall projected highway fatalities and injuries from single vehicle run-off-the-road crashes will decrease[3]. The recommendation is for TxDOT to monitor this trend as this technology continues to be adopted in the future.

[3] Refer to Department of Transportation, National Highway Traffic Safety Administration, 49 CFR Parts 571 and 585 [Docket No. NHTSA-2007-27662] RIN: 2127-AJ77 Federal Motor Vehicles Safety Standards; Electronic Stability Control Systems; Controls and Displays

4.4 Crashes by Location

The crash data was divided into TxDOT's control sections with the communities of Alpine, Marfa, and Presidio separated into their own segments. **Figure 6** shows the US 67 study corridor control sections. Control sections 0104-06, 0104-07, 0104-08 and 0104-09 are between Marfa and Presidio; control sections 0020-08, 0020-09, 0020-10 and 0020-11 are between Marfa and Alpine; and control sections 0021-01, 0075-01, 0075-02 and 0075-03 are between Alpine and the US 67/I-10 interchange.



Source: TxDOT Statewide Planning Map

Figure 6: US 67 Study Corridor Control Sections

Table 3 presents the split between the crashes occurring within and outside the communities. A large proportion (43 percent) of all crashes occurred in Alpine.

Table 3: Crashes by Location

Geographic Location	TxDOT Highway Segments	Outside of the communities	Within the communities
North of Presidio	0104-09	31	
Shafter	0104-08	56	
North of Shafter	0104-07	96	
South of Marfa	0104-06	26	
East of Marfa	0020-08	50	
South of Paisano Pass	0020-09	4	
Paisano Pass	0020-10	7	
West of Alpine	0020-11	20	
East of Alpine	0021-01	16	
North of US 67/US 90 Interchange	0075-01	54	
North of Brewster/Pecos County Line	0075-02	42	
South of US 67/I-10 Interchange	0075-03	43	
Alpine city limits	Alpine		375
Marfa city limits	Marfa		29
Presidio city limits	Presidio		29
Total	All	445 (50.7%)	433 (49.3%)

Source: TxDOT Crash Records Information System, 2010-2018

4.5 Bicycle and Pedestrian Crashes

There were a limited number of bicycle and pedestrian crashes in the data set. As shown in **Table 4**, nine pedestrian and bicycle crashes occurred across the US 67 study corridor over the nine years of data; all of them occurred in either Marfa or Alpine. Eight of these crashes involved a pedestrian and one crash involved a bicycle. Three pedestrian crashes were incapacitating injury crashes, one was a non-incapacitating injury crash, and four of them were minor or no-injury crashes. **Figure 7** shows the crash locations.

Table 4: Pedestrian and Bicycle Crashes

Crash Involving	Total Number of Crashes	Non-incapacitating Injury Crashes	Incapacitating Injury Crashes	Fatal Crashes	Minor or No-injury Crashes
Pedestrian	8	1	3	0	4
Bicycle	1	0	0	0	1
Total	9	1 (11%)	3 (33%)	0 (0 %)	5(56%)

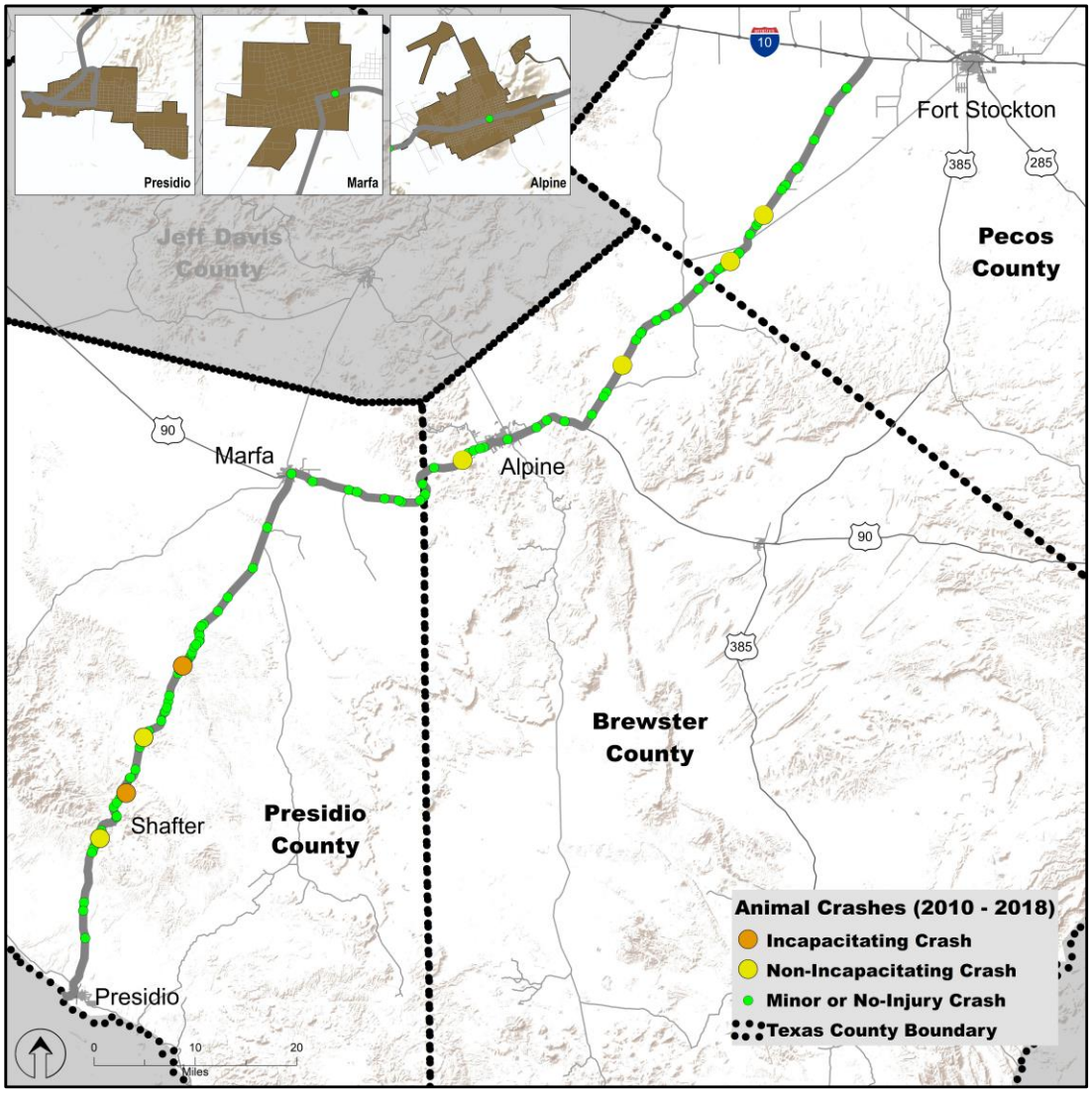
Source: TxDOT Crash Records Information System, 2010-2018

Source: TxDOT Crash Records Information System, 2010-2018

Figure 7: Pedestrian and Bicycle Crashes in Marfa and Alpine

4.6 Other Crashes: Animal-on-Road, Commercial Motor Vehicle, Train, and Unrestrained Driver/Passenger

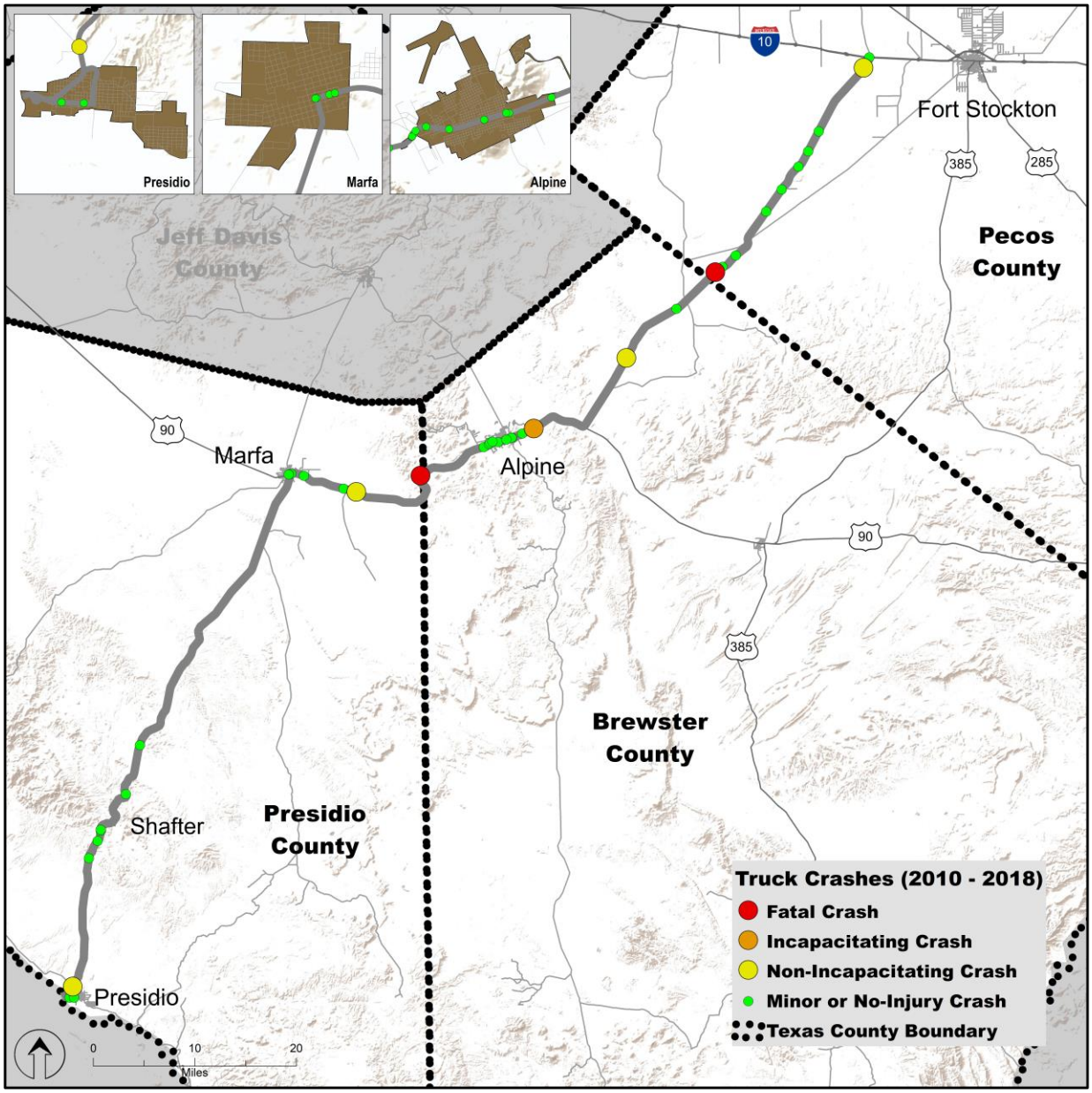
There were 127 (14.5 percent) reported crashes involving animals in the roadway with eight of them being severe crashes. Out of the eight severe animal-on-road crashes, there were no fatalities, but there were two incapacitating injury and six non-incapacitating injury crashes. **Figure 8** shows the crashes involving animals along the US 67 study corridor.



Source: TxDOT Crash Records Information System, 2010-2018

Figure 8: Animal Crashes

For the nine years of crash data, commercial motor vehicles were involved in 50 crashes (six percent). As shown in **Figure 9**, out of the 50 commercial-motor-vehicle-involved crashes, seven of them were severe crashes. Two out of the seven severe crashes were fatal crashes, one was an incapacitating injury crash, and four were non-incapacitating injury crashes.



Source: TxDOT Crash Records Information System, 2010-2018

Figure 9: Commercial Motor Vehicle Crashes

For the nine years of crash data, there were two train-involved crashes that occurred at the Old Alpine Highway. The crashes were minor or no-injury crashes.

Table 5 below shows the other crash types broken down by severity.

Table 5: Other Crashes

Crash Involving	Total Number of Crashes	Non-incapacitating Injury Crashes	Incapacitating Injury Crashes	Fatal Crashes	Minor or No-injury Crashes
Animal	127	6	2	0	119
Commercial Motor Vehicles	50	4	1	2	43
Train	2	0	0	0	2

Source: TxDOT Crash Records Information System, 2010-2018

There were three unrestrained driver or passenger crashes that also included children without restraint. All three crashes were non-incapacitating; however, the CRIS database may not reflect a representative count of the total number of unrestrained drivers during the collision.

4.7 Comparison of US 67 Study Corridor to Texas Crash Data

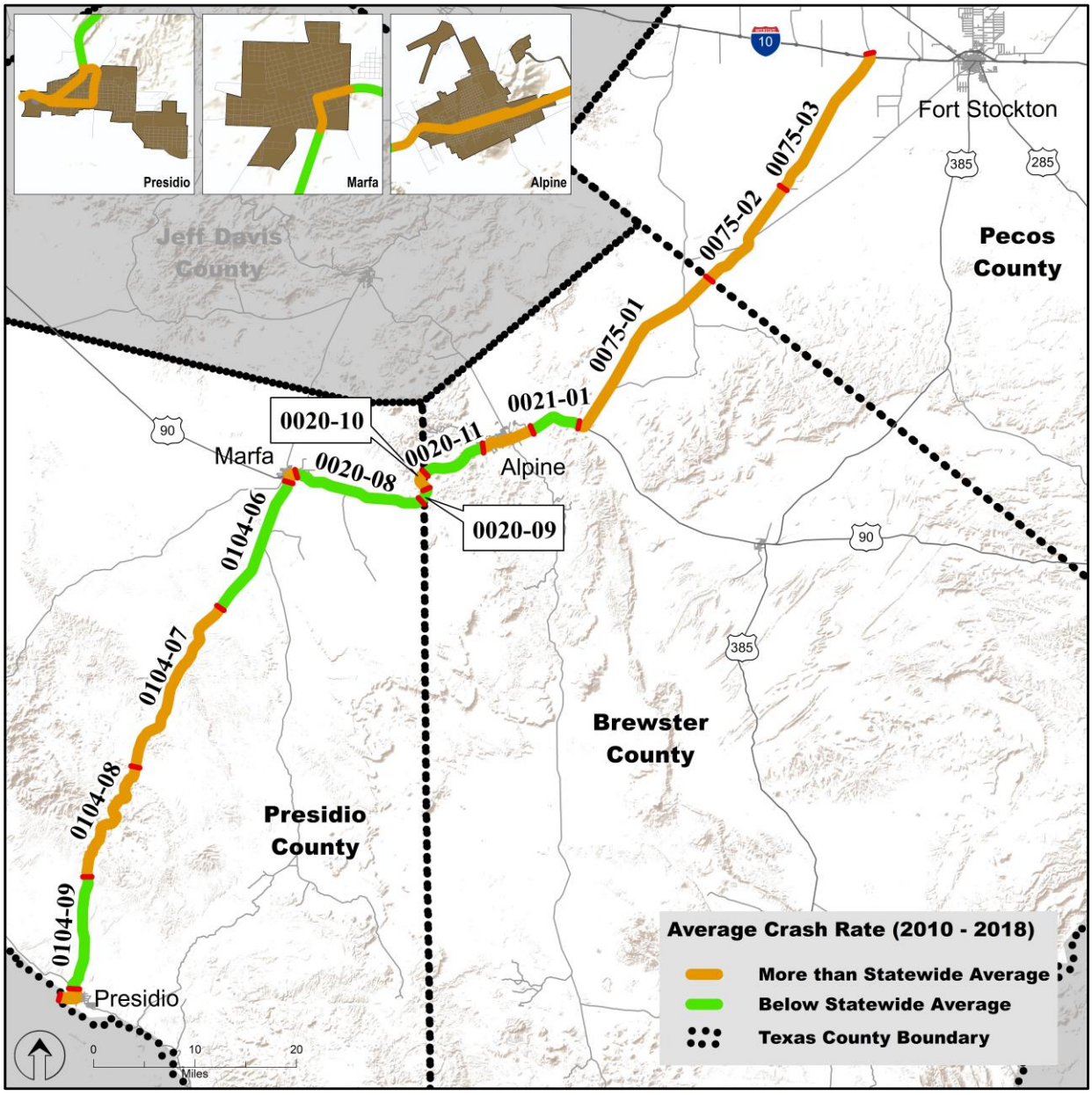
Table 6 presents the average crash rate, which is the number of crashes per 100 million vehicle miles traveled (VMT), for the US 67 study corridor from 2010 to 2018, accounting for crashes within the communities of Presidio and Marfa but not Alpine. Alpine is a borderline rural/urban town with a population slightly over 5,000; hence, for the purpose of the rural crash rate analysis, crashes in Alpine are not taken into consideration as part of the rural crash rate calculation. From **Table 6**, we see that the US 67 rural crash rate surpassed the Texas rural statewide crash rate for five of the nine years from 2010 to 2018.

Table 6: US 67 Rural and Texas Statewide Rural Crash Rates

Year	Number of Crashes	Average Corridor AADT	US 67 Crash Rate	Rural Statewide Crash Rate	Percentage of Statewide Average
2010	43	1,500	55.42	65.95	84%
2011	52	1,400	71.94	54.12	133%
2012	54	1,600	67.54	61.26	110%
2013	58	1,300	86.19	59.81	144%
2014	59	1,300	87.68	66.60	132%
2015	58	1,600	71.27	70.42	101%
2016	54	2,000	52.72	66.35	79%
2017	57	1,700	65.01	68.63	95%
2018	68	2,100	62.82	72.08	87%
2010 to 2018	503	1,600	68.95	65.02	106%

Source: Texas Motor Vehicle Crash Statistics; TxDOT Crash Records Information System, 2010-2018

In addition to the corridor-wide rural crash rate analysis, **Figure 10** breaks down the rural and urban average crash rates for each TxDOT control section along the US 67 study corridor. The crash rate for Alpine was compared to the Texas urban statewide average, whereas all other control sections were compared to the Texas rural statewide average. The green sections have crash rates below the statewide average and the orange sections have crash rates above the statewide average.



Source: Texas Motor Vehicle Crash Statistics; TxDOT Crash Records Information System, 2010-2018

Figure 10: Comparison of Average Crash Rate by Control Section

4.8 Key Conclusions of Traditional Safety Analysis

Following are the key conclusions of all US 67 study corridor crashes:

- The total annual number of crashes has fluctuated slightly up and down between 2010 and 2018.
- There were 731 crashes with possible or no injuries along the corridor; 100 crashes that caused non-incapacitating injuries; 35 crashes that involved incapacitating injuries; and 12 fatal crashes.
- Out of the 878 crashes, 478 (54 percent) were roadway departure/run-off-the-road crashes resulting in 92 severe injury crashes and 8 fatal crashes.
- There were 433 crashes that occurred in Alpine, Marfa, and Presidio, with 375 of them being in Alpine. There were 445 crashes that occurred along the US 67 study corridor outside of Alpine, Marfa, and Presidio.
- Nine crashes involved a bicycle or pedestrian, with three of them being incapacitating pedestrian crashes.
- There were 127 reported crashes involving animals in the roadway, with eight of them being severe crashes.
- There were 50 commercial motor vehicle involved crashes, out of which seven were severe crashes. Four were non-incapacitating injury crashes, one was an incapacitating injury crash, and two were fatal crashes.
- There were two train-involved crashes that were possible or no-injury crashes.
- US 67 study corridor had a higher rural crash rate than the Texas rural statewide average for five of the nine years during the period of 2010 and 2018.

5.0 Federal Highway Administration Systemic Approach to Safety

The US 67 traditional safety analysis focuses on specific locations with a history of crash clusters, often known as hotspots or blackspots. However, compelling evidence from FHWA and NHTSA[4] indicates that severe crashes are widely distributed across rural highway systems and very few definite locations experience a high number of severe crashes. The systemic approach to safety involves broadly implemented low-cost countermeasures for roadways exhibiting high-risk features

[4]FHWA Office of Safety website: A Systemic Approach to Safety – Using Risk to Drive Action. Accessed 9/24/19 https://safety.fhwa.dot.gov/systemic/why.cfm

that are associated with the most prevalent severe crash types. This approach is a more comprehensive approach to safety and complements the traditional safety analysis.

The systemic safety planning process is similar to other common safety management processes in that it involves identifying the problem, screening and prioritizing candidate locations, selecting countermeasures, and prioritizing projects. The process consists of four steps as explained in the following subsections.

5.1 Step 1: Identify Focus Crash Types and Risk Factors

In order to implement a systemic safety approach, the crash data set is refined from all crashes to only severe crashes across the corridor. Severe crashes are identified as fatal, incapacitating, and non-incapacitating crashes. The focused crash types are then disaggregated by focus facilities and potential risk factors are developed.

5.1.1 Identify focus crash types

This section aims to identify focus crash types by breaking down crashes by emphasis area and area type. The Texas SHSP emphasis areas are:

- Distracted Driving
- Impaired Driving
- Pedestrian Safety
- Intersection Safety
- Speeding
- Roadway and Lane Departures
- Older Users

Based on conversations with various stakeholders and TxDOT, the analysis included additional emphasis areas that are context sensitive to the US 67 study corridor. These are listed below:

- Young Drivers
- Bicycle Crashes
- Towed-trailer Crashes
- Commercial Motor Vehicle Crashes
- Animal-On-Road Crashes
- Head-on Crashes

Using TxDOT CRIS data from 2010 to 2018 along with vehicle characteristics and driver behavior information, the analysis identified the focus crash types by breaking down crashes by emphasis area and area type, i.e., whether they are within the three communities of Alpine, Marfa, and Presidio or outside community limits. **Table 7** shows the crash data for the US 67 study corridor distributed by emphasis area and area type. Note, the number of crashes by emphasis area does not add up to the total number of crashes as multiple emphasis areas may be present for some crashes.

Table 7: Fatal and Severe Injury Crashes by Emphasis Area

Emphasis Area		Outside the Communities (135 miles)		Within Communities (8.7 miles)	
Drivers	Young Drivers (under 21)	15	14%	8	**22%**
	Older Drivers (over 64)	14	13%	7	19%
	Aggressive Driving and Speeding-related	31	**28%**	4	11%
	Drug and Alcohol-related	10	9%	3	11%
	Inattentive, Distracted, Asleep Drivers	33	**30%**	19	**50%**
Special Users	Pedestrian Crashes	0	0%	4	11%
	Bicycle Crashes	0	0%	0	0%
Vehicles	Towed-trailer Crashes	15	14%	1	3%
	Commercial Motor Vehicle Crashes	7	6%	0	0%
Highways	Animal-on-Road Crashes	8	7%	0	0%
	Road Departure Crashes (non-intersection)	87	**78%**	4	11%
	Intersection Crashes	6	5%	26	**72%**
	Head-on (opposite) Crashes	11	10%	2	6%
	Dark (no street lights) Crashes	25	23%	3	8%
Total Fatal/Incapacitating/Non-incapacitating Injury Crashes		111		36	

Source: TxDOT Crash Records Information System, 2010-2018

Table 7 highlights how sections within the communities and sections outside the communities require different priorities. Of the 147 most severe crashes (fatal, incapacitating, non-incapacitating), 111 crashes occurred outside the communities and 36 occurred in the communities of Alpine, Marfa, and Presidio. Following are the key conclusions of the focus crash types:

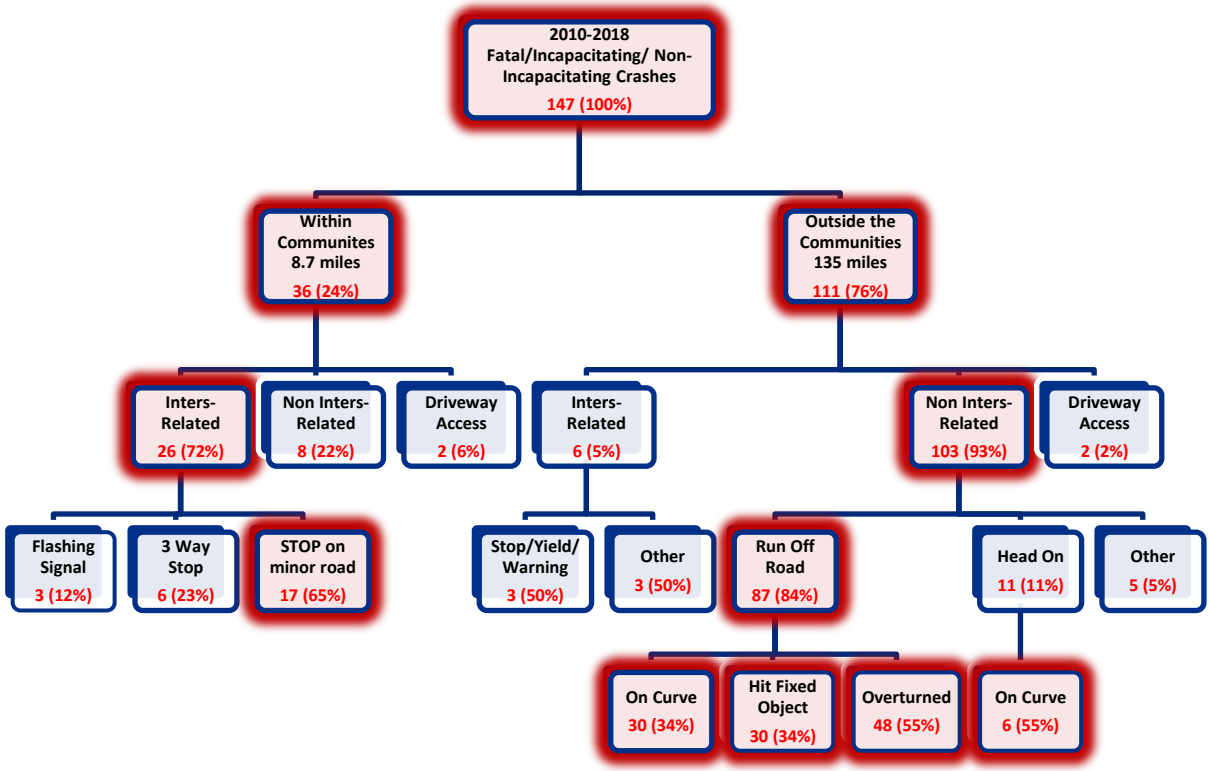
- Out of the 111 severe crashes outside the communities, roadway departure crashes account for 87 of the crashes (78 percent), making it the focus crash type for sections outside the communities.
- For the crashes occurring outside the communities, driver behavior, such as inattentive/distracted/asleep and aggressive driving/speeding accounted for 30 percent and 28 percent of the crashes, respectively.

- Out of the 36 severe crashes within the communities, 26 crashes (72 percent) occurred at intersections, making it the focus crash type for Alpine, Marfa, and Presidio.
- For the crashes occurring within the communities, driver inattention accounts for 50 percent of the crashes, and 22 percent of the crashes are caused by young drivers.

Detailed collision diagrams of the 147 severe crashes are shown in **Attachment A**.

5.1.2 Disaggregate focus crash types by facility

After identifying the focus crash types, the second step of the FHWA Systemic Safety process breaks down the crashes by focus facility type. **Figure 11** is a crash-tree diagram that shows the total number of crashes at the highest level. Each subsequent level separates the severe crashes by their facility type, such as urban vs. rural, segment vs. intersection, straight segment or curved, and intersection control type. The tree diagram helps identify the types of locations where the focus crash types are occurring. This is done to assign appropriate countermeasures that will be discussed in the next steps of the systemic approach to safety. The boxes highlighted in red represent the locations and crash types which have the highest risk of occurring.



Source: TxDOT Crash Records Information System, 2010-2018

Figure 11: Crash Tree of Severe Crashes

The crash-tree diagram shows that out of a total of 147 severe crashes on US 67, 111 (76 percent) are outside the communities and 36 (24 percent) are within the communities.

- Between the communities, out of the 111 severe crashes, 103 (93 percent) are non-intersection related, six (5 percent) are intersection related, and two (2 percent) are driveway access related crashes.
  - Out of the 103 rural non-intersection related severe crashes, 87 (84 percent) are run-off-the-road crashes, 11 (11 percent) are head-on crashes, and five (5 percent) are other types of crashes such as rear-end and angle collisions.
  - Out of the 87 rural severe non-intersection run-off-the-road crashes, 30 (34 percent) happened on a curve, 30 (34 percent) involved hitting a fixed object after leaving the roadway, and 48 (55 percent) involved overturning. (Note: These numbers and percentages exceed the total of 87 due to the presence of multiple crash risk conditions for some crashes).
- Within the communities, out of the 36 severe crashes, 26 (72 percent) were intersection-related crashes.
  - Seventeen (65 percent) of the severe intersection-related crashes occurred at an intersection with STOP control on the minor road.
  - Six (23 percent) of the severe intersection-related crashes occurred at a 3-way stop intersection. Two of them were pedestrian crashes.
  - Three (12 percent) of the severe intersection-related crashes occurred at an intersection with a flashing stop signal. One of them was a pedestrian crash.

5.1.3 Identify potential risk factors

The next step was to identify the appropriate potential risk factors for the focus crash types. **Table 8** presents some examples of potential risk factors from FHWA Office of Safety website.

Table 8: Sample of Potential Risk Factors for Focus Crash Types

Focus Crash Type	Potential Risk Factors
Road Departure	▪ Road edge condition ▪ Access density ▪ Curve density

Focus Crash Type	Potential Risk Factors
Road Departure in Horizontal Curve	▪ Curve radius ▪ Speed differential (from tangent approach) ▪ Visual trap ▪ Intersection in the curve ▪ Traffic volume
Intersections (Rural/Urban)	▪ Skewed approach ▪ Proximity to horizontal and/or vertical curve ▪ Presence of commercial development ▪ Proximity to at-grade railroad crossing ▪ Distance from previous controlled intersection ▪ Left or right-turn lanes ▪ Left-turn signal phasing ▪ Right-turn on red ▪ Red-light enforcement ▪ Intersection control ▪ Number of lanes on major approach ▪ Divided or undivided ▪ Lighting ▪ Traffic volume ▪ Speed

Source: Federal Highway Administration Office of Safety, The Systemic Safety Project Selection Tool

Based on initial analysis, field visits, and conversations with various stakeholders and TxDOT, the analysis included additional potential risk factors that are sensitive to the US 67 study corridor.

Table 9 summarizes the potential risk factors, and whether the data are available for US 67.

Table 9: Potential Risk Factors for Roadway Departure and On-Curve Crashes

Risk Factors	Data Available
Roadway Departure	
Inadequate Lane Width	Yes
Inadequate Roadway Shoulders	Yes
Inadequate Median Width	Yes
Slippery Pavement	Yes
Poor Delineation (pavement markings, RPM's, chevron signs, object markers, PMDs)	No

Risk Factors	Data Available
Poor Visibility	No
Excessive Speed	No
Inadequate Roadway Geometry	Yes
Vehicle Rollover	
Roadside Design (e.g. non-traversable side slopes, pavement edge drop-off)	Yes
Pavement Design	Yes
Night-time	
Poor Night-Time Visibility or Lighting	No
Poor Sign Visibility	No
Inadequate Channelization or Delineation	No
Inadequate Sight Distance	Yes

Source: Highway Safety Manual

5.2 Step 2: Evaluate Risk Factors and Prioritize Candidate Locations

The purpose of this step is to evaluate risk factors and prioritize candidate locations for potential safety improvements.

The risk factors were identified and evaluated based on common characteristics of roadway and traffic patterns of locations associated with the greatest number of focus crash types. Risk factors were evaluated to prioritize candidate locations for safety improvements. The evaluation was done separately for each of the following four focus facility types.

- Segments outside the communities
- Horizontal curves outside the communities
- Intersections and interchanges outside the communities
- Intersections within the communities

This analysis looked beyond crash information into roadway and intersection inventories, such as as-builts, video logs, aerial images, traffic and truck percentage counts, geographic information systems (GIS), etc. to provide an additional level of detail for the analysis. The following subsections include the evaluation of the risk factors and the prioritization of candidate locations for the four aforementioned focus facility types.

5.2.1 Segments outside the communities

This section focuses on evaluating risk factors associated with the segments outside the communities. The analysis includes an assessment of each of the following risk factors and concludes with prioritizing locations for potential safety improvements.

- Density of road departure crashes
- Annual average daily traffic
- Curve critical-radius
- Clear zone
- Truck percentage
- Slippery pavement
- In-the-dark crashes

Density of road departure crashes

Severe roadway departure crash density signifies the number of severe roadway departure crashes per mile per year. The average severe roadway departure crash density for the US 67 study corridor outside the communities is 0.072 crashes per mile per year. Segments along the US 67 study corridor having higher than average roadway departure density were identified for this risk factor. The data in **Table 10** reveals that there are five potential risk sections that are highlighted in red.

OUTCOME

Severe roadway departure density higher than the corridor average of 0.072 crashes per mile per year is selected as a risk factor.

Table 10: Roadway Departure Crash Density

Item	Segments outside Communities											
	Between Presidio and Marfa				Between Marfa and Alpine				Between Alpine and US67/I-10 Intersection			
	0104-09	0104-08 (Shafter)	0104-07	0104-06	0020-08	0020-09	0020-10 (Paisano Pass)	0020-11	0021-01	0075-01	0075-02	0075-03
Length (miles)	12.0	13.1	18.3	14.9	13.6	1.3	1.5	7.1	5.8	19.7	11.9	15.8
Severe Road Departure Crashes	6	8	19	3	12	0	4	4	3	7	10	11
Severe Road Departure Crash Density	0.056	0.068	**0.115**	0.022	**0.098**	0.00	**0.296**	0.063	0.057	0.039	**0.093**	**0.077**

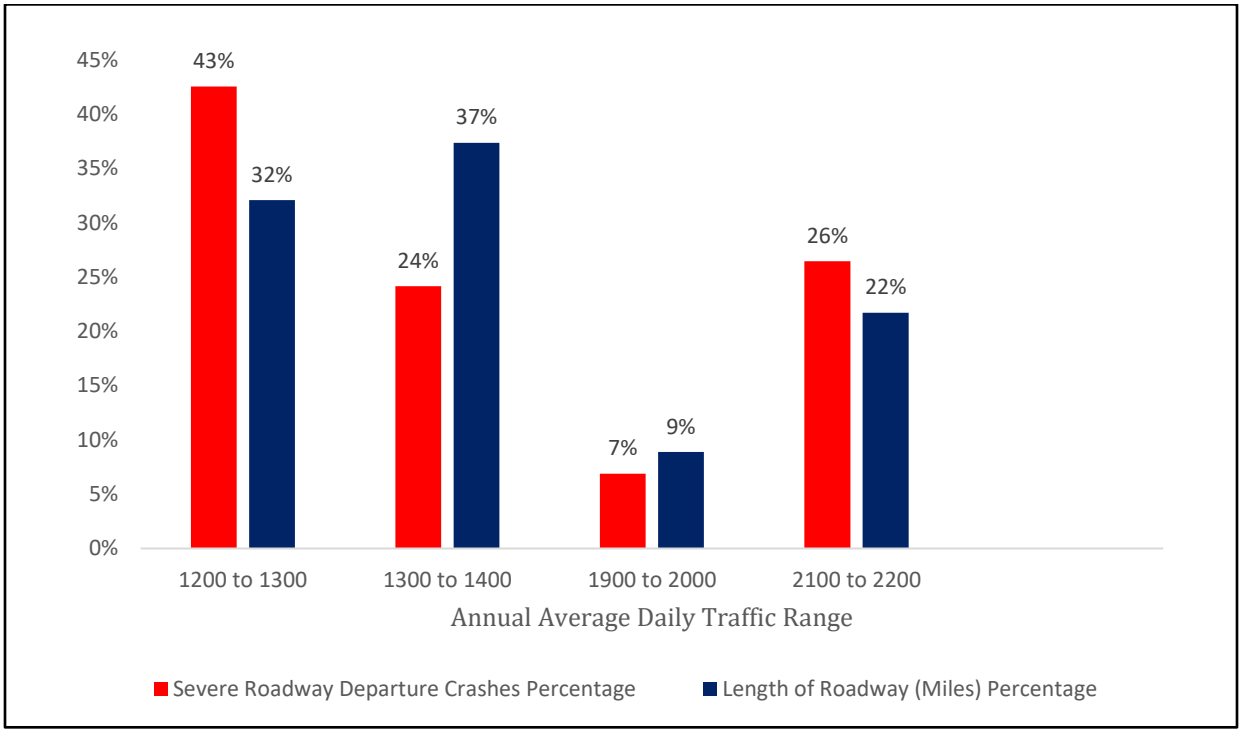
Source: TxDOT Crash Records Information System, 2010-2018

Annual average daily traffic

The annual average daily traffic (AADT) was computed for each segment of US 67 using data from the Statewide Traffic Analysis Reporting System (STARS II)[5] website. The percentage of severe roadway departure crashes and the percentage of roadway mileage were computed for AADT ranges 1,200 to 1,300, 1,300 to 1,400, 1,900 to 2,000, and 2,100 to 2,200. As shown in **Figure 12**, the severe roadway departure crashes in percent (shown by red bars) are higher than the roadway mileage percent (shown by the blue bars) for AADT ranges from 1,200 to 1,300 and from 2,100 to 2,200.

OUTCOME

AADT less than 1,300 vehicles per day or AADT greater than 2,100 vehicles per day is considered as a risk factor.



Source: TxDOT Crash Records Information System, 2010-2018

Figure 12: Roadway Departure Crashes and Roadway Mileage vs. AADT

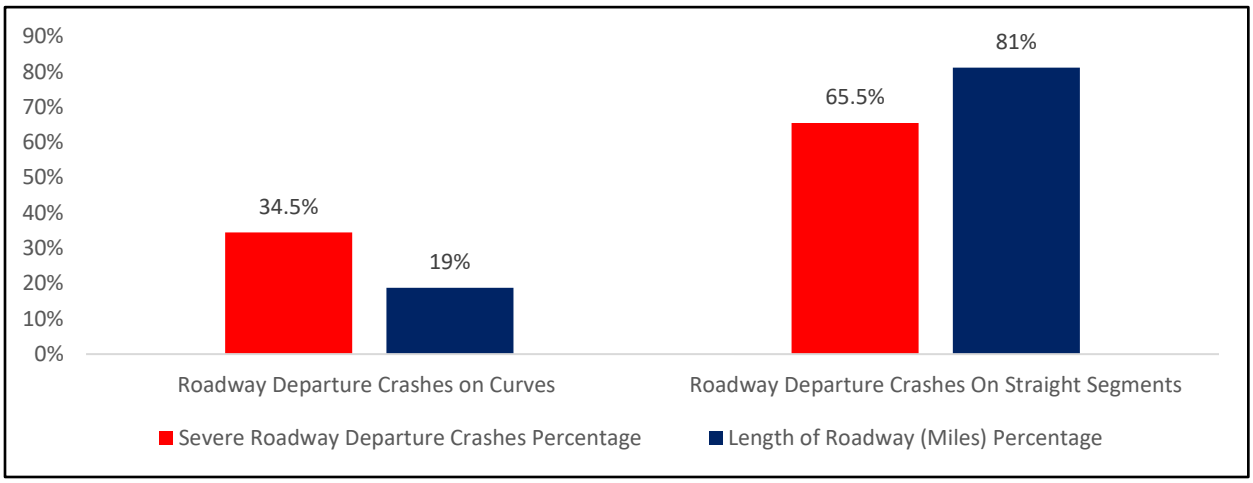
[5] Statewide Traffic Analysis Reporting System (STARS II) Website: txdot.ms2soft.com

Curve critical-radius

Based on as-built drawings of the study corridor outside the communities, 19 percent is comprised of curves and 81 percent of straight segments. A total of 34.5 percent of severe roadway departure crashes along the study corridor occurred on curves compared to 65.5 percent on straight segments (**Figure 13**). Thus, crashes are overrepresented on curves. Further analysis also found that roadway departure crashes were overrepresented on curves with radii less than 1,800 feet (**Figure 14**).

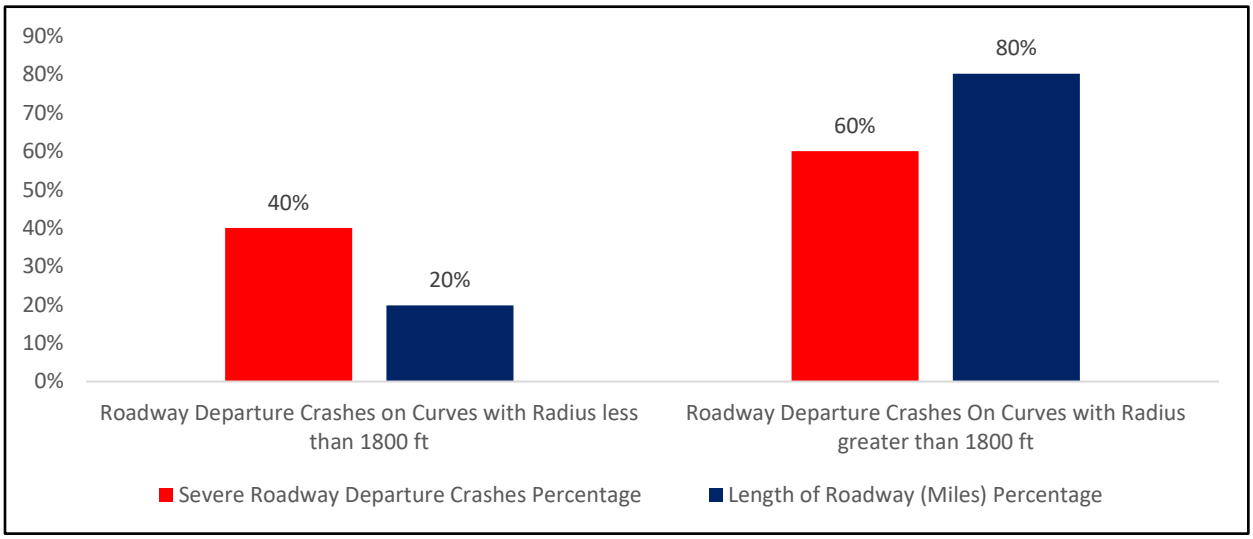
OUTCOME

Radius less than 1,800 feet is identified as a risk factor.



Source: TxDOT Crash Records Information System, 2010-2018

Figure 13: Roadway Departure Crashes on Curves and Straight Segments



Source: TxDOT Crash Records Information System, 2010-2018

Figure 14: Roadway Departure Crashes on Curves with Radius Less and Greater than 1,800 Feet

Clear zone

TxDOT's Roadway Design Manual recommends a front slope rate of 1V:6H and suggests using a longitudinal barrier when the front slope is steeper than 1V:3H to keep vehicles from traversing the slope. From field observations, it was noted that many locations along the corridor do not have recoverable slopes beyond the shoulder. There are many steep hills located within 30 feet of the roadway edge of traveled way and downslopes steeper than 1V:3H slope that are not protected by guardrails. These features are predominant at the 0104-07 and 0104-08 control segments between Presidio and Marfa and at intermittent locations along other segments.

There are several miles of earth mounds beyond the shoulder between the US 67/US 90 interchange east of Alpine and the US 67/I-10 interchange. These make the slopes non-traversable for a vehicle that departs the roadway. Field information and detailed analysis of video logs were used to measure the length in miles of poor clear zone conditions for each segment. After using similar methods as in the previous risk factor assessments, it was identified that the crash rate was higher in locations with poor clear zone conditions than in locations with good clear zone conditions.

As shown in **Table 11,** the severe roadway departure crash rate per 100 million VMT is 15.69 for locations with poor clear zone condition, which is 54 percent higher than the crash rate of 10.17 for locations with good clear zone conditions. This shows that there is a higher risk of severe road departure crashes to occur in locations with poor clear zone conditions.

OUTCOME

Poor clear zone condition is identified as a risk factor.

Table 11: Severe Roadway Departure Crash Rate vs. Clear Zone

Item	Proportion of System (Miles)	Severe Roadway Departure Crashes (2010 to 2018)	Average AADT	Severe Roadway Departure Crash Rate (Per 100 M VMT)
Roadway having crashes in poor clear zone	63	49	1,500	15.69
Roadway having crashes in good clear zone	72	38	1,600	10.17

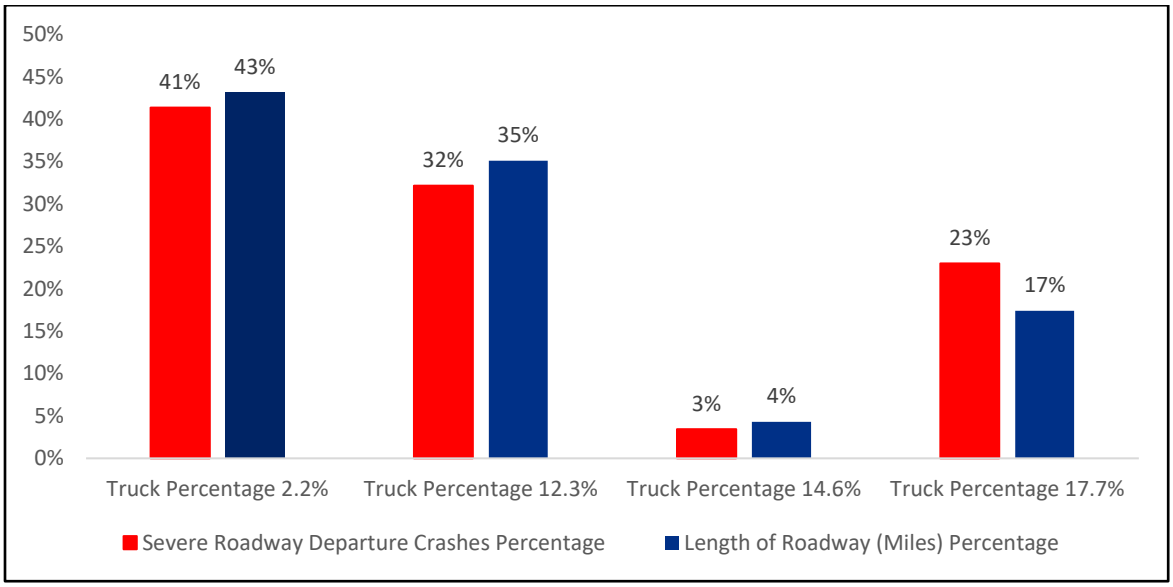
Source: TxDOT Crash Records Information System, 2010-2018

Truck percentage

Figure 15 shows that the proportion of severe crashes increases with the increase in truck percentage. The truck percentages were obtained from TxDOT's CRIS Database, which gives the combined percentages of single-axle and multiple-axle trucks. As seen from the figure, severe crashes are overrepresented when trucks make up 17.7 percent of the traffic, which is the case between Marfa and Alpine.

OUTCOME

Truck percentage of 17.7 percent or greater is considered as a risk factor.



Source: TxDOT Crash Records Information System, 2010-2018

Figure 15: Rural Severe Crashes by Truck Volume Percentage

Slippery pavement

This risk factor included analysis of segments outside the communities related to the occurrence of roadway departure crashes during bad weather conditions. In Public Meeting Series No. 1 held from May 14, 2018, through May 17, 2018, in the communities of Alpine, Fort Stockton, Marfa, and Presidio, attendees expressed concern about the crashes between Marfa and Alpine and on the segment north of the US 67/US 90 intersection due to bad weather conditions such as hail, snow, sleet, and fog. Input from the public indicated that the pavement on these sections is comparatively new and thus becomes slippery during bad weather, making the roads more prone to crashes. The study team, therefore, looked at the number of crashes on each segment that happened during inclement weather. Out of nine severe weather-related crashes, seven happened between Marfa and Alpine and two occurred at control segments 0021-01 just east of Alpine and segment 0075-02 in the middle of the stretch between the US 67/ US 90 Intersection and the US 67/ I-10 Interchange. Based on as-built plans for all the segments between Marfa and Alpine, the pavement type is hot-mix asphalt. According to TxDOT's Pavement Design Manual, hot-mix asphalt pavements do not have enough resistance to skidding, particularly under wet weather conditions. Aggregate properties such as texture, shape, size, and resistance to polish are all factors related to skid resistance. **Table 12** lists the weather-related crash rates for the segments and shows the crash rate is higher in the slippery pavement than a non-slippery one.

Table 12: Severe Roadway Departure Crash Rate vs. Pavement Condition

Item	Length of System (Miles)	Severe Roadway Departure Crashes (2010 to 2018)	Average AADT	Severe Roadway Departure Crash Rate (Per 100 M VMT)
Slippery Pavement	40	33	1900	13.18
Non-Slippery Pavement	95	54	1400	12.39

Source: TxDOT Crash Records Information System, 2010-2018

In-the-dark crashes

The last risk factor included an analysis of segments that experience severe roadway departure crashes during the night or during absence of light. It was observed that 84 percent of the study corridor experienced some severe crashes in the dark, whereas only 16 percent of the corridor experienced zero severe crashes in the dark. **Table 13** lists the crash rates for the segments that experienced crashes in the dark and for segments that did not experience crashes occurring in the dark. As can be seen, the crash rate is higher for segments that experienced crashes in the dark.

OUTCOME

In-the-dark crashes is considered as a risk factor.

Table 13: Severe Roadway Departure Crash Rate vs. In-the-Dark Crashes

Item	Length of System (Miles)	Severe Roadway Departure Crashes (2010 to 2018)	Average AADT	Severe Roadway Departure Crash Rate (Per 100 M VMT)
Roadway having crashes in-the-dark	113	81	1,500	14.19
Roadway not having crashes in-the-dark	22	6	1,600	5.20

Source: TxDOT Crash Records Information System, 2010-2018

Prioritization of locations for safety improvements

As shown in **Table 14,** the risk factors were scored by segment to screen and prioritize candidate segments for countermeasures. A greater total score identifies higher priority candidates for safety investment.

Table 14: Prioritization of Segments Outside the Communities

Location	Control Section	Severe Road Departure Crashes	Road Departure Crash Density	AADT Range	Critical Curve Radius Density	Clear Zone	Truck Percentage	Slippery Pavement	In-the-Dark Crashes	Total Score
North of Presidio	0104-09	6			1				1	2
Shafter	0104-08	8		1	1	1			1	4
North of Shafter	0104-07	19	1	1	1	1			1	5
South of Marfa	0104-06	3		1						1
East of Marfa	0020-08	12	1	1			1	1	1	5
South of Paisano Pass	0020-09	0		1		1	1			3
Paisano Pass	0020-10	4	1	1	1	1	1	1	1	7
West of Alpine	0020-11	4		1		1	1	1	1	5
East of Alpine	0021-01	3		1		1		1		3
North of US 67/US 90	0075-01	7		1					1	2
North of Pecos County Line	0075-02	10	1	1				1	1	4
South of US 67/I-10	0075-03	11	1	1		1			1	4
Total average score of all the rural sections along the US 67 Study Corridor										3.75

Source: TxDOT Crash Records Information System, 2010-2018

As shown in **Table 14**, all highlighted control sections received a total score higher than the corridor average score of 3.75, and therefore, were prioritized for available safety improvements. Control segment 0020-10 near the Paisano Pass between Marfa and Alpine received the highest total score of seven since it met all the risk factors. This was followed by segments 0104-07 (north of Shafter), 0020-08 (east of Marfa), and 0020-11 (west of US 67/US 90 interchange), all of which received a score of five.

5.2.2 Horizontal curves outside the communities

This section aims to evaluate the risk factors associated with the horizontal curves outside the communities. The analysis recommends prioritizing curves with a higher total risk score for potential safety improvements. In addition, the study team conducted a superelevation analysis to identify curves that require superelevation adjustment.

As discussed earlier, severe roadway departure crashes are overrepresented on curves whose radius is less than 1,800 feet. Thus, the risk factors considered for the prioritization of rural horizontal curves are:

- Curves with a radius less than 1,800 feet
- Each occurrence of a severe crash on a curve

These risk factors were shown to have an influence on the occurrence of severe crashes. Each curve is given a unique ID starting with the control section number in which it is located. A total of 54 out of 112 curves are listed in **Attachment B** with their corresponding risk factors and these will be prioritized candidates for safety improvements described in detail in **Section 5.4**.

Superelevation treatment

Superelevation is the amount of cross slope or "bank" provided on a horizontal curve to counterbalance, in combination with the side friction, the centrifugal force of a vehicle taking the curve. The maximum rate of superelevation (emax) is an overall superelevation control used in the design of curves. Its selection depends on several factors including weather conditions, terrain conditions, type of area (rural or urban), and highway functional classification.

According to the TxDOT Roadway Design Manual[6], for urban freeways and all types of rural highways, emax of 6 to 8 percent are generally used for design. Based on the emax of 6 percent, 48 out of 112 curves on the US 67 study corridor do not meet the minimum required superelevation. This number is significantly higher under the emax of 8 percent methodology, where 88 curves do not meet the minimum required superelevation. **Attachment B** shows the difference between the minimum required superelevation based on the emax of 6 and 8 percent methodologies and the existing superelevation rates along the US 67 study corridor.

The emax of 8 percent methodology allows for higher speeds on tighter curves making them safer and reduces the need for advisory speed limit signs. This improves safety as drivers traveling at a constant speed are less likely to reduce speed regardless of an advisory speed limit sign. Thus, curves with deficient superelevation are recommended to be treated based on emax of 8 percent.

Figure 16 shows the 88 curves with deficient superelevation based on the emax of 8 percent, classified into three different ranges. The map inset highlights the section near Shafter, where the majority of curves are deficient by more than 1 percent. The curves which are still deficient after providing the maximum superelevation of 8 percent can be provided with additional side friction to improve safety, as described in detail in **Section 5.4**.

As a part of one of the tasks under this study, superelevation rates were obtained from Mobile LiDAR Survey data. The LiDAR study concluded that 89 curves along the US 67 study corridor need superelevation treatment. Eighty-five of them match with the findings of this safety analysis. The

[6] Roadway Design Manual. http://onlinemanuals.txdot.gov/txdotmanuals/rdw/index.htm

findings are provided in greater detail in the **Appendix L – Mobile LiDAR Survey Procedures and Findings**.

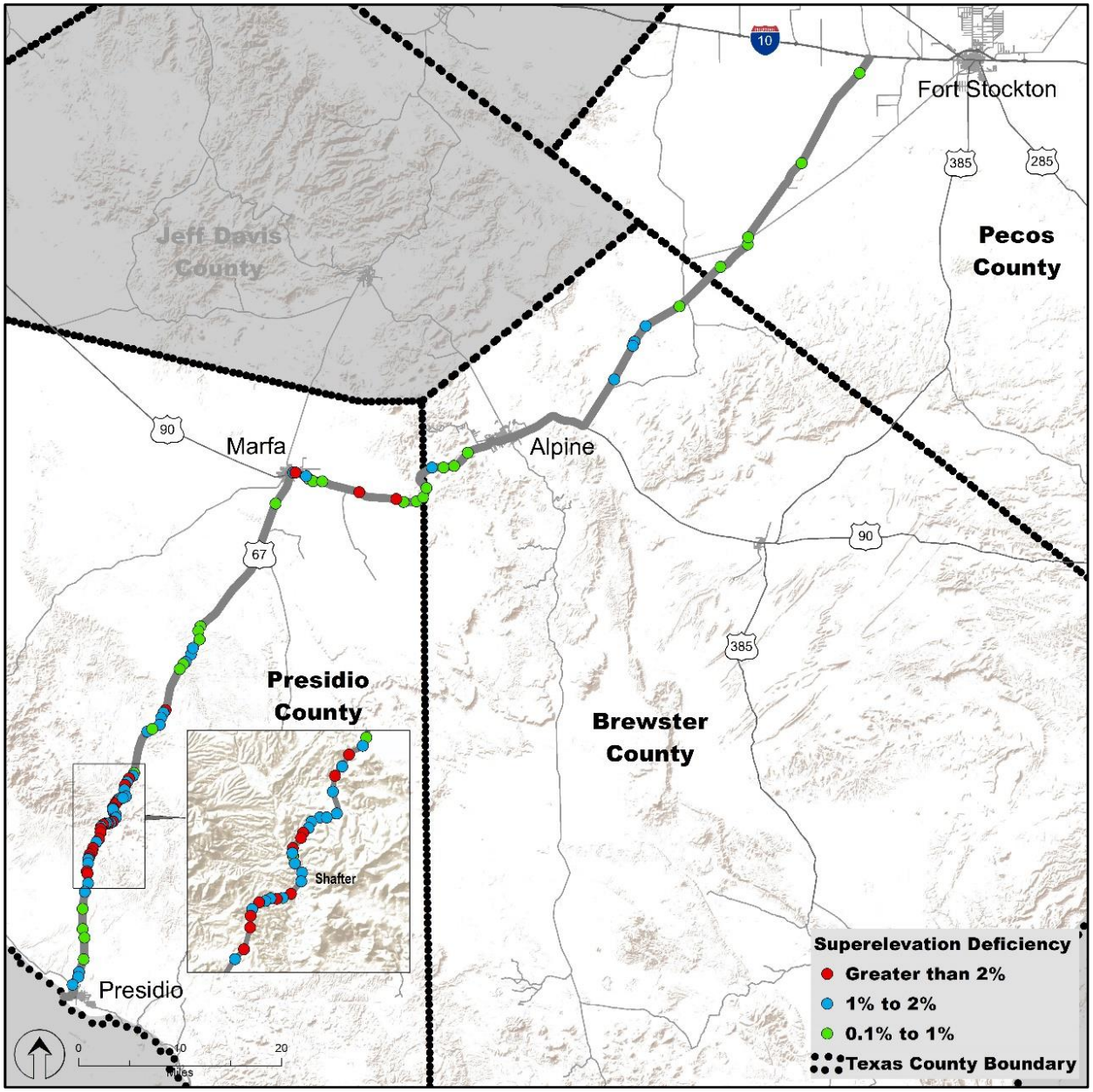


Figure 16: Curves with Superelevation Deficiency (emax of 8 Percent methodology)

5.2.3 Intersections and interchanges outside the communities

This section aims to evaluate the risk factors associated with the intersections and interchanges outside the communities. The analysis recommends prioritizing locations with a higher total risk score for potential safety improvements. The risk factors selected for intersections and interchanges outside of the communities are:

- Each occurrence of a severe intersection-related crash
- Skewed minor approaches (greater than 15 degrees)
- Proximity to curves (within 150 feet)
- Proximity to railroad crossing (within 150 feet)

There are 13 intersections and interchanges within the study corridor limits that are outside of the communities. Each intersection or interchange that had one of the risk factors present gets a score of 1. The total score for each intersection and interchange are calculated based on the number of risk factors present. **Table 15** highlights five locations that have higher scores than the study corridor average score. These intersections and interchanges are considered as candidates for safety investments. **Figure 17** shows the locations of the 13 intersections and interchanges.

Table 15: Intersection/Interchange outside of the Communities Risk Factor Score Summary

ID	Cross Street Name	Control	On Curve	Skewed (>15 deg.)	Severe Crashes (within 150 ft of intersection)	Proximity to a Railroad Crossing	Total Score
1	Old Road 170 and Utopia Road	Stop	1	1	1		3
2	Upper Shafter Road	Stop					0
3	Cibolo Creek Road	Stop	1				1
4	Church Road	Stop	1	1			2
5	Ranch Road 169	Stop					0
6	Mitchel Road	Stop					0
7	Golf Course Road	Stop					0
8	Paisano Drive	Stop	1				1
9	Old Marathon Road	Stop		1			1
10	US 90	Yield	1	1	1		3
11	Hovey Road	Stop					0
12	Old Alpine Highway	Stop	1		1	1	3
13	I-10	Stop	1		2		3

Source: TxDOT Crash Records Information System, 2010-2018

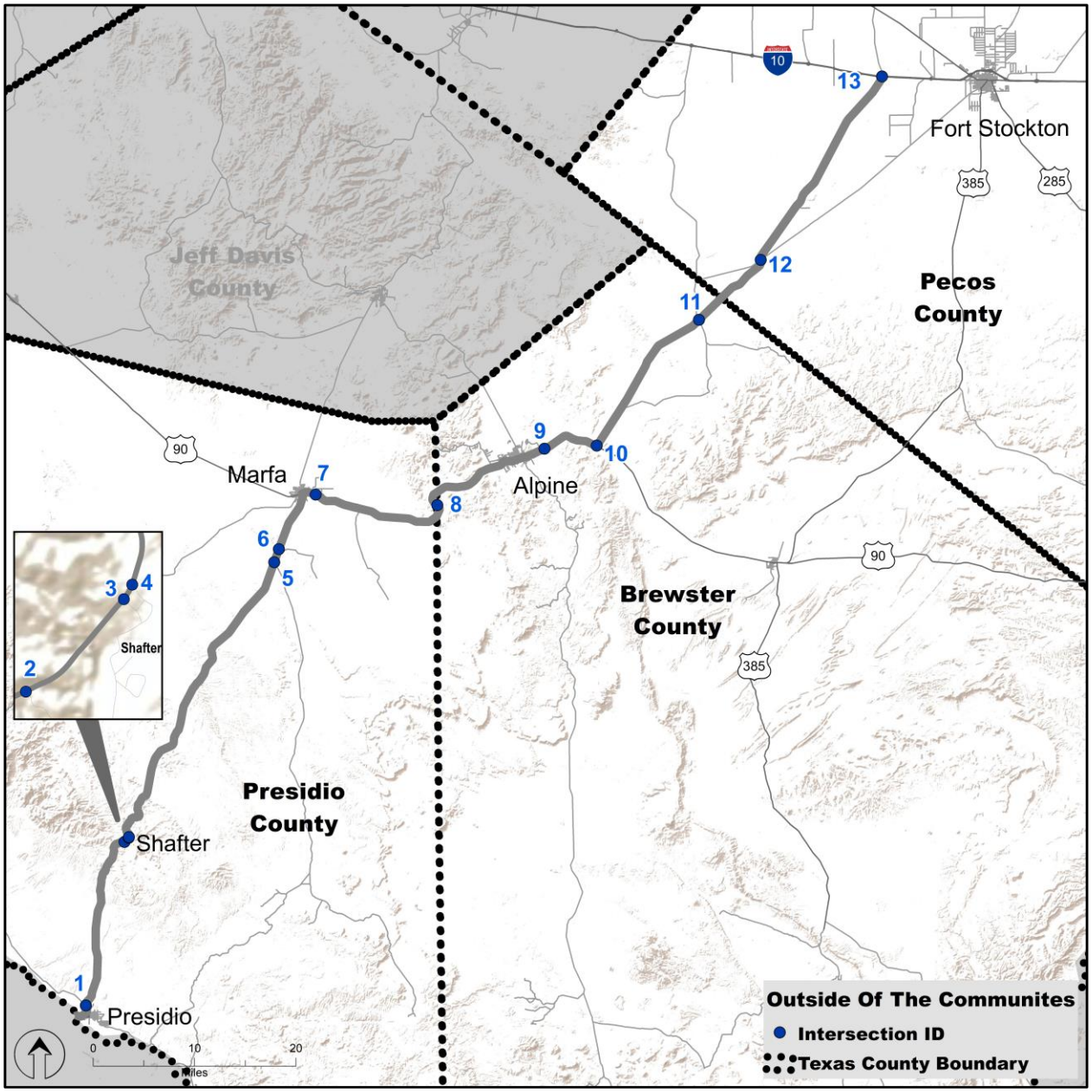


Figure 17: Intersections and interchanges outside of the communities

5.2.4 Intersections within communities

This section evaluates the risk factors for intersections within the communities of Alpine, Marfa, and Presidio.

Table 16 displays the severe crashes within the communities of Alpine, Marfa, and Presidio. Thirty-one out of 36 crashes occurred in Alpine, two in Marfa, and three in Presidio. The analysis indicated that 30 of the 36 severe crashes were non-incapacitating crashes. The remaining six crashes were incapacitating crashes. Three of the six incapacitating crashes were pedestrian-related, two of them occurred in Alpine and one in Marfa.

Table 16: Severe Crashes by Community

Community	Non-Incapacitating Crash	Incapacitating Crash	Fatal Crash	Total Number of Severe Crashes
Presidio	1	2	0	3
Marfa	1	1	0	2
Alpine	28	3	0	31
Total	30	6	0	36

Source: TxDOT Crash Records Information System, 2010-2018

The primary contributing cause of the crashes indicates that 26 out of the 36 severe crashes within the communities were due to driver behavior related issues. Driver inattention played a role in 20 of the 26 severe crashes. The crashes due to driver behavior issues are presented in **Table 17**.

Table 17: Driver Behavior Factors by Urban Area

Community	Intoxicated Drivers	Aggressive Drivers	Distracted Drivers	Total Number of Driver Behavior Related Crashes
Presidio	0	0	1	1
Marfa	1	0	0	1
Alpine	2	3	19	24
Total	3	3	20	26

Source: TxDOT Crash Records Information System, 2010-2018

Twenty-six out of 36 severe crashes occurred at intersections. Out of those 26 crashes, 17 had a stop sign on the minor road only, six had a 3-way stop sign, and three had flashing signal traffic control. Twenty three out of 26 intersection crashes occurred in Alpine, one occurred in Marfa, and two occurred in Presidio. The speed limit is 30 mph for all intersections within the communities, except the FM 1703 intersection in Alpine, where the speed limit is 45 mph.

The risk factors considered for intersections within the communities are:

- Occurrence of a severe right-angle/head-on collision

- Occurrence of a severe pedestrian crash
- Presence of speed limit change within 1,000 feet of the intersection
- Presence of skewed intersection leg with skew angle being greater than 15 degrees
- Presence of curve within 150 feet of the intersection

Table 18 shows all 11 intersections within the communities having at least one risk factor**.** The intersection of Harrison Street (SH 223) in Alpine with westbound US 67 has the highest score for total risk factors present. This is the first major intersection after westbound US 67 diverges from the eastbound direction on the east side of Alpine. The speed limit drops from 45 mph to 30 mph approximately 1,000 feet before the intersection. The intersection is within 150 feet of a curve. All these factors make the SH 223 and westbound US 67 Intersection in Alpine the highest priority intersection requiring safety improvements.

Table 18: Intersections Within Communities Score Summary

Community	Cross Street Name	US 67 Direction of Crash	Traffic Control	Occurrence of a Severe Right-Angle/ Head-on Collision	Occurrence of a Severe Pedestrian Crash	Speed Limit Change Sign within 1,000 ft of Intersection	Skewed Intersection (Skew Angle > 15 deg.)	Within 150 ft of a Curve	Total Score
Alpine	Harrison Street	WB	Flashing Beacon with Stop on SH 223	3		1		1	5
Alpine	Bird Street	EB-WB	Stop on Bird Street	1		1		1	3
Alpine	Lackey Street	EB	Stop on Lackey Street	1		1		1	3
Alpine	5th Street	EB	3-Way Stop with flashing beacon		2				2
Alpine	Orange Street	WB	Stop on Orange Street			1	1		2
Alpine	FM 1703	EB	Stop on FM 1703				1	1	2
Alpine	Phelps Street	EB	Stop on Phelps Street	1					1
Alpine	Harrison Street	EB	Stop on SH 223	1					1
Alpine	13th Street	WB	Stop on 13th Street	1					1
Alpine	Harmon Street	WB	Stop on Harmon Street		1				1
Marfa	Highland Avenue	EB	3-Way Stop with Flashing Beacon		1				1
Presidio	Howard Street	EB-WB	Driveway	1					1
Presidio	Tremont Street	EB-WB	Stop on Tremont Street	1					1

Source: TxDOT Crash Records Information System, 2010-2018

The second-highest scoring intersections are:

- US 67 and Bird Street. This intersection is at the divergence between eastbound and westbound US 67. It is on a curve and there is speed limit change within 1,000 feet.
- US 67 and Lackey Street. This intersection is located east of the Bird Street intersection.

The third-highest scoring intersections are:

- The 5th Street and eastbound US 67 intersection in Alpine where both incapacitating pedestrian crashes occurred. There was also a minor injury pedestrian crash at this intersection. The Kids Kloset business located at the northwest corner of this intersection is a pedestrian generator, as is the Alpine Amtrak station, which lies southwest of the intersection. This is a 3-way-stop controlled intersection with the width of the roadway across US 67 being 42 feet at the east end and 30 feet at the west end of the intersection.
- The Orange Street, West Sul Ross Avenue, and US 67 intersection in Alpine, which is 900 feet after the point where westbound and eastbound US 67 divide to the west of Alpine. There was one severe same-direction rear-end crash at this intersection during nighttime between two vehicles traveling eastbound. Nine hundred feet to the west of the intersection, the speed limit changes from 45 mph to 30 mph. West Sul Ross Avenue is highly skewed with respect to US 67 and intersects US 67 within 150 feet of Orange Street.
- The FM 1703 intersection, which is approximately 1,500 feet to the east of the railroad overpass in West Alpine.

The fourth-highest scoring intersections are:

- The Phelps Street and eastbound US 67 intersection in Alpine.
- The Harrison Street (SH 223) and eastbound US 67 intersection in Alpine.
- The 13th Street and westbound US 67 intersection in Alpine.
- The Harmon Street (near Sul Ross State University) and US 67 intersection in Alpine.
- US 67 and US 90 intersection in Marfa where a severe pedestrian crash occurred. This is a 3-way stop-controlled intersection with flashing beacons. The northern and southern ends of the intersection have a median divider while there is none at the eastern and western ends. The roadway widths at these two locations are approximately 47 feet. One motor vehicle traveling eastbound failed to yield the right-of-way to a pedestrian while turning left.
- The O'Reilly Street (BUS 67) and US 67 intersection in southern Presidio.
- The Tremont Street and BUS 67 intersection in Presidio.

There were also severe crashes close to fuel stations or other business attractions. For example, all three severe crashes on North Cockrell Street in Alpine were Same Direction-One Straight One Left-Turn type of crashes. The presence of a gas station at that intersection may explain the turning movements that contributed to all three crashes.

5.3 Step 3: Select Potential Countermeasures

This step selects potential countermeasures to address predominant focus crash types and identified risk factors. The countermeasures are selected through a synthesis of different reports and studies from the FHWA Office of Safety website, National Cooperative Highway Research Program (NCHRP), and discussions with study stakeholders and TxDOT. The selected countermeasures were grouped to develop projects in **Section 5.4**.

NCHRP has developed a series of guides to assist state and local agencies in reducing injuries and fatalities in targeted areas. NCHRP Report 500 contains 23 guidebooks that focus on the emphasis areas outlined in the American Association of State Highway and Transportation Officials (AASHTO) Strategic Highway Safety Plan. Each guidebook includes a general description of the problem and the strategies/countermeasures to address the problem. The NCHRP guidebooks are the basis for identifying countermeasures that may be most applicable for the US 67 safety analysis.

Based on a review of NCHRP Report 500, the study team assembled a comprehensive list of Intelligent Transportation System (ITS) and non-ITS potential countermeasures to reduce or prevent the occurrence of severe crashes based on the identified focus crash types and facility types. The countermeasures were then reviewed for their relative cost to implement and maintain, effectiveness, and timeframe for implementation and are shown in **Attachment C.**

Roadway departure crashes are the focus of this section, as they are the predominant crash type in the US 67 study corridor, with 68 percent of severe crashes between 2010 and 2018. The Transportation Research Board (TRB) sent an online survey to the Departments of Transportation (DOTs) of all 50 states to determine their experience with 20 countermeasures they selected and had an 80 percent response rate. The survey asked if the agencies had used these 20 countermeasures and the issues they experienced with them. These survey results are detailed in NCHRP SYNTHESIS 515 *Practices for Preventing Roadway Departures* by the National Academy of Sciences and TRB, effective September 2016.

The key findings from NCHRP Synthesis 515 are summarized in **Table 19** to assist TxDOT and stakeholders select potential countermeasures to prevent and reduce the severity of roadway departure crashes on the US 67 study corridor.

Table 19: Countermeasures-Advantages and Disadvantages to prevent roadway departure

Counter-measures	Most Recent Literature Findings	Percent of States Responding (%) *				Advantages/Disadvantages
		Use Counter-measure	Frequency of Use			
			Often	Sometimes	Rarely	
Edge-Line Widths Greater than the Standard 4 inch	Based on data from three states, reduction in total crashes is 15% to 30%, fatal and injury crashes is 15% to 38%, day crashes is 12% to 29%, and night crashes is -2% to 31%.	76	39	32	29	▪ Countermeasure was not cost-effective. ▪ Maintenance concerns. ▪ Wider lines make shoulder look like a bicycle lane.
Advance Curve Warning Pavement Marking (no data available)	No changes in crash data available.	27	18	0	82	▪ Maintenance concerns. ▪ Need to re-mark frequently to ensure visibility. ▪ Concern about vehicles and motorcycles sliding on the markings, particularly if thermoplastic is used.
Speed Advisory Marking in Lane	NCHRP 600 found that "Curve-55-mph" text reduced speeds on a rural road by 4 mph and curve arrow with "SLOW" text on a suburban road reduced percentage of drivers exceeding speed limit by more than 5 mph.	22	0	0	100	▪ Maintenance concerns. ▪ Need to re-mark frequently to ensure visibility. ▪ Concern about vehicles and motorcycles sliding on the markings, particularly if thermoplastic is used. ▪ Preference for using warning and regulatory signing.
Special Pavement Marking to Encourage Speed Reduction	Two studies demonstrate speed reduction benefit; one study showed minor changes in speed.	54	0	0	100	▪ Pilots were tried on two-lane and four-lane undivided highway. Probably will be replaced with the next overlay due to limited success on speed reductions. ▪ Spot treatment with limited safety benefits. ▪ Maintenance issue. ▪ Not effective long-term. ▪ Alternate countermeasures such as speed feedback signs preferable.

Counter-measures	Most Recent Literature Findings	Percent of States Responding (%) *				Advantages/Disadvantages
		Use Counter-measure	Frequency of Use			
			Often	Sometimes	Rarely	
Sequential Dynamic Curve Warning System	Several studies showed speed reductions and crash reduction of 7% to 91% at seven locations.	61	0	28	72	▪ Maintenance concerns. ▪ Countermeasure is not effective. ▪ Solar devices tend to get stolen; power source and upkeep of the devices are typically a concern. ▪ Criteria for consideration of this countermeasure needs to be identified.
Flashing Beacons on Warning Sign	A Crash Modification Factor (CMF) Clearinghouse lists a 37% to 76% reduction in various crashes based on a study from Italy.	98	23	47	30	▪ Installed on a case-by-case basis. ▪ Spot treatment that is used when standard traffic control devices have proven to be ineffective. ▪ Maintenance concerns.
Centerline Rumble Strips	Eleven states and one national study have shown that crossover crashes were reduced by 18% to 64%, with most studies showing 40% to 60%.	98	55	32	13	▪ Most districts have concerns about the reduced lifespan of the centerline pavement joint with centerline rumble strips. Districts use this treatment in conjunction with resurfacing to keep costs low.
Shoulder Rumble Strips**	Fourteen states and two multistate studies report 14% to 80% reduction in run-off-road crashes, with most reporting reductions in the 30% to 40% range.	100	85	8	7	▪ Shoulder rumble strips cause noise complaints. ▪ Concerns over bicycle conflicts.
Edge-Line Rumble Strips	On rural freeways, edge-line rumble strip single vehicle run-off-road fatal and injury crashes can be reduced by 29%.	75	59	17	24	▪ The edge-line rumble strip has the added benefit of improved visibility of striping. ▪ Used when shoulder widths are inefficient. ▪ Concerns over bicycle conflicts. ▪ Standard practice for all rural paving projects.

Counter-measures	Most Recent Literature Findings	Percent of States Responding (%) *				Advantages/Disadvantages
		Use Counter-measure	Frequency of Use			
			Often	Sometimes	Rarely	
Raised (profiled) Pavement Markings**	A study using data from two-lane and multi-lane roads in Florida and South Carolina showed only night-time wet-road crash reductions yielding a CMF of 0.908.	40	44	31	25	▪ Maintenance concerns-Easily damaged by snowplowing operations. ▪ In no-snow regions, thicker thermoplastic material provides longer service life than that of standard pavement markings. ▪ Less effective than centerline or edge-line rumble strip. ▪ Less costly.
Safety Edge	Significant reductions in fatal and injury, run-off-road, opposite direction and drop-off related crashes on two-lane rural roads. Benefit-cost ratios range from 590:1 to 1180:1 for run-off-road crashes and from 730:1 to 1460:1 for fatal and injury crashes.	85	63	26	11	▪ Several states have adopted it as part of their design standards and guidance, especially for resurfacing projects. ▪ Maintenance concerns. ▪ Negative public feedback. ▪ One state responded that it was working to incorporate this procedure into its standard practice but was receiving some resistance from contractors based on liability.
High Friction Surface Treatment	Recommended by FHWA. Kentucky used this countermeasure on 30 curves in 2009 and observed a crash reduction of 70% to 75% at these curves.	90	8	46	46	▪ Costly. ▪ One state questioned its durability.
Pavement Grooving***	New York State DOT evaluation found a 55% reduction in wet-pavement related crashes and a 23% reduction for both wet and dry pavement crashes. For diamond grooving, a significant overall benefit for total crashes was observed.	49	10	37	53	▪ Not part of a safety program but part of pavement group repair strategies. ▪ Maintenance concerns. ▪ Not proven to be cost-effective.

Counter-measures	Most Recent Literature Findings	Percent of States Responding (%) *				Advantages/Disadvantages
		Use Counter-measure	Frequency of Use			
			Often	Sometimes	Rarely	
Cable Median Barrier	Louisiana DOT concluded from several before-and-after studies that these systems are highly effective in reducing fatal and severe injury crashes, but result in an increase in total, property damage only, and minor injury collisions.	90	57	30	13	▪ Maintenance concerns. ▪ Implemented on high-volume and narrow median stretches. ▪ Have been highly effective in reducing crossover crashes in Michigan.
Tree Removal**	Clemson University researchers analyzed sites with and without adequate clear zones and concluded that South Carolina could realize a notable decrease in fatal and injury crashes if the recommended clear zones were provided.	98	10	48	42	▪ No general policy or guideline, done on a case-by-case basis. ▪ More research needed to determine at what speed levels does tree removal become more critical.
Increased Clear Zone***	None.	56	9	59	32	▪ Difficult to implement. ▪ Not cost-effective. ▪ Additional right-of-way may have to be purchased. ▪ Negative public feedback. ▪ Maintenance concerns. ▪ Increasing clear zone on the outside of horizontal curves may be cost-effective where increased banking or other countermeasures are not feasible.
Flatten Side Slope***	CMF Clearinghouse contains several CMF's for slope flattening. Flattening side slopes from 1V:3H to 1V:4H can realize a 42% reduction in injury crashes, while a side slope improvement of 1V:4H to 1V:6H can realize a 22% reduction in injury crashes.	77	10	60	30	▪ Mostly done during reconstruction. ▪ Typically, 3R (resurfacing, restoration, rehabilitation) or widening project-driven. ▪ Not proven to be cost-effective.

Counter-measures	Most Recent Literature Findings	Percent of States Responding (%) *				Advantages/Disadvantages
		Use Counter-measure	Frequency of Use			
			Often	Sometimes	Rarely	
Shoulder Widening on Curved Section	Highway Safety Manual states crash reduction between 2% to 13% observed when 8 ft or more shoulder width provided instead of 6 ft on rural two-lane roads.	73	10	57	33	▪ Mitigates truck off-tracking issues. ▪ Maintenance concern. ▪ Would be done as part of a paving project. ▪ Not effective. ▪ Requires right-of-way. ▪ Done in the past for erosion control issues rather than safety.
Increase Sight Distance on Curves**	CMFs developed from a recent study of curve realignments are: Total Crashes: 0.315 Injury and Fatal: 0.259 Run-off-road plus fixed object: 0.216. Benefit-cost ratio range of 1.75:1 to 4.38:1.	94	3	58	39	▪ Costly. ▪ May include right-of-way acquisition. ▪ Done on a case-by-case basis and as part of reconstruction.
Superelevation Improvement**	Highway Safety Manual provides a function for calculating CMFs for horizontal curves for two-lane rural roads based on Superelevation variance.	93	11	43	46	▪ Typically, 3R (resurfacing, restoration, rehabilitation) project-driven and done on a case-by-case basis.

Notes: *Percentage based on 41 states responding.
**Percentage based on 40 states responding.
***Percentage based on 39 states responding.

Source: NCHRP SYNTHESIS 515 Practices for Preventing Roadway Departure, 2016

NCHRP Synthesis 515: Practices for Preventing Roadway Departures also provided countermeasures used by other states. Examples are provided below.

- **Fluorescent yellow sheeting**: Noted by Alabama DOT, this can improve the effectiveness of curve warning signs and delineation signs by increasing visibility.
- **Culvert extensions**: Noted by Hawaii DOT, this is a roadside improvement that might prevent rollovers or vehicles hitting a fixed object.
- **LED in-pavement lighting**: Noted by Colorado DOT and by Ohio DOT as being used on interchange ramps and rural curves.
- **Motorcycle barrier attenuator**: Noted by Utah DOT, this attaches to a standard roadside guardrail to protect errant motorcyclists from impacting the guardrail post during crashes.

5.4 Step 4: Develop Projects

The objective of this step is to support TxDOT and other involved agencies in implementing safety projects along the at-risk locations, thereby reducing the predominant type of severe crashes.

5.4.1 Projects approved by TxDOT

TxDOT has already begun implementing various safety-related projects along the US 67 study corridor as listed below.

- **Addition of Passing Lanes.** There are multiple projects in and around the corridor which are scheduled to upgrade the roadways to a Texas Super Two Passing Lanes (a periodic passing lane is added to a two-lane rural highway to allow the passing of slower vehicles and the dispersal of traffic platoons. The passing lane will alternate from one direction of travel to the other within a section of roadway allowing passing opportunities in both directions):
    - The Odessa District selected Pecos County to implement two projects along US 67. The limits of these projects are from I-10 to 16.8 miles south of I-10 (15.8 miles) and from 16.8 miles south of I-10 to the Brewster County line (11.7 miles). These projects are being finalized for construction. The estimated construction cost is $33M and the anticipated construction let date is Spring of 2021.
    - An 18.7-mile stretch along US 67, from 9 miles south of RM 169 to 22.9 miles north of FM 170. Along this stretch, TxDOT also plans on working on safety treatment of fixed objects.
- **Safety Treat Fixed Objects.** TxDOT has initiated four projects related to safety in terms of fixed objects, in different areas on the US 67 study corridor. These projects aim to remove, relocate or safety treat all fixed objects including the installation of guardrail for safety treatment of a fixed object or drainage structures within the project limits, including both, point and continuous objects. In addition to the safety improvements along the earlier mentioned 18.7-mile stretch from south of RM 169 to 22.9 miles north of FM 170, there are three more projects in the finalizing stage for construction:
    - A 0.2-mile stretch from 9.2 miles south of I-10 to 9.4 miles south of I-10.
    - A 1.4-mile stretch from 1 mile west of Brewster County Line to 2.4 miles west of Brewster County Line.
    - A 1.4-mile stretch located between the Presidio and Brewster County Line.
- **Pedestrian & Bicycle Facilities.** Several sidewalk and bicycle-lane projects have been funded under the Transportation Alternatives Set-Aside Program to enhance the multimodal transportation within Presidio and Marfa:
    - Marfa: A total of $280,490 in funding was awarded to construct a shared use path in Marfa.

- Presidio: A total of $4.1M in funding was awarded to improve the pedestrian and bicycle facilities in Presidio.

5.4.2 Safety analysis recommendations

This technical memorandum is part of a larger overall Corridor Master Plan. As such, the safety projects described below should be considered as potential considerations and as an input into the overall plan. Some of these projects will be superseded due to redundancy and/or irrelevancy by other recommended projects. Therefore, this section is intended to be more inclusive of all potential safety projects, even if some of them are not included in the final corridor plan.

Segments outside of the communities

All identified at-risk segments outside of the communities with a score above 3.75 (refer to **Table 14**) would be prioritized to receive safety improvements. Recommendations for the US 67 study corridor segments are as follows:

- All segments are recommended to have centerline and shoulder/edge rumble strips. The shoulder/edge rumble strips should include a 12-foot wide gap every 40 feet to 60 feet to provide bicyclists better access to the roadway lane and to avoid hazards and debris. Gaps are needed because rumble strip pavement depressions can cause a bicyclist to fall. All segments are recommended to have advanced warning signs following Manual on Uniform Traffic Control Devices (MUTCD) guidelines.

- Traveler information systems are recommended to help travelers plan their trips. The recommendation is to add small Dynamic Message Signs (DMS) approaching and leaving Alpine, Marfa, and Presidio. The DMS would provide motorists with travel time information, traffic conditions, road incidents and safety/public service. Providing information before a traveler departs the communities, allows travelers to decide to delay their trip rather than become stranded in a rural area exposed to the elements with no services. This recommendation is provided in greater detail in **Appendix G – Intelligent Transportation Systems (ITS) Plan**.

- The dynamic speed feedback system would help to reduce the speeds of incoming motorists as they enter the communities. Dynamic speed feedback systems are recommended to be placed at a few select locations between Marfa and Alpine, where a cluster of speeding-related severe crashes have been observed.

- Wildlife Warning Systems are recommended for locations that experienced a cluster of animal-related severe crashes. Crashes tend to be located throughout the study corridor, but concentrations are present between Presidio and Marfa and between Alpine and I-10. This recommendation is provided in greater detail in Appendix G – Intelligent Transportation Systems (ITS) Plan.

- A Highway Rail Grade Crossing Safety System is recommended in control segment 0075-02 at the crossing of US 67 and Old Alpine Highway. This system provides detection and warnings for stopped or slow-moving vehicles at and near the crossing. This improvement may be more directly applicable to the future when train and vehicular operations increase. This recommendation is provided in greater detail in Appendix G – Intelligent Transportation Systems (ITS) Plan.
- Rest areas and/or turnouts are recommended between Marfa and Presidio and between the US 67/US 90 intersection and I-10 interchange where there is an abundance of distraction-related crashes.
- Passing lanes are recommended for segment 0104-07 (north of Shafter), segment 0020-11 (between Paisano Pass and Alpine), segment 0075-02, and segment 0075-03 (in Odessa district south of I-10).
- Safer slopes are recommended for non-recoverable slopes along the sides of the roadway.
- Guardrails are recommended to be placed along roadway segments with deficient clear zones that cannot be remedied via the use of safer slopes. The design of existing guardrails and end treatments would be improved if deemed necessary.
- Shoulders are recommended to be widened to 10 feet in areas where shoulder width is currently less than 10 feet. This includes all the segments between Marfa and Presidio that currently have a shoulder width of 6 feet and passing lane segments in the rest of the corridor where shoulder widths vary from 0 feet to less than 10 feet.
- Tree-trimming and brush removal within clear zones will also be recommended for all segments.

Horizontal curves outside of the communities

All identified high priority curves outside of the communities with a score of 1 or above (refer to **Attachment B**) would qualify to receive some type of safety treatment. Per TxDOT Roadway Design Manual Table 2-3, the absolute minimum horizontal curve radius is 1,810 feet for a design speed of 70 mph based on emax of 8 percent. Various countermeasures have been proposed based on the radius of the existing curve and the proximity to a severe crash. These countermeasures are based on the MUTCD recommendations as well as traffic analysis and include measures such as proposing an advisory speed sign prior to the curve, chevron signs, and flashing beacons. **Table 20** provides improvement details as well as the number of curves each proposed set of countermeasures will impact.

Table 20: Horizontal Curve Countermeasures Criteria

Criteria	Countermeasure	Count
Radius of curve less than 1,810 ft and presence of severe crash within 150 feet of curve	Sequential Dynamic Curve Warning Sign	7
Radius of curve less than 1,810 ft and no presence of severe crash within 150 feet of curve	Flashing Beacon	10
Radius of curve between more than 1,810 ft and presence of severe crash within 150 feet of curve	Chevron Sign	17
Radius of curve between more than 1,810 ft and no presence of severe crash within 150 feet of curve	Horizontal Curve Warning Sign	39
If existing superelevation is lower than minimum superelevation	Adjust Superelevation	88
Curves with a maximum superelevation but still need side friction	High Friction Surface Treatment	30
If Curve Design Speed < Speed Limit	Advisory Speed Limit Sign	32
Radius of curve greater than 10,000 ft	None	24

According to the *Texas Manual on Uniform Traffic Control Devices Section 2C.07 Horizontal Alignment Signs*, where there are two changes in roadway alignment in opposite directions that are separated by a tangent distance of less than 600 feet, the reverse turn sign should be used instead of multiple turn signs. This guidance was used for the recommendations on the horizontal curve warning sign placement on US 67 and was expanded for placing flashing beacons. One flashing beacon would be used for a group of consecutive curves when each of the curves is separated by a tangent distance of less than 600 feet. This is most applicable for control section 0104-08 (near Shafter) where multiple consecutive curves were grouped to get a single flashing beacon and an advisory speed limit sign in each travel direction. Curves with deficient superelevation rates are recommended to receive superelevation treatment.

Project sheets

Based on the above recommendations, a list of safety improvement projects was developed for the at-risk segments between communities. Recommended improvements for each segment outside of the communities, broken down by short-(up to 5 years), mid-(5 to 10 years), and long-term (10 plus years) improvements and associated costs (assuming 2019 average unit prices) are shown in **Attachment D**. The total cost for these projects is $332,100,000.

Segments within the communities

The general approach for recommending safety improvements within the communities along US 67 study corridor includes the following:

- For intersections that are at risk for severe crashes involving pedestrians and bicycles, pedestrian hybrid beacons and bicycle safety systems are recommended. In general, for all intersections, Americans with Disabilities Act (ADA) compliant sidewalks and curb returns, raised intersections, curb extensions, tighter curb radius, and median pedestrian refuges

between opposite-direction travel are recommended. In addition, it is recommended to move parking lanes away from the intersection to improve visibility at the intersection.

- Recommend striping all crossings. High visibility ladder, zebra, and continental crosswalk markings are preferable to standard parallel or dashed pavement markings. Recommend placing an advanced stop bar at least eight feet in advance of the crosswalk.
- For all segments within the communities, raised medians separating opposite directions of traffic and controlled access management techniques are recommended. This is applicable for Marfa, Presidio, and Alpine two-way streets. Midblock crosswalks and curb extensions are also recommended for blocks longer than 400 feet between intersections, e.g., in Alpine between 8th Street and 10th Street, 11th Street and 13th Street, and Garnett Street and 2nd Street.
- Bicycle lanes, with a minimum of a four-foot buffer distance from the travel lane, are recommended on both sides for two-way streets and one side for one-way streets. Bicycle lanes would be striped through key intersections with distinct green markings and bicycle parking would be provided at key destinations.
- Two low bridge locations in Alpine are candidates for an over-height vehicle detection system. Both systems would provide active flashers and a warning when over-height vehicles are approaching the bridges.
- Recommend providing adequate lighting at all intersections.
- Recommend improving existing pavement marking and signage at all locations.

Detailed analysis of at-risk intersections

Intersections with risk factors higher than the corridor average were studied in more detail. Eighteen intersections and interchanges along the US 67 study corridor met this criterion. Five out of the 18 intersections and interchanges are located outside of the communities and 13 intersections are located within the communities. These intersections and interchanges were studied holistically as potential candidates for safety, design, and ITS improvements.

To supplement the Systemic Approach to Safety methodology described in **Section 3.0** and given the low number of severe crashes (non-incapacitating injury, incapacitating injury, and fatal crashes) at these selected intersections, a more detailed crash analysis was performed for the 18 intersections based on the nine years (2010-2018) of crash data, available imagery, field visits, bus tour notes, and discussions with TxDOT. With the available data, collision diagrams were prepared for each of the intersections to include all crash severities (non-injury, possible injury, non-incapacitating injury, incapacitating injury, and fatal crashes) to better understand the causes and trends, if any, of these events.

Out of the 18 intersections, only six intersections were eventually identified as potentially warranting an ITS improvement. Four of these intersections have a recommended potential improvement that

utilizes some type of flashing lights. The majority of the remaining intersections will benefit from new pavement marking and signage changes. While some of the issues could be addressed with simple pavement striping changes, some are more suited for long-term solutions, as they would involve changing the alignment or complete reconfiguration of the intersections.

Table 21 shows all 18 intersections, with the type of potential suggested improvements. Collision diagrams are provided along with potential geometric and ITS improvements in **Attachment E**. Recommendations are made from safety and operational perspective on proposed short, medium, and long-term solutions whenever applicable. The geometric improvements are provided in greater detail in **Appendix N – Alternatives Analysis**. **Figure 18** shows the potential 18 at-risk intersections along the corridor.

Table 21: At-Risk Intersections and Type of Improvement

No.	Intersection/Interchange	ITS	Other*	Geometric Concepts
1	BUS 67/ O'Reilly St and Howard Street	✓		✓
2	BUS 67/O'Reilly St and Tremont Street		✓	
3	US 67 and Old Rd 170 and Utopia Road		✓	✓
4	US 67 and Cibolo Creek Rd		✓	
5	Highland Avenue and San Antonio Street	✓		✓
6	US 67 and FM 1703		✓	✓
7	US 67 and Orange Street		✓	✓
8	Holland Avenue and 13th Street	✓		✓
9	Holland Avenue and 5th Street		✓	✓
10	Holland Avenue and Phelps Street		✓	
11	Holland Avenue and Harrison Street		✓	✓
12	E Avenue and Harrison Street	✓	✓	✓
13	E Avenue and Bird Street		✓	✓
14	US 67 and Lackey Street		✓	✓
15	US 67 and Harmon Street		✓	
16	US 67 and US 90 Interchange		✓	✓
17	US 67 at Old Alpine Highway (Railway Crossing)	✓		
18	US 67 and I-10 Interchange	✓		✓

* Other includes a recommendation to improve and maintain striping, lighting, signing, and pavement markings

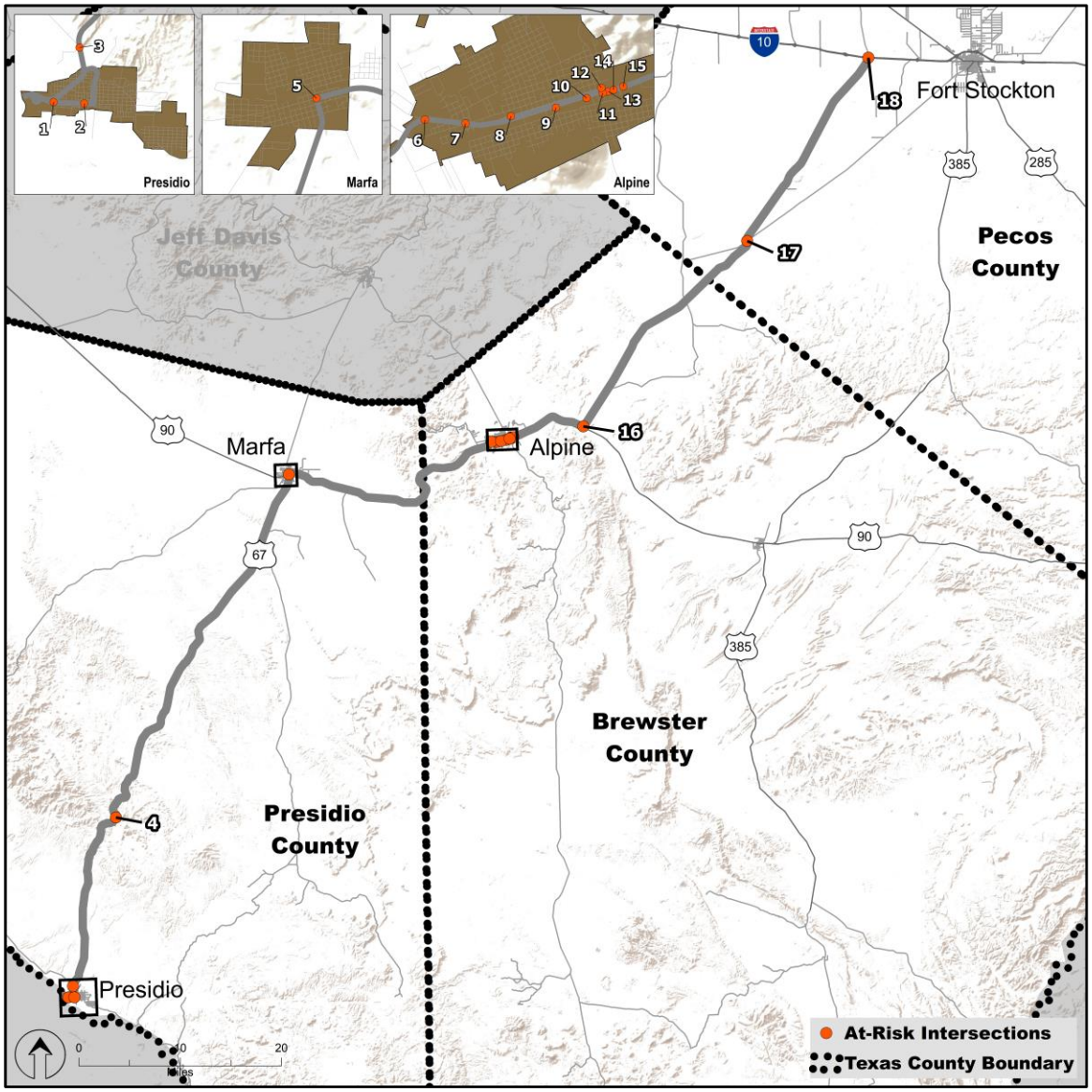


Figure 18: At Risk Intersections

6.0 Predictive Safety Analysis

The next step in performing the safety analysis for the US 67 study corridor is to evaluate the potential safety impact of implementing the recommendations. The Highway Safety Manual (HSM) published by AASHTO was used for evaluating the safety performance of the geometry-related improvements. The HSM analysis was limited to the geometry-related countermeasures and a few low-cost recommendations due to the limitations of the analysis tools. The purpose of the predictive analysis is to forecast the number of crashes by severity and type and evaluate the safety performance before and after accounting for the recommended countermeasures along the US 67

study corridor. **Section 7.0** will utilize the results of this analysis to perform a benefit-cost analysis to determine if the selected geometry-related countermeasures are financially feasible.

6.1 HSM Analysis Tools

The HSM includes the Interactive Highway Safety Design Model (IHSDM), a suite of software analysis tools used to evaluate the safety and operational effects of geometric design decisions on highways, and its Enhanced Interchange Safety Analysis Tool (ISATe) software for freeways, for its predictive crash methodology. According to FHWA, "IHSDM is a decision-support tool that provides estimates of a highway design's expected safety, performance, and checks existing or proposed highway designs against relevant design policy values." The latest version available at the time of this analysis was IHSDM 14.0.0 released on September 26, 2018 and was used to produce the results presented in this memorandum.

The study team performed the IHSDM analysis on the seven at-risk US 67 study corridor segments (see **Table 14**) based on the selected risk factors in **Section 5.2.1** using IHSDM. At the I-10 and US 67 interchange, the FHWA's spreadsheet-based ISATe was used to forecast crashes before and after improvements. The two crash forecasting models estimate different future years; the IHSDM calculates 2045 and the ISATe calculates 2040.

6.2 IHSDM Analysis on Freeway Segments

6.2.1 Modeling input

All geometric, traffic volume, and traffic control data available for US 67 were coded within IHSDM. Data input requirements vary with each roadway type, whether freeway, arterial, ramp, or ramp terminal. Most of the data were obtained from as-built drawings, a review of Google Earth images, CRIS data, and STARS II traffic data. The following list provides the data inputs for IHSDM, as applicable.

- Evaluation Duration
- General: area type, functional classification
- Geometric data of road segments:
  - Passing lanes
  - Number of lanes and lane width
  - Cross slopes
  - Inside and outside shoulder width
  - Horizontal and vertical curves
  - Driveway densities

  - Bicycle facilities
  - Design and posted speed
- Traffic volume and observed crash data
- Other data: terrain, lighting, and shoulder rumble strips

6.2.2 Available countermeasures

The IHSDM countermeasures are useful when considering changes to the highway geometry and crash history. The IHSDM available countermeasures are limited to the following:

- Horizontal curve geometrical changes
- Vertical curve geometrical changes
- Addition of passing lane
- Addition of climbing lane
- Shoulder widening
- Access management
- Centerline rumble strip
- Shoulder rumble strip
- Adding Guardrail (Roadside Hazard Rating)
- Edge risk reduction (Roadside Hazard Rating)
- Street lighting
- Speed enforcement

6.2.3 Results

The Crash Prediction Module of the IHSDM was used to predict the frequency, type, and severity of crashes for each of the seven at-risk segments for the following three scenarios:

- **Existing (2010-2017)**[7]: The results of the predicted number of crashes were compared to the observed number of crashes to validate the existing data with the IHSDM process. Also, this scenario was used as a base to estimate the reduction in the number of crashes for future No-build and Build scenarios.
- **Future No-build (2020-2045)**: The corridor segments included TxDOT approved projects in addition to the existing (2010-2017) model.
- **Future Build (2020-2045)**: The corridor segments included approved projects and the recommended countermeasures.

[7] At the time of the IHSDM analysis performed in December 2018, the only crash data available for the corridor was 2010 – 2017.

Existing (2010-2017) analysis

The IHSDM analysis was performed to calculate the predicted number of crashes in the time period of 2010 to 2017, with the existing conditions data inputs. This was done to validate the model using the existing observed crash data. **Figure 19** compares the number of actual and predicted crashes per mile in the selected control sections. It can be noted that in five of the sections, the predicted crashes have been slightly over or underestimated except for control section 0020-11 (east of Alpine), where the predicted crashes are 200 percent of the actual crashes. Hence, the decision was made to perform a comparative study to determine the reduction in the number of crashes between the No-Build and the Build scenarios and apply the reduction percentage to the observed number of crashes. The comparative analysis between the different scenarios didn't include calibration due to the limitation of available data.

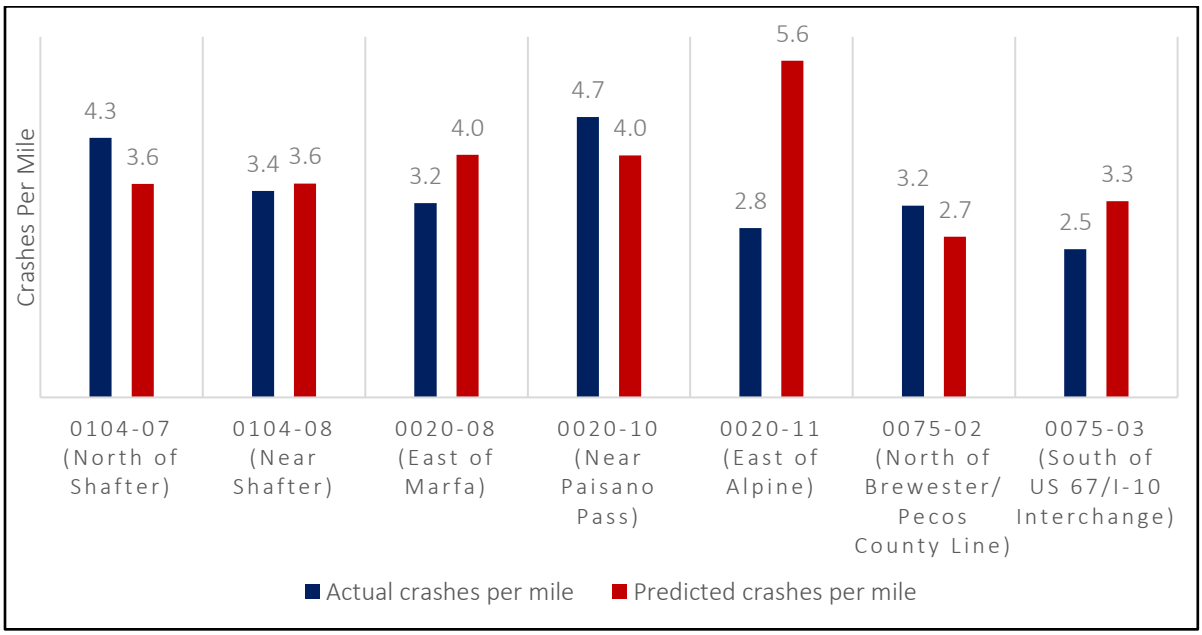


Figure 19: Observed versus Predicted Crashes Per Mile for Years 2010 to 2017

Future No-build and Build (2020-2045) analysis

The IHSDM analysis was run for the future No-build scenario (2020-2045). This step determined the predicted number of crashes in the future if no improvement was made to the existing conditions. This was followed by an analysis of the Build scenario. Different countermeasures were chosen to be applied to these control sections using the Crash Modification Factors (CMFs) for the Build scenario. **Table 22** summarizes the countermeasures that were applied for the respective sections.

Table 22: Countermeasures Applied to Respective Sections

Countermeasures	0104-08 Near Shafter	0104-07 N. of Shafter	0020-08 E. of Marfa	0020-10 Paisano Pass	0020-11 East of Alpine	0075-02 N. of Brewster/ Pecos County Line	0075-03 S. of US 67/ I-10 Interchange
Lighting			✓	✓			
Shoulder Rumble Strips	✓	✓					✓
Centerline Rumble Strips	✓	✓	✓	✓	✓		✓
Shoulder Widening	✓	✓	✓	✓	✓		✓
Superelevation Adjustment	✓	✓	✓		✓	✓	
Guardrail Extension	✓	✓	✓	✓	✓		
Texas Super 2 Passing Lanes		✓			✓	✓	
Safer Side Slopes						✓	✓

The study team then completed the IHSDM analysis for the 2045 improved segments with CMFs applied. These results were then post-processed to reflect the variance between the actual 2017 crash data and the IHSDM predicted 2017 crashes. **Attachment F** summarizes the IHSDM output for the seven at-risk segments, including the evaluated length, AADT, total crashes (summarized by severity), crash rate, and a comparison between future No-build and Build scenarios.

The tables summarized in **Attachment F** show that for all the sections, the Build scenario crash rate (per 100 million vehicle miles) is consistently decreasing 20 to 40 percent compared to the No-build scenario. **Figure 20** shows the total number of crashes along each at-risk control segment for the No-build scenario and the Build scenario during a period of 25 years between 2020 and 2045.

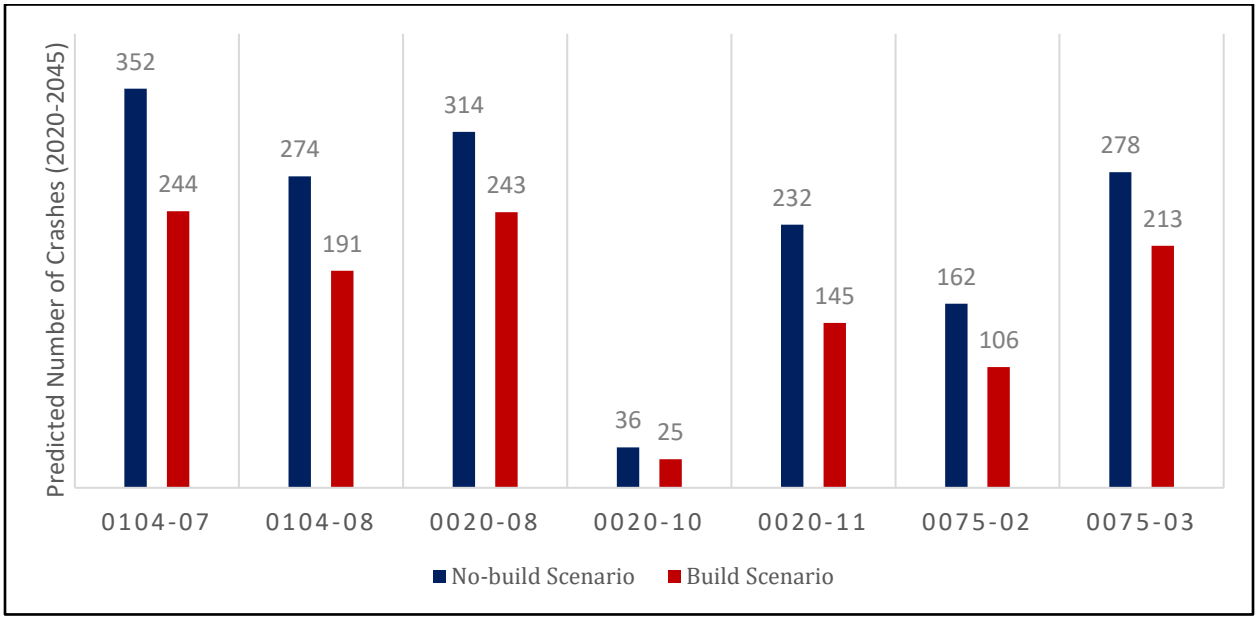


Figure 20: Predicted Crashes for No-build and Build Scenarios for years 2020-2045

6.3 ISATe Analysis on US 67 and I-10 Interchange

The ISATe quantifies the relationship between various design elements (e.g., lane width, left-turn bay, etc.) and average crash frequency. The ISATe software, which is based on algorithms and equations implemented in a Microsoft ® Excel ® workbook was used to evaluate the I-10/US 67 interchange safety. The crash estimation process involved estimating the crashes individually for:

- Freeway (HSM, Chapter 18)
- Ramps (HSM, Chapter 19)
- Ramp Terminals (HSM, Chapter 19)

The safety performance of the US 67 and I-10 interchange was performed using ISATe. First, the interchange boundary, entrance and exit ramps, and ramp terminals were defined as shown in **Figure 21**. Next, the geometry of the different interchange components and the projected future AADT volumes was added and the model was run for the No-build scenario to summarize the safety performance for a duration of 20 years between the years 2020 and 2040.

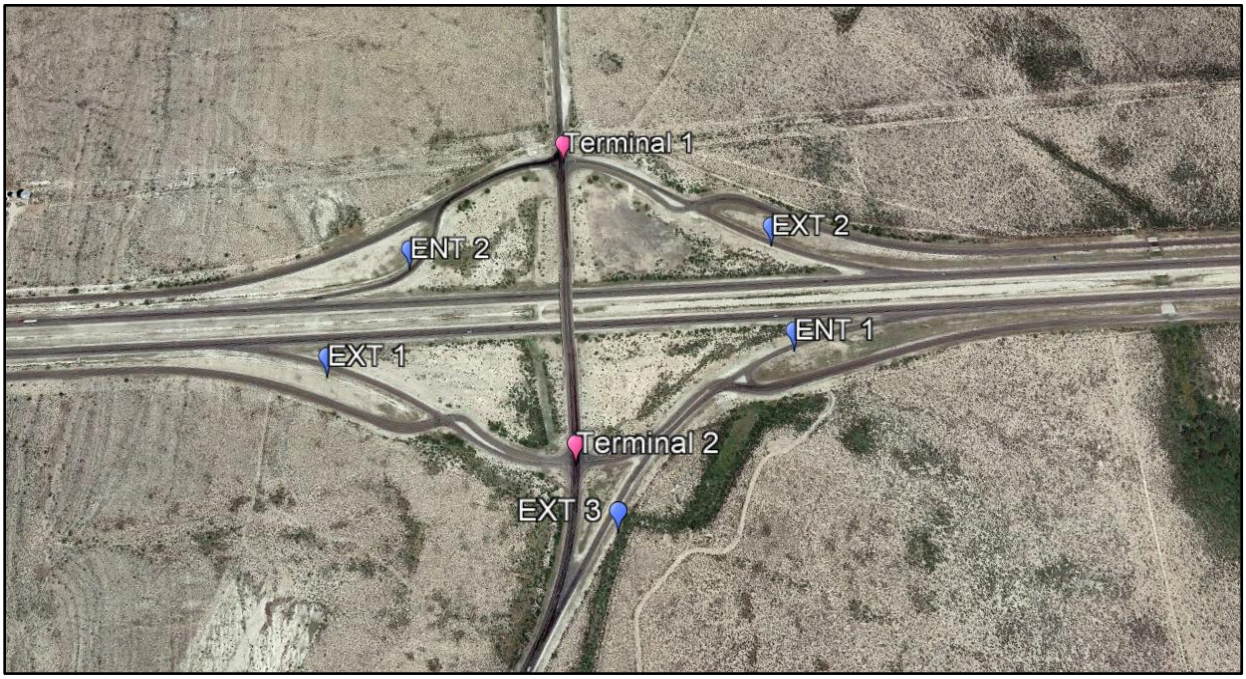


Figure 21: US 67 and I-10 Interchange Components

The study team analyzed the Build scenario with the addition of the following countermeasures:

- Recommend removal of the redundant northbound exit ramp (EXT 3) from US 67 to I-10 to avoid merge conflict.
- Recommend increasing the exit ramp deceleration and taper lengths for ramps EXT 1 and EXT 2 to 780 feet per TxDOT Roadway Design Manual's recommended value for speed change lane length.
- Recommend increasing the entrance ramp acceleration and taper lengths for ramps ENT 1 and ENT 2 to 1,110 feet per TxDOT Roadway Design Manual's recommended value for speed change lane length.

Attachment G summarize**s** the predicted number of crashes for the freeway segments, entrance and exit ramps, and ramp terminals for the No-build and the Build scenarios. Since the improvements address the ramps and ramp connections to the freeway, there is only a slight decrease in the number of crashes for the ramps and improved crash severity for the freeway segments under the Build scenario.

7.0 Benefit-Cost Analysis

Appendix C – Development of Goals and Objectives identified safety as a critical local concern, warranting improvements. Various safety-improvement options were considered, and a preliminary project list was developed. A benefit-cost analysis (BCA) was conducted herein to assess the economic feasibility of selected countermeasures that were analyzed using IHSDM in **Section 6.2**. An overview of the BCA methodology and assumptions is followed by a summary of results and conclusions.

7.1 Methodology and Assumptions

A BCA was conducted for the seven at-risk US 67 segments. Characteristics of the improvement types, roadway segments, and related crashes were compiled and incorporated into the analysis. Such data-enabled modeling and assumptions regarding timing, costs, and safety-related benefits. Modeling output was then monetized and compared via standard BCA metrics: net present value (NPV) and benefit-cost ratio (BCR). An overview of general BCA methodologies is followed by specific scenario, cost, and benefits assumptions.

7.1.1 Methodology

BCA is a quantitative process of determining if a project, program, or policy alterative is societally worthwhile given certain assumptions. It compares expected monetized benefits against the incremental cost of implementing over the alternative's lifecycle. BCAs typically follow four broad steps, with details contingent on project complexity:

1. **Define project/program and assumptions** – baseline and alternatives, lifecycle horizon, cost and benefit timing and categories, and discount rate(s)

2. **Calculate implementation costs** – e.g., construction, operations, maintenance, etc.
3. **Calculate benefits** – e.g., safety, environmental, time, etc.
4. **Conduct BCA and standard metrics** – BCR, NPV, Internal Rate of Return (IRR), Payback Period, etc.

Of the four, benefits are typically the most complex. Regardless of potential complexity, the BCA framework enables standardized and comparable metrics that help identify if an alternative is economically worthwhile to implement. Such metrics are defined as:

- **Net Present Value (NPV)** – discounted benefits less discounted costs; a positive monetary value indicates the investment is economically feasible. Effectively, the absolute gain (or loss) in current net worth associated with the alternative.
- **Benefit-Cost Ratio (BCR)** – discounted benefits divided by discounted costs; a ratio greater than 1.0 indicates the project is economically feasible. Effectively, the relative multiplier on the alternative's investment.
- **Internal Rate of Return (IRR)** – discount rate at which the present value of the benefits is equal to the present value of the costs; an IRR greater than the threshold discount rate (either 3 percent or 7 percent) indicates the project is economically feasible. Effectively, the yield on an alternative, indicates the relative speed in which benefits are returned. In instances, an IRR is incalculable, which may occur when benefits are notably insufficient and/or costs are varied and staggered (as herein).
- **Payback Period** – the timeframe threshold in which the net benefits offset the costs of implementing, beyond which, additional benefits are a surplus. Effectively, the time required for a project or program to break even.

Benefits are compared with costs across a multi-year period for the different results metrics, which provide different perspectives as to the dollar-magnitude, relativity, robustness, and timeframe of implementing an alternative project. Each metric provides a different perspective, but the economic feasibility can be determined by any metric. Herein, only the NPV and BCR are presented for simplicity.

7.1.2 Scenario Assumptions

Safety improvements were identified for seven at-risk sections of US 67. Characteristics of the segments are shown in **Table 23**; and, an identification of which safety improvement types are associated with each segment is depicted in **Table 24**.

Table 23: Roadway Characteristics

Section:	2	3	5	7	8	11	12	US67
Section Name:	0104-08	0104-07	0020-08	0020-10	0020-11	0075-02	0075-03	Total
Roadway Characteristics								
Length (miles)	13.1	18.3	13.6	1.5	7.1	11.9	15.8	81.3
Number of lanes	2	2	2	4	2	2	2	2.04
Current (2016)								
AADT	1,570	1,637	2,697	2,703	2,714	1,572	1,646	1,909
Average speed (mph)	70	70	75	70	70	75	75	73
VMT (daily)	20,567	29,957	36,679	4,055	19,269	18,707	26,007	155,241
VHT (daily)	294	428	489	58	275	249	347	2,140
Future (2045)								
AADT	2,481	2,907	4,789	4,800	4,820	2,484	2,923	3,296
Average speed (mph)	70	70	75	70	70	75	75	73
VMT (daily)	32,501	53,198	65,137	7,200	34,219	29,560	46,184	267,999
VHT (daily)	464	760	868	103	489	394	616	3,694

Table 24: Safety Improvement Types by Segment

Section:	2	3	5	7	8	11	12
Section Name:	0104-08	0104-07	0020-08	0020-10	0020-11	0075-02	0075-03
Lighting	N	N	Y	Y	N	N	N
Shoulder Rumble Strips	Y	Y	N	N	N	N	Y
Centerline Rumble Strips	Y	Y	Y	Y	Y	N	Y
Adjust Super-Elevation	Y	Y	Y	N	Y	Y	N
Extend Guardrail	Y	Y	Y	Y	Y	N	N
Design Safer Slope	N	N	N	N	N	Y	Y
Widen Shoulders	N	N	N	Y	Y	N	N

Years and Timing – 2019 is the analysis year, with costs and benefits through the year 2045, expressed in 2018 constant dollars. Safety improvements are assumed to occur during three periods: the short-, mid-, or long-term. Short-term is assumed to occur within 5 years; mid-term is assumed for five to ten years later; and, long-term is assumed for more than ten-years later. All safety projects are assumed to be constructed within a year and benefits are assumed to realize in the following year and thereafter through 2045. Projects are assumed short-, mid-, and long-term accordingly:

- **Short-term** – lighting, shoulder rumble strips, centerline rumble strips
- **Mid-term** – adjust super-elevation, extend guardrail, design safer slope
- **Long-term** – widen shoulders

Discounting – Costs and benefits in constant dollars (excluding inflation) are applied to a real discount rate to account for the opportunity cost and timing differences associated with diverting

investment resources. In accordance with the United States Office of Management and Budget (OMB) Circular A-94[8], public infrastructure feasibility analyses are instructed to apply a real discount rate (i.e., net of the inflation rate) of 7 percent per year. As the 7 percent real discount rate may be steep, the OMB recommends also applying an alternative, lower real discount rate of 3 percent. BUILD grant guidelines now only require a 7 percent real discount rate; however, both 3 and 7 percent are applied and presented below.

7.1.3 Cost Assumptions

Safety-related improvement costs are based on unit costs (e.g., dollars per mile of rumble strip), units (e.g., miles of rumble strips), and segment need assumptions. Costs are then allocated to the respective year for short-, mid-, and long-term types. Unit assumptions hinge on data sourced from the following:

- TxDOT El Paso District Average Low Bid Unit Prices
- TxDOT Odessa District Average Low Bid Unit Prices
- TxDOT Statewide Average Low Bid Unit Prices
- Costs for Pedestrian and Bicyclist Infrastructure Improvements Report (October 2013)[9]

Such cost data were amended with additional considerations: mobilization (10%), contingencies (25%); engineering (10%); and traffic control (10%), for a total unit cost in constant dollars, as tabulated in **Table 25**; total costs with a percentage breakdown by improvement type are presented in **Table 26**.

Table 25: Unit Cost Assumptions

Safety Improvement	Unit Cost	Unit
Lighting	$10,000	each
Shoulder Rumble Strips	$800	mile
Centerline Rumple Strips	$1,650	mile
Adjust Super-Elevation	$120	ton
Extend Guardrail	$160,000	mile
Design Safer Slope	$50	cubic yard
Widen Shoulders	$1,300,000	mile

[8] United States Office of Management and Budget (OMB) Circular A-94 https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/circulars/A94/a094.pdf

[9] Bushell, M.A., Poole, B.W., Zegeer, C.V., & Rodriguez, D.A. (2013). *Costs for Pedestrian and Bicyclist Infrastructure Improvements: A Resource for Researchers, Engineers, Planners, and the General Public*. Chapel Hill, NC: University of North Carolina, Chapel Hill, Highway Safety Research Center.

Table 26: Total Cost Assumptions (millions)

Section:	2	3	5	7	8	11	12
Section Name:	0104-08	0104-07	0020-08	0020-10	0020-11	0075-02	0075-03
Lighting	0.0%	0.0%	49.9%	1.8%	0.0%	0.0%	0.0%
Shoulder Rumble Strips	0.7%	1.7%	0.0%	0.0%	0.0%	0.0%	0.8%
Centerline Rumple Strips	0.8%	1.7%	5.9%	0.1%	0.7%	0.0%	0.8%
Adjust Super-Elevation	59.1%	51.2%	31.5%	0.0%	5.7%	32.3%	0.0%
Extend Guardrail	39.4%	45.5%	12.6%	6.6%	17.3%	0.0%	0.0%
Design Safer Slope	0.0%	0.0%	0.0%	0.0%	0.0%	67.7%	98.3%
Widen Shoulders	0.0%	0.0%	0.0%	91.5%	76.3%	0.0%	0.0%
Total	$2.84	$1.76	$0.38	$2.19	$1.57	$0.56	$3.10

Costs for each segment range from $380,000 for the least expensive segment (0020-08) to $3.1 million for the most expensive (0075-03). Short-term improvements are the relatively least expensive, comprising just 3.4 percent of the total, with the remaining mid- and long-term improvements each about a fourth or fifth of the total, each.

7.1.4 Benefit Assumptions

Safety improvement benefits stem from traffic crash reductions, resulting in fewer fatalities, injuries, and/or property damages. Recent historical crash-related data (2010-2018) were extracted from the CRIS database by segment in terms of annual affected people (fatalities and injuries) and vehicles (property).

Reductions in current and future crashes were modeled for the segments via IHSDM. IHSDM model calculates baseline and alternative estimates of KABCO-scaled crashes for a current and future year (K=Killed; A=Incapacitating; B=Non-Incapacitating; C=Possible Injury; O=No Injury, or Property-Damage-Only). IHSDM calculates changes for Killed, Injured, and combined.

Baseline historical crashes (**Table 27**) were annually averaged and extrapolated through the year 2045 based on the IHSDM, which is mostly driven by assumed growth in AADT – about 2.0 percent annually.

Table 27: Baseline Crashes 2010-2018

Section:	2	3	5	7	8	11	12	US67
Section Name:	0104-08	0104-07	0020-08	0020-10	0020-11	0075-02	0075-03	Total
Total Crashes (2010-'18)								
K - Killed	3	0	1	1	0	4	3	12
A - Incapacitating	6	13	7	1	0	4	3	34
B - Non-Incapacitating	17	20	15	2	9	12	13	88
C - Possible Injury	6	5	7	5	7	10	7	47
O - No Injury	61	103	44	3	14	36	40	301
Average Annual								
K - Killed	0.333	0.000	0.111	0.111	0.000	0.444	0.333	1.333
A - Incapacitating	0.667	1.444	0.778	0.111	0.000	0.444	0.333	3.778
B - Non-Incapacitating	1.889	2.222	1.667	0.222	1.000	1.333	1.444	9.778
C - Possible Injury	0.667	0.556	0.778	0.556	0.778	1.111	0.778	5.222
O - No Injury	6.825	11.429	4.921	0.317	1.587	3.968	4.444	33.492
Average Annual / million VMT								
K - Killed	0.044	0.000	0.008	0.075	0.000	0.065	0.035	0.024
A - Incapacitating	0.089	0.132	0.058	0.075	0.000	0.065	0.035	0.067
B - Non-Incapacitating	0.252	0.203	0.124	0.150	0.142	0.195	0.152	0.173
C - Possible Injury	0.089	0.051	0.058	0.375	0.111	0.163	0.082	0.092
O - No Injury	0.909	1.045	0.368	0.215	0.226	0.581	0.468	0.591

The IHSDM forecasting models estimate base and future years; it calculates 2016 and 2045. Interim years are interpolated/extrapolated from the average annual growth. Relative crash savings are tabulated in **Table 28**.

Table 28: IHDSM Crash Reduction Estimates

Section:	2	3	5	7	8	11	12
Section Name:	0104-08	0104-07	0020-08	0020-10	0020-11	0075-02	0075-03
Base Year (2016)							
Killed or Injured	-29.4%	-18.3%	-21.4%	-26.7%	-18.6%	-12.4%	-23.6%
Property Damage	-29.1%	-18.2%	-19.2%	-29.2%	-18.6%	-12.4%	-23.3%
Future Year (2040)							
Killed or Injured	-30.5%	-18.3%	-19.1%	-27.8%	-18.7%	-12.2%	-23.4%
Property Damage	-30.5%	-18.3%	-19.0%	-29.6%	-18.6%	-12.5%	-23.3%

Annual crash savings by segment are estimated for each analysis year by KABCO-scale based on historical fatalities, injuries and property damage, modeling growth rates, and modeling reduction estimates. Such annually-estimated crash reductions are scaled over the short-, mid-, and long-term phasing of the safety improvement types to reflect the staggered investments and ensuing results.

Safety-related benefits are monetized for comparison with the implementation costs by applying statistical values of life, injuries, and property damage, as sourced from the FHWA BUILD guidelines[10], shown in **Table 29**.

Table 29: FHWA Cost per Crash Assumptions

Severity	Cost
K - Killed	$9,600,000
A - Incapacitating	$459,100
B - Non-Incapacitating	$125,000
C - Possible Injury	$63,900
O - No Injury	$3,200

With the crash saving assumptions applied, the results over the 2020 to 2045 benefits timeframe are presented in **Table 30**, depicting the total savings in KABCO-scaled crashes for the segments and the total undiscounted monetization of those savings. Note that segments 3 and 8 have no fatalities avoided given no historical/modeled fatalities were observed or estimated in the baseline.

Table 30: Crash Benefits Summary (2020-2045 Total)

Segment	K	A	B	C	O	Undiscounted Benefits
2 (0104-08)	3.1	6.3	17.8	6.3	63.9	$35,786,236
3 (0104-07)	0.0	8.9	13.7	3.4	70.2	$6,237,713
5 (0020-08)	0.7	5.1	11.0	5.1	31.5	$11,153,609
7 (0020-10)	0.9	0.9	1.9	4.7	2.9	$9,996,733
8 (0020-11)	0.0	0.0	5.5	4.3	8.7	$987,456
11 (0075-02)	1.5	1.5	4.6	3.8	14.0	$16,306,262
12 (0075-03)	2.6	2.6	11.5	6.2	35.0	$28,568,412
Total	9.1	25.6	66.8	34.6	226.7	$110,038,196

7.2 Results

Annual costs and resultant benefits associated with safety improvement scenarios (defined by project types and segments), are evaluated within a standard BCA framework. Future costs and benefits are discounted (at both 3 and 7 percent) and summarized below by NPV and BCR; full-table calculations are tabulated in **Attachment H**.

Results, which are summarized in **Table 31,** indicate that all but segment 8 are economically feasible, with positive NPVs and BCRs greater than 1.0 at both the 3 and 7 percent real discount rates applied. Segment 8 is economically infeasible at either discount rate, mostly because the baseline and forecasted crash types do not include the relatively higher-valued fatalities or incapacitating injuries;

[10] https://www.transportation.gov/sites/dot.gov/files/docs/mission/office-policy/transportation-policy/14091/benefit-cost-analysis-guidance-2018.pdf

it only has relatively lower-value injuries and property damage that are insufficient to warrant the $1.5 million expenditures.

Table 31: BCR Results Summary

Segment	NPV (millions)		BCR	
	3%	7%	3%	7%
2 (0104-08)	$20.70	$12.04	9.421	6.903
3 (0104-07)	$2.49	$1.16	2.634	1.911
5 (0020-08)	$6.88	$4.08	20.256	13.295
7 (0020-10)	$4.60	$2.48	3.783	3.131
8 (0020-11)	($0.61)	($0.54)	0.500	0.391
11 (0075-02)	$9.68	$5.39	21.172	14.594
12 (0075-03)	$15.88	$9.14	6.919	5.105
Total	$60.12	$34.01	6.684	4.997

NPV – The two most expensive segments (segment 2 and 12) yield the largest net present value (greatest societal value), due to the largest fatality reductions.

BCR – While segments 2 and 12 exhibit the largest societal NPV, they do not exhibit the highest "bang-for-the-buck" return. Instead, segments 5 and 11 yield the highest BCRs because they are the relatively cheapest yet and are estimated to save about one human life over the analysis horizon (in addition to injuries and property damage). The effectiveness of these relatively low-cost safety improvements in mitigating crashes results in the relatively high BCRs.

8.0 Conclusion

Safety concerns along US 67 expressed by members of the public prompted identification of potential safety improvements that could be implemented on certain segments along the study corridor, including lighting, rumble strips, guardrails, and other relatively easily-implementable and low-cost options. The effectiveness of such improvements assessed the historical traffic incidents/crashes along US 67 and modeled the expected reductions in such future crashes via specialized and tailored software.

The analysis described in this technical memorandum followed the FHWA HSIP procedures which are built on a data-driven, strategic approach to improving highway safety. This safety analysis relied on TxDOT CRIS data to understand safety trends and safety concerns along US 67. This database contains nine years of crash records from 2010 to 2018 with various tables including crash types, the number of vehicles, driver information, and vehicle characteristics.

The traditional safety analysis for US 67 included the evaluation of all the crash data for the number of crashes, crash types, crash severity, crash rates, crash locations, lighting condition, and crashes involving animals, bicycles, and pedestrians, to name a few. This analysis provided a corridor level review for all crashes for nine years of data.

To make the greatest impact, the study team used the FHWA Systemic Approach to Safety, to focus on the most severe crashes (non-incapacitating, incapacitating, and fatal). This approach focuses on the data to address the root cause of each severe crash and then apply appropriate countermeasures. It was found that out of the 103 non-intersection related severe crashes occurring outside of the communities, 87 (84 percent) were run-off-the-road crashes (Roadway Departure Crashes). Out of the 36 severe crashes occurring within communities, 26 (72 percent) were intersection-related crashes.

Risk Factors for these crash types were identified from the FHWA *Systemic Safety Project Selection Tool* and input from stakeholders and the public. These risk factors were then evaluated on the 12 TxDOT control segments of the study corridor and countermeasures were selected to address them. NCHRP Synthesis 515 provided state DOT guidance on relevant countermeasures and aided in the process.

The next step of the safety effort was to develop a plan to implement safety projects along the at-risk segment locations, thereby reducing the predominant type of severe crashes. During the safety analysis, TxDOT selected some easy to implement projects in response to the safety analysis and stakeholder recommendations.

Using specific crash reduction criteria, project sheets were developed for each of the control sections on the corridors showing the recommended improvements along with unit/cost information.

Complementary to the Systemic Approach to Safety analysis, an HSM based IHSDM Analysis was performed for specific geometric improvements. The HSM analysis was instrumental to quantify the crash reductions which ranged between 12 percent and 31 percent as a result of implementing the proposed projects.

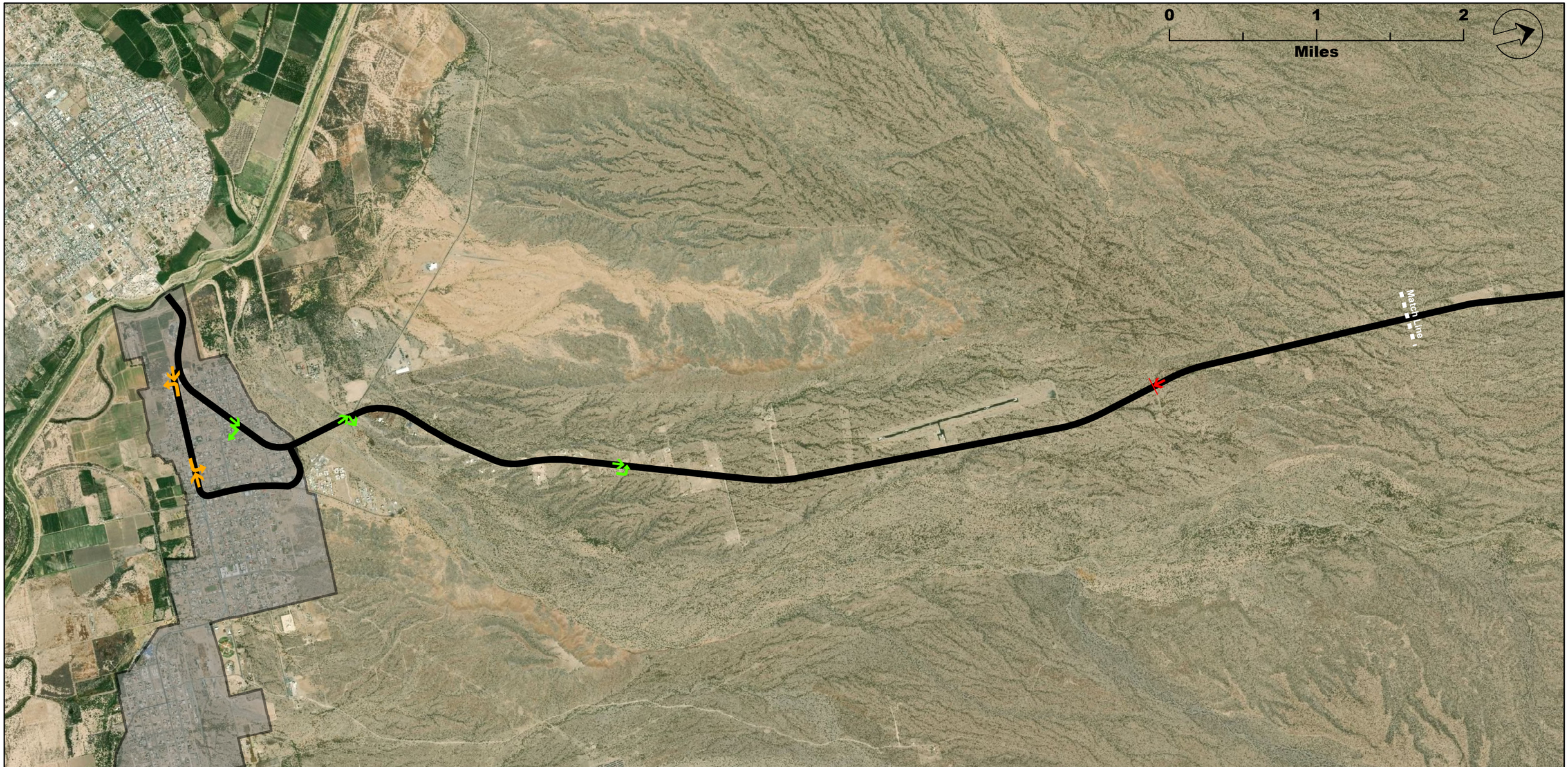
Results of the safety modeling were monetized via FHWA BUILD grant guidance and compared with estimated incremental costs of implementing the improvements in a benefit-cost analysis. Results indicate that all but one of the segments and improvement scenarios yield economically-justifiable results, with positive NPVs and BCRs greater than 1.0. If all segments/interchange/projects are implemented, costing an estimated $12.6 million, the NPV would range between $34.0 and $60.1 million, with a BCR between 5.0 and 6.7, depending on the real discount rate applied. Generally, the BCRs are high by traditional transportation-related standards; as a result, the relatively low-cost options are expected to yield savings of at least 9 fatalities through 2045 (in addition to injuries and property damage). Such crash savings stemming from such relatively low-cost options are highly efficient and are worthwhile to pursue, given available funding.

US 67 CORRIDOR
MASTER PLAN

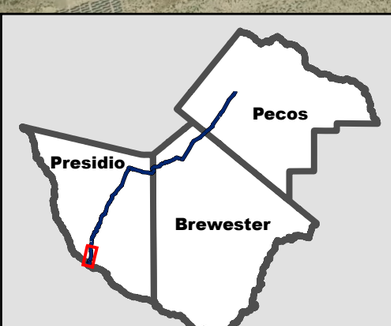
Attachment A
Collision Diagrams

February 2020

Texas Department of Transportation



US 67 Safety Assessment
Collision Diagrams
by Severity
Sheet 1 of 15



US 67 CORRIDOR
MASTER PLAN

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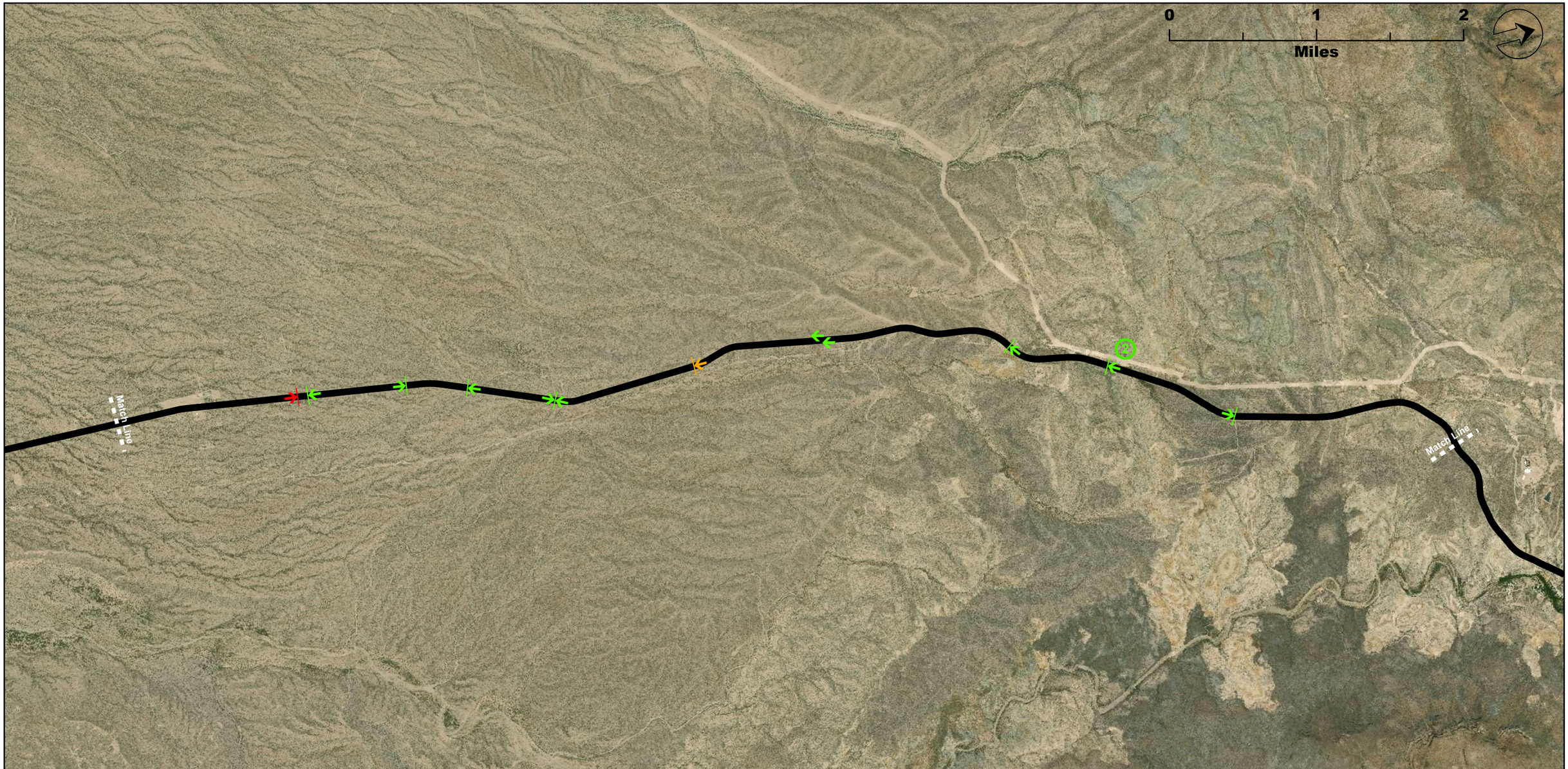

US 67 Safety Assessment
Collision Diagrams
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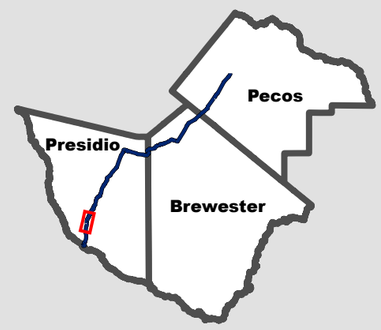
Sheet 2 of 15



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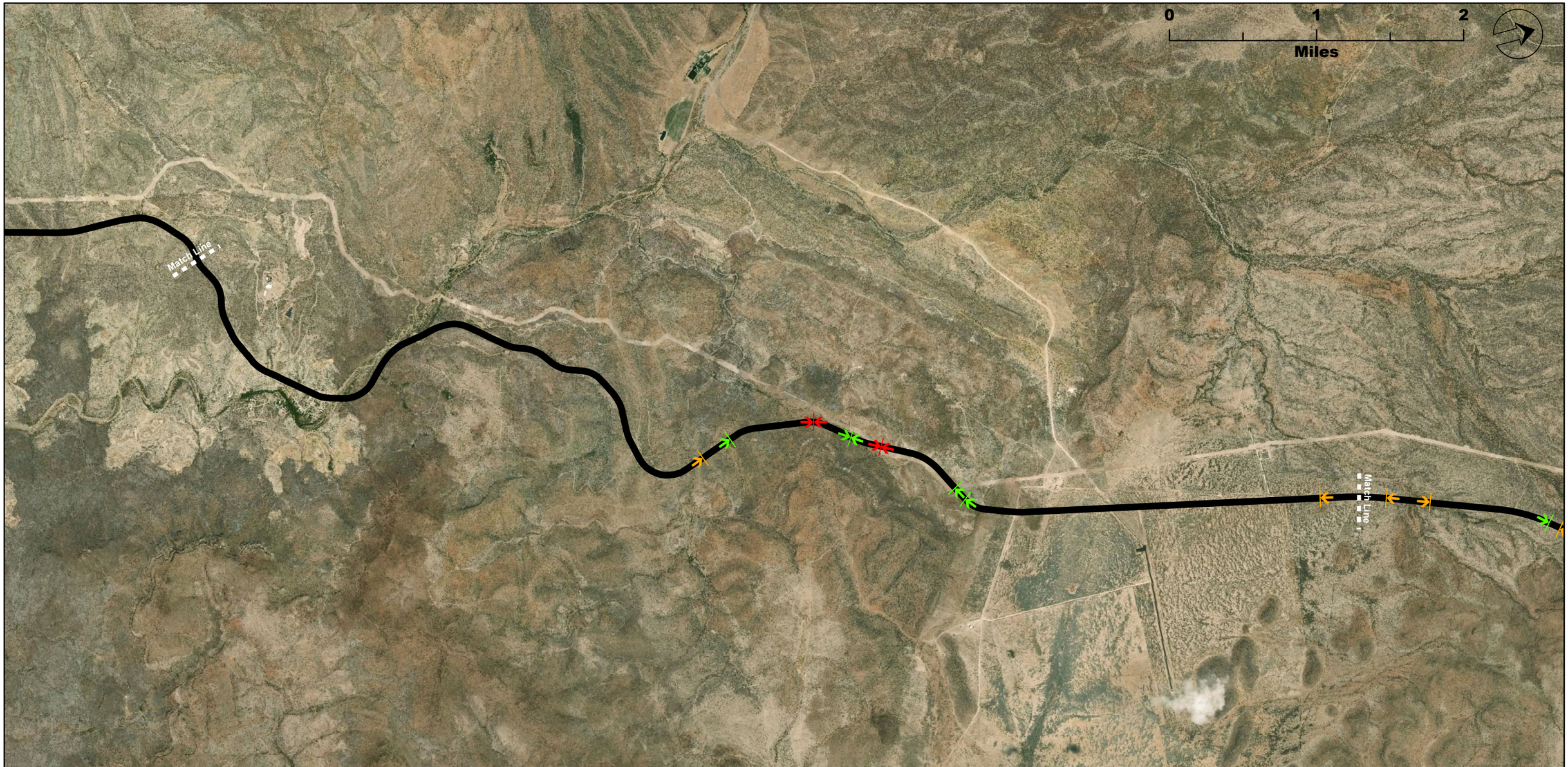

US 67 Safety Assessment
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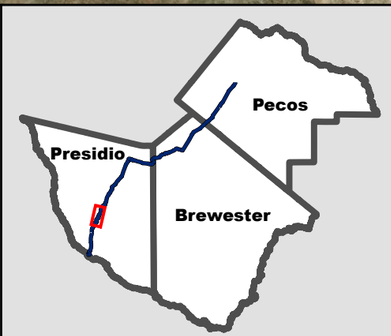
Sheet 3 of 15



US 67 CORRIDOR
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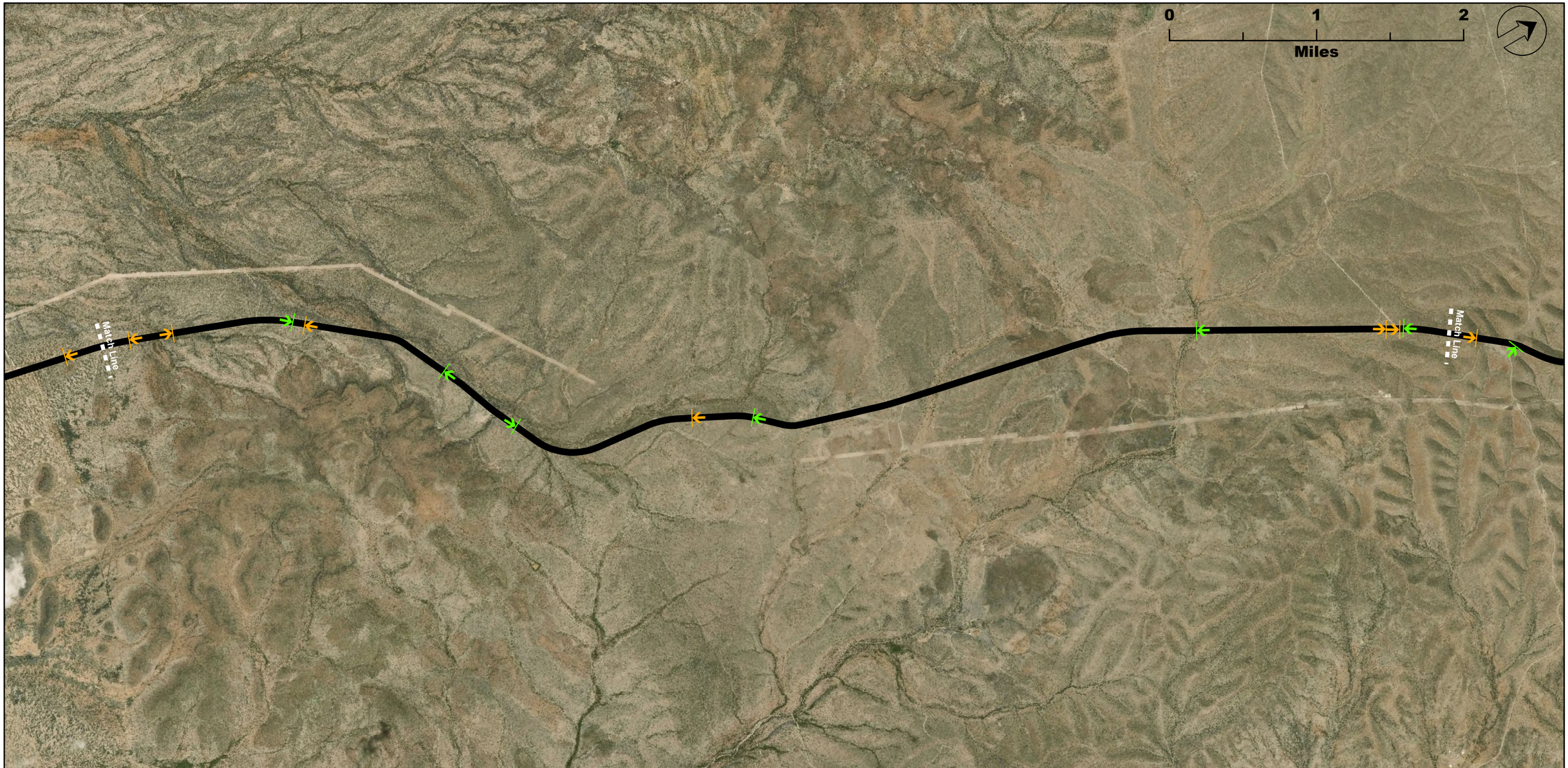

US 67 Safety Assessment
Collision Diagrams
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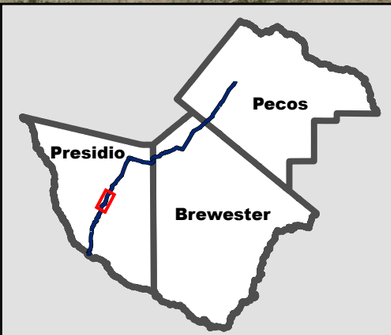
Sheet 4 of 15



US 67 CORRIDOR
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US 67 Safety Assessment
Collision Diagrams
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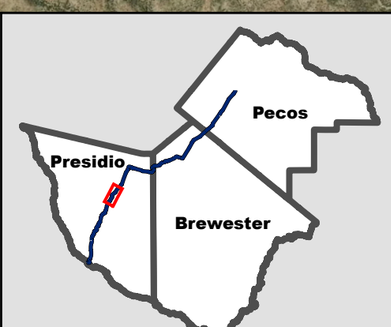
Sheet 5 of 15



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US 67 Safety Assessment
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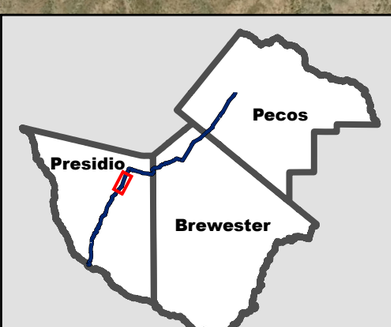
Sheet 6 of 15



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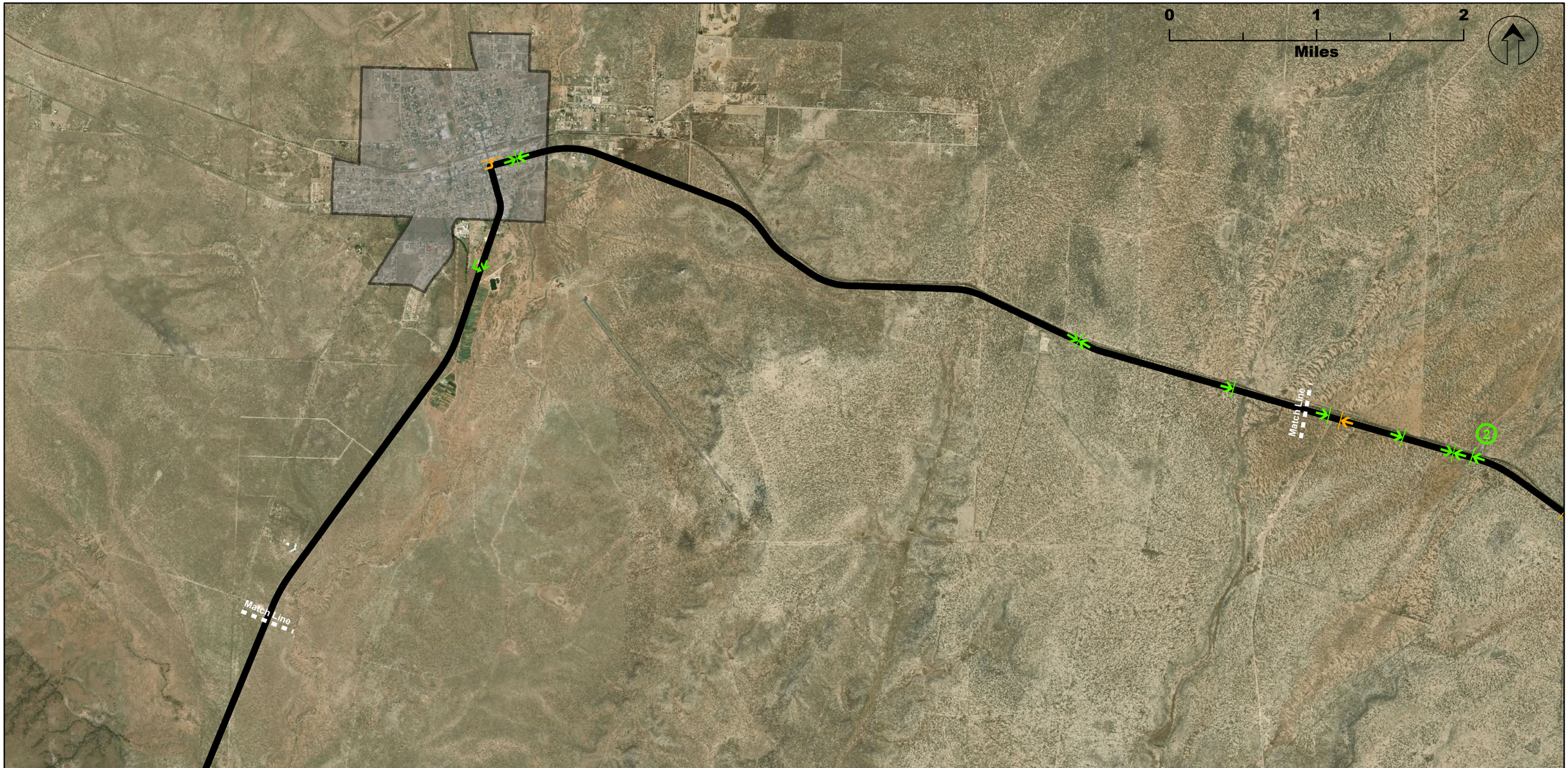

US 67 Safety Assessment
Collision Diagrams
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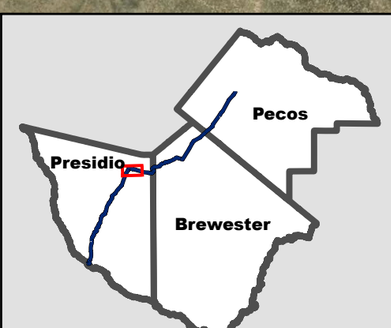
Sheet 7 of 15



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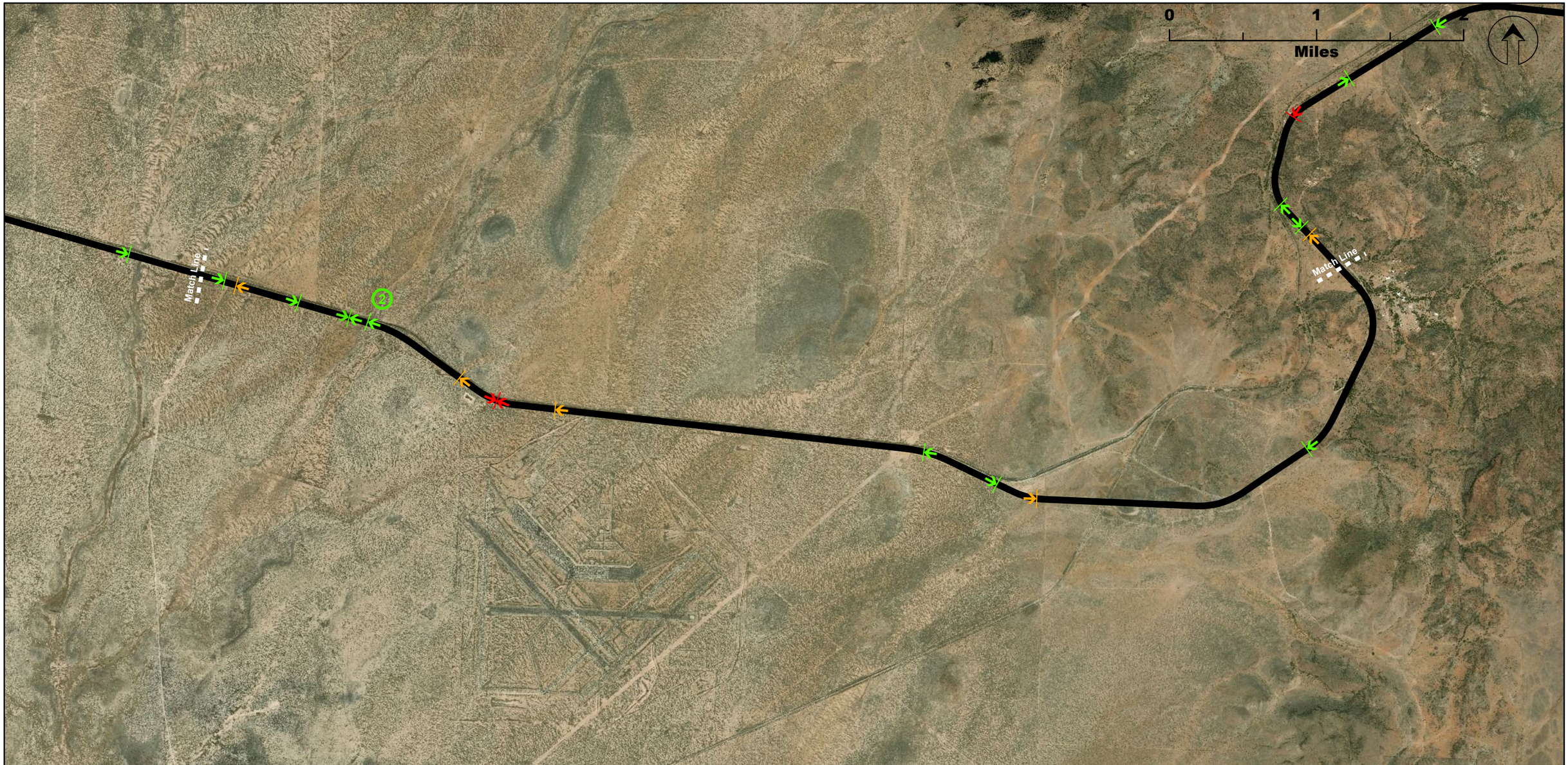
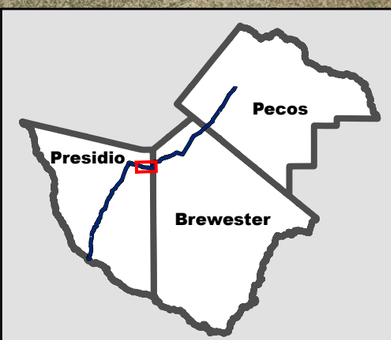


US 67 Safety Assessment
Collision Diagrams
by Severity
Sheet 8 of 15



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US 67 Safety Assessment
Collision Diagrams
by Severity
Sheet 9 of 15

US 67 CORRIDOR
MASTER PLAN

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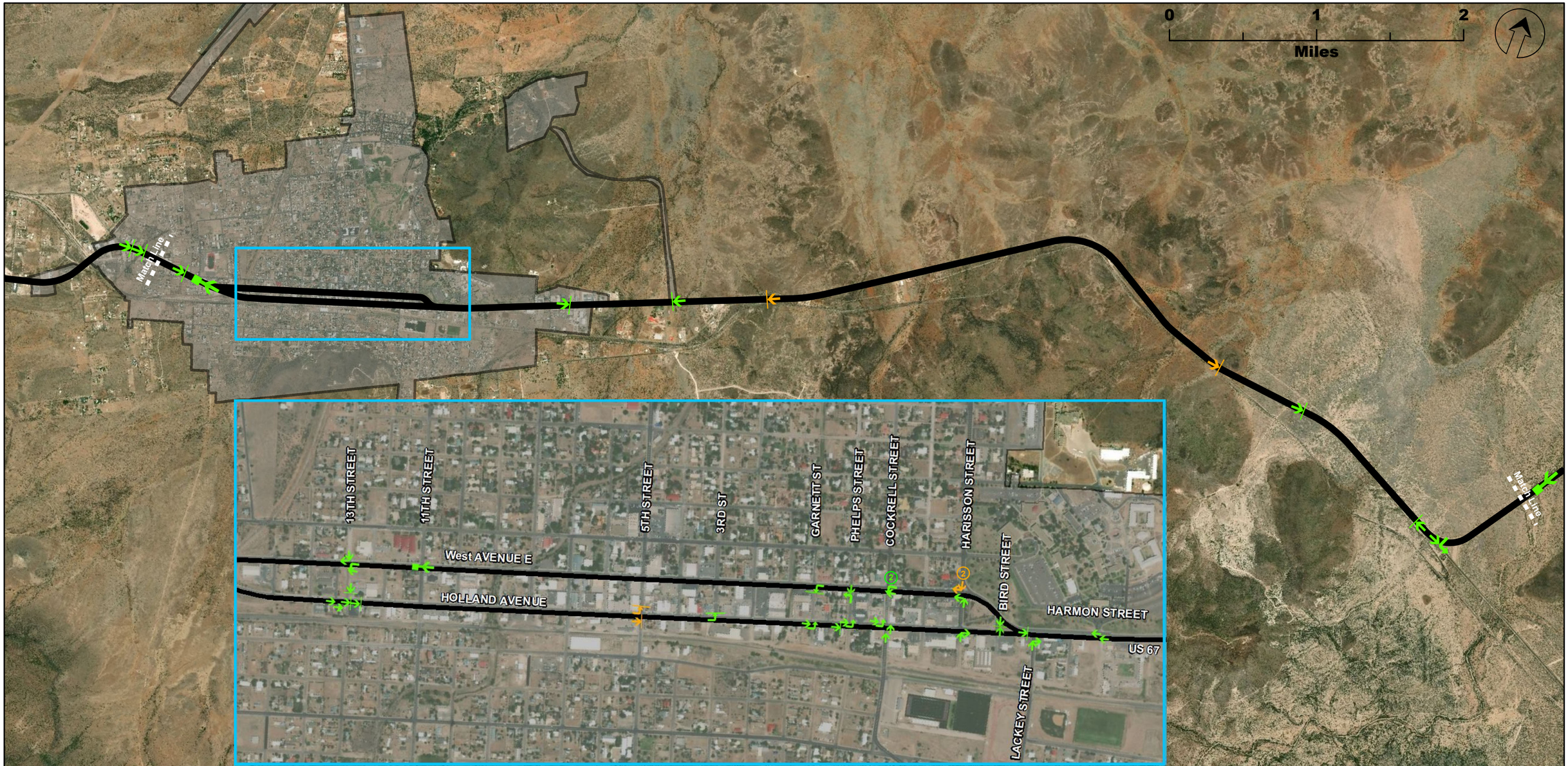
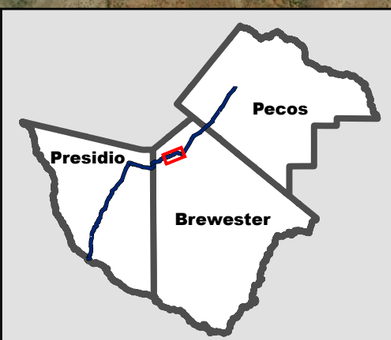


US 67 Safety Assessment
Collision Diagrams
by Severity
Sheet 10 of 15



OUR 67
US 67 CORRIDOR
MASTER PLAN

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US 67 Safety Assessment
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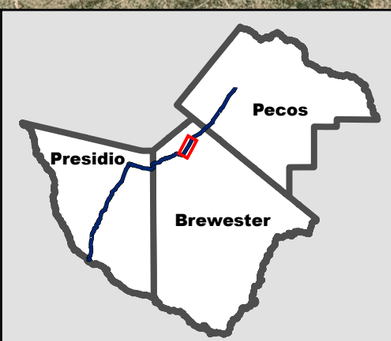
Sheet 11 of 15



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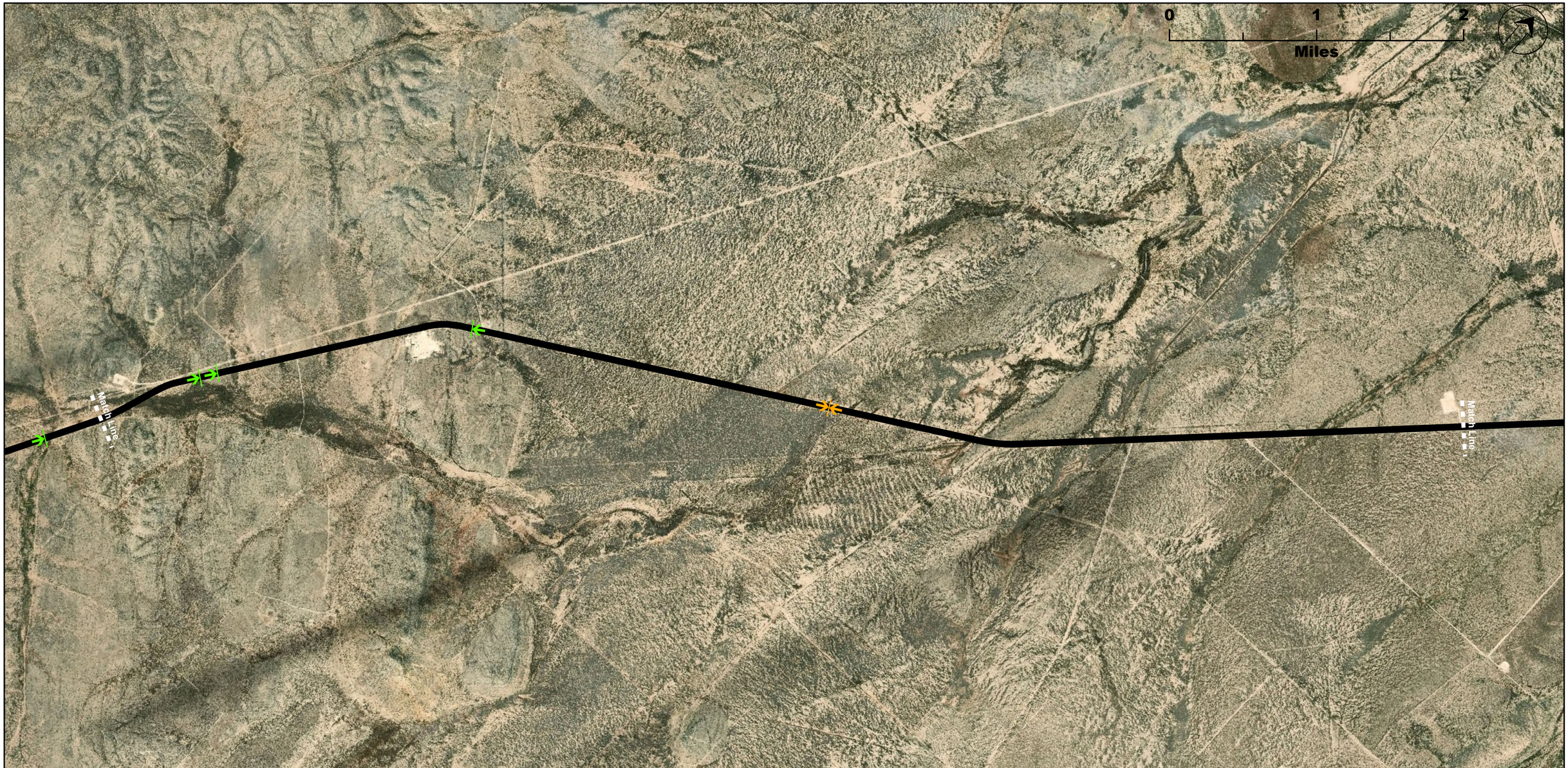

US 67 Safety Assessment
Collision Diagrams
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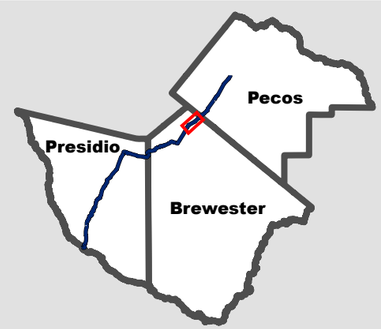
Sheet 12 of 15



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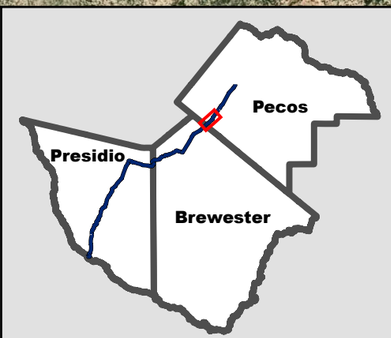

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US 67 Safety Assessment
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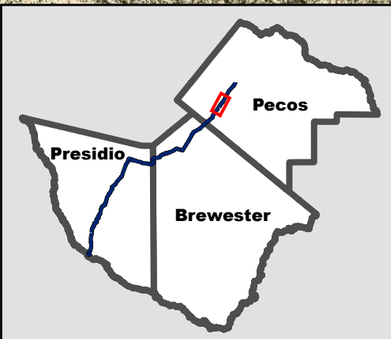

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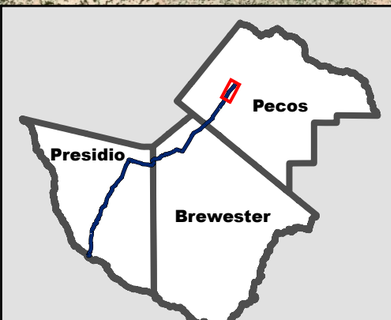

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US 67 CORRIDOR
MASTER PLAN

Attachment B

Horizontal Curve Data and Superelevation Analysis

February 2020

Texas Department of Transportation

Table 1: US 67 Horizontal Curve Data

Curve Control Section	Degree of Curve	Radius (ft)	Length (ft)	Radius Less than 1800 ft	Occurrence of a Severe Crash	Total Score
0104-06-C4	1.0	5,730	750	0	1	1
0104-07-C3	4.0	1,433	900	1	2	3
0104-07-C4	4.0	1,433	1,273	1	2	3
0104-07-C6	4.0	1,433	435	1		1
0104-07-C8	2.0	2,865	772	0	1	1
0104-07-C9	1.0	5,730	952	0	1	1
0104-07-C12	4.0	1,433	660	1		1
0104-07-C13	2.0	2,865	817	0	1	1
0104-07-C18	4.0	1,433	651	1		1
0104-07-C19	1.0	5,730	1,831	0	1	1
0104-07-C20	0.5	11,460	1,685	0	1	1
0104-08-C2	5.0	1,146	840	1	1	2
0104-08-C4	2.0	2,865	612	0	1	1
0104-08-C5	5.0	1,146	629	1	1	2
0104-08-C6	4.0	1,433	688	1		1
0104-08-C7	5.0	1,146	1,917	1		1
0104-08-C9	4.0	1,433	750	1		1
0104-08-C10	5.0	1,146	879	1		1
0104-08-C11	4.5	1,274	793	1		1
0104-08-C12	4.5	1,274	778	1		1
0104-08-C13	4.5	1,274	453	1		1
0104-08-C14	5.0	1,146	813	1		1
0104-08-C15	4.0	1,433	346	1		1
0104-08-C18	5.0	1,146	1,238	1		1
0104-08-C19	4.5	1,274	524	1		1
0104-08-C20	4.0	1,433	626	1		1
0104-08-C21	4.0	1,433	377	1		1
0104-08-C22	4.0	1,433	514	1		1
0104-08-C23	4.5	1,274	880	1		1
0104-08-C24	4.0	1,433	548	1		1
0104-08-C25	5.0	1,146	709	1		1
0104-08-C26	4.0	1,433	1,007	1		1
0104-08-C31	2.0	2,865	1,055	0	1	1
0104-08-C32	4.5	1,274	995	1	1	2
0104-08-C34	4.0	1,433	542	1		1
0104-09-C1	4.0	1,433	703	1		1
0104-09-C3	4.0	1,433	675	1		1
0104-09-C4	3.0	1,910	492	0	1	1
0104-09-C5	4.0	1,433	613	1		1
0104-09-C14	3.0	1,910	1,947	0	1	1
0020-08-C1	2.2	2,651	187	0	1	1
0020-08-C3	2.0	2,881	1,826	0	1	1
0020-08-C4	2.0	2,892	1,154	0	1	1
0020-08-C5	1.3	4,581	1,519	0	1	1
0020-08-C7	1.3	4,432	1,511	0	1	1
0020-10-C1	3.5	1,638	1,648	1	1	2
0020-10-C2	3.5	1,638	1,253	1	1	2

Curve Control Section	Degree of Curve	Radius (ft)	Length (ft)	Radius Less than 1800 ft	Occurrence of a Severe Crash	Total Score
0020-11-C1	1.5	3,820	3,059	0	1	1
0075-01-C2	2.0	2,865	1,254	0	1	1
0075-02-C2	2.0	2,865	1,412	0	3	3
0075-02-C4	2.0	2,865	2,839	0	1	1
0075-02-C5	2.0	2,865	2,037	0	1	1
0075-03-C3	1.0	5,730	1,990	0	1	1
0075-03-C7	1.0	5,730	848	0	1	1

Table 2: US 67 Horizontal Curve Superelevation Data

Curve Control Section	Radius (ft)	Length (ft)	Existing Super (%)	Super based on emax= 6%	Difference with 6% Criteria	Super based on emax = 8%	Difference with 8% Criteria
0104-06-C1	5,730	1,745	3.8%	3.4%	0.4%	3.6%	0.2%
0104-06-C2	5,730	1,400	3.0%	3.4%	-0.4%	3.6%	-0.6%
0104-06-C3	5,730	2,350	4.2%	3.4%	0.8%	3.6%	0.6%
0104-06-C4	5,730	750	3.7%	3.4%	0.3%	3.6%	0.1%
0104-07-C1	5,730	1,453	3.7%	3.4%	0.3%	3.6%	0.1%
0104-07-C2	2,865	1,252	5.5%	5.4%	0.1%	6.4%	-0.9%
0104-07-C3	1,433	900	7.0%	6.0%	1.0%	8.0%	-1.0%
0104-07-C4	1,433	1,273	7.7%	6.0%	1.7%	8.0%	-0.3%
0104-07-C5	1,910	781	6.2%	6.0%	0.2%	8.0%	-1.8%
0104-07-C6	1,433	435	6.3%	6.0%	0.3%	8.0%	-1.7%
0104-07-C7	2,865	923	4.6%	5.4%	-0.8%	6.4%	-1.8%
0104-07-C8	2,865	772	5.6%	5.4%	0.2%	6.4%	-0.8%
0104-07-C9	5,730	952	3.3%	3.4%	-0.1%	3.6%	-0.3%
0104-07-C10	5,730	1,698	3.6%	3.4%	0.2%	3.6%	0.0%
0104-07-C11	11,460	901	2.7%	2.0%	0.7%	2.0%	0.7%
0104-07-C12	1,433	660	5.9%	6.0%	-0.1%	8.0%	-2.1%
0104-07-C13	2,865	817	5.3%	5.4%	-0.1%	6.4%	-1.1%
0104-07-C14	2,865	1,028	5.3%	5.4%	-0.1%	6.4%	-1.1%
0104-07-C15	2,292	2,362	6.2%	6.0%	0.2%	7.4%	-1.2%
0104-07-C16	5,730	523	3.7%	3.4%	0.3%	3.6%	0.1%
0104-07-C17	5,730	572	3.2%	3.4%	-0.2%	3.6%	-0.4%
0104-07-C18	1,433	651	6.5%	6.0%	0.5%	8.0%	-1.5%
0104-07-C19	5,730	1,831	3.6%	3.4%	0.2%	3.6%	0.0%
0104-07-C20	11,460	1,685	2.5%	2.0%	0.5%	2.0%	0.5%
0104-08-C1	5,730	875	2.9%	3.4%	-0.5%	3.6%	-0.7%
0104-08-C2	1,146	840	6.1%	6.0%	0.1%	8.0%	-1.9%
0104-08-C3	1,910	1,185	5.7%	6.0%	-0.3%	8.0%	-2.3%
0104-08-C4	2,865	612	4.8%	5.4%	-0.6%	6.4%	-1.6%
0104-08-C5	1,146	629	5.9%	6.0%	-0.1%	8.0%	-2.1%
0104-08-C6	1,433	688	6.3%	6.0%	0.3%	8.0%	-1.7%
0104-08-C7	1,146	1,917	6.2%	6.0%	0.2%	8.0%	-1.8%
0104-08-C8	1,910	554	6.0%	6.0%	0.0%	8.0%	-2.0%
0104-08-C9	1,433	750	6.3%	6.0%	0.3%	8.0%	-1.7%
0104-08-C10	1,146	879	6.5%	6.0%	0.5%	8.0%	-1.5%
0104-08-C11	1,274	793	6.2%	5.8%	0.4%	8.0%	-1.8%
0104-08-C12	1,274	778	5.9%	6.0%	-0.1%	8.0%	-2.1%
0104-08-C13	1,274	453	5.9%	6.0%	-0.1%	8.0%	-2.1%
0104-08-C14	1,146	813	4.3%	6.0%	-1.7%	8.0%	-3.7%
0104-08-C15	1,433	346	6.1%	6.0%	0.1%	8.0%	-1.9%
0104-08-C16	2,865	290	5.8%	5.4%	0.4%	6.4%	-0.6%
0104-08-C17	1,910	1,236	6.2%	6.0%	0.2%	8.0%	-1.8%
0104-08-C18	1,146	1,238	6.4%	6.0%	0.4%	8.0%	-1.6%
0104-08-C19	1,274	524	6.3%	6.0%	0.3%	8.0%	-1.7%
0104-08-C20	1,433	626	5.8%	6.0%	-0.2%	8.0%	-2.2%
0104-08-C21	1,433	377	6.4%	6.0%	0.4%	8.0%	-1.6%

Curve Control Section	Radius (ft)	Length (ft)	Existing Super (%)	Super based on emax= 6%	Difference with 6% Criteria	Super based on emax = 8%	Difference with 8% Criteria
0104-08-C22	1,433	514	5.7%	6.0%	-0.3%	8.0%	-2.3%
0104-08-C23	1,274	880	6.3%	6.0%	0.3%	8.0%	-1.7%
0104-08-C24	1,433	548	6.0%	6.0%	0.0%	8.0%	-2.0%
0104-08-C25	1,146	709	5.7%	6.0%	-0.3%	8.0%	-2.3%
0104-08-C26	1,433	1,007	6.5%	6.0%	0.5%	8.0%	-1.5%
0104-08-C27	2,865	314	4.3%	5.4%	-1.1%	6.4%	-2.1%
0104-08-C28	2,865	719	4.0%	5.4%	-1.4%	6.4%	-2.4%
0104-08-C29	1,910	1,014	5.3%	6.0%	-0.7%	8.0%	-2.7%
0104-08-C30	2,865	674	4.6%	5.4%	-0.8%	6.4%	-1.8%
0104-08-C31	2,865	1,055	3.9%	5.4%	-1.5%	6.4%	-2.5%
0104-08-C32	1,274	995	5.9%	6.0%	-0.1%	8.0%	-2.1%
0104-08-C33	1,910	1,583	5.7%	6.0%	-0.3%	8.0%	-2.3%
0104-08-C34	1,433	542	5.6%	6.0%	-0.4%	8.0%	-2.4%
0104-09-C1	1,433	703	6.0%	6.0%	0.0%	8.0%	-2.0%
0104-09-C2	5,730	875	2.5%	3.4%	-0.9%	3.6%	-1.1%
0104-09-C3	1,433	675	5.7%	6.0%	-0.3%	8.0%	-2.3%
0104-09-C4	1,910	492	5.4%	6.0%	-0.6%	8.0%	-2.6%
0104-09-C5	1,433	613	6.3%	6.0%	0.3%	8.0%	-1.7%
0104-09-C6	2,865	700	4.6%	5.4%	-0.8%	6.4%	-1.8%
0104-09-C7	5,730	717	2.6%	3.4%	-0.8%	3.6%	-1.0%
0104-09-C8	5,730	1,425	2.6%	3.4%	-0.8%	3.6%	-1.0%
0104-09-C9	5,730	1642	2.6%	3.4%	-0.8%	3.6%	-1.0%
0104-09-C10	5,730	1,677	2.8%	3.4%	-0.6%	3.6%	-0.8%
0104-09-C11	5,730	1,612	2.5%	3.4%	-0.9%	3.6%	-1.1%
0104-09-C12	1,910	1,111	6.3%	6.0%	0.3%	8.0%	-1.7%
0104-09-C13	11,460	1,753	2.2%	2.0%	0.2%	2.0%	0.2%
0104-09-C14	1,910	1,947	6.4%	6.0%	0.4%	8.0%	-1.6%
0020-08-C1	2,651	187	5.9%	5.6%	0.3%	6.8%	-0.9%
0020-08-C2	2,901	1,025	5.6%	5.4%	0.2%	6.4%	-0.8%
0020-08-C3	2,881	1,826	5.8%	5.4%	0.4%	6.4%	-0.6%
0020-08-C4	2,892	1,154	3.2%	5.4%	-2.2%	6.4%	-3.2%
0020-08-C5	4,581	1,519	5.7%	4.0%	1.7%	4.4%	1.3%
0020-08-C6	2,865	1,457	3.0%	5.4%	-2.4%	6.4%	-3.4%
0020-08-C7	4,432	1,511	5.7%	4.0%	1.7%	4.4%	1.3%
0020-08-C8	2,972	489	5.9%	5.4%	0.5%	6.2%	-0.3%
0020-08-C9	2,851	1,174	6.0%	5.4%	0.6%	6.4%	-0.4%
0020-08-C10	2,547	1,459	6.4%	5.8%	0.6%	7.0%	-0.6%
0020-08-C11	2,868	1,026	5.3%	5.4%	-0.1%	6.4%	-1.1%
0020-08-C12	2,855	1,716	4.0%	5.4%	-1.4%	6.4%	-2.4%
0020-08-C13	3,234	1,897	4.1%	5.0%	-0.9%	5.8%	-1.7%
0020-09-C1	1,910	2,311	7.9%	6.0%	1.9%	8.0%	-0.1%
0020-10-C1	1,638	1,648	9.5%	6.0%	3.5%	8.0%	1.5%
0020-10-C2	1,638	1,253	9.6%	6.0%	3.6%	8.0%	1.6%
0020-11-C1	3,820	3,059	4.1%	4.6%	-0.5%	5.2%	-1.1%
0020-11-C2	2,865	639	5.5%	5.4%	0.1%	6.4%	-0.9%
0020-11-C3	6,876	3,480	2.0%	2.8%	-0.8%	3.0%	-1.0%

US 67 CORRIDOR
MASTER PLAN

Attachment C

Potential Countermeasures

February 2020

Texas Department of Transportation

Table 1: Comprehensive List of Potential Countermeasures

	Objectives	Potential Countermeasures	Relative Cost to Implement and Operate	Effectiveness	Typical Timeframe for Implementation
1	**Rural Roadway Departure Crashes (Non-Intersection)**	Install Shoulder Rumble Strip	Low	Tried	Short
		Install Centerline Rumble Strip	Low	Tried	Short
		Install Transverse Rumble Strip	Low	Tried	Short
		Provide Advance Warning of Unexpected Changes in Horizontal Alignment	Low	Tried	Short
		Enhanced Delineation of Sharp Curve	Low	Proven	Short
		Enhanced Pavement Marking at Appropriate Locations	Low	Tried	Short
		Prevent Edge Drop-off	Low	Tried	Short
		Remove/Relocate Objects in Hazardous Locations	Low	Proven	Short
		Implement Variable Speed Limit	Low	Tried	Short
		Convert Culvert Headwalls to Traversable End Treatments	Low to Moderate	Proven	Short
		Provide Turnout Areas	Low to Moderate	Tried	Short
		Improve Speed Limit Signage	Moderate	Tried	Short
		Provide Dynamic Curve Warning Systems	Moderate to High	Tried	Medium
		Provide Skid Resistant Pavement Surfaces	Moderate to High	Proven	Medium
		Design Safer Slopes and Ditches to Prevent Rollovers	Moderate to High	Proven	Medium
		Improve Design and Application of Barrier and Attenuation Systems	Moderate to High	Tried	Medium
		Provide Lighting at the Curves	Moderate to High	Tried	Medium
		Install Automated Anti-Icing System	Moderate to High	Tried	Medium
		Interactive Truck Rollover Advisory System	Moderate to High	Proven	Medium
		Install Passing or Climbing Lane	High	Proven	Long
		Increase shoulder widths	High	Proven	Long
		Improve Super Elevation at Horizontal Curve Locations	High	Proven	Long
		Construct medians	High	Proven	Long
		Install Median Cable Barriers	High	Proven	Long
		Install Concrete Median Barriers	High	Proven	Long
		Improve Highway Geometry for Horizontal Curves	High	Proven	Long
2	**Young Drivers (Under 21)**	Enact Graduated Licensing System	Low	Proven	Long
		Require at Least 6 Months of Supervised Driving for Beginners	Low	Proven	Short
		Implement a Nighttime Driving Restriction	Low	Proven	Short
		Implement a Teenage Passenger Restriction Allowing No Young Passengers	Low	Tried	Short
		Prohibit Cell Phone Use by Drivers with a Graduated Driver Licensing (GDL)	Low	Tried	Short
		Publicize and Enforce Laws Pertaining to Underage Drinking and Driving	Low/Moderate	Proven	Short/Medium/ Long
		Publicize and Enforce Safety Belt Laws	Low	Proven/Tried	Short/Medium
		Eliminate Early School Start Times (i.e., before 8:30 a.m.)	Moderate/ High	Tried	Medium/Long
3	**Older Drivers (Over 64)**	Provide Advance Warning Signs	Low	Tried	Short
		Improve Roadway Delineations	Low	Tried	Short
		Improve Lighting at Intersections, Horizontal Curves, Railroad Grade Crossings	Moderate/High	Tried	Medium

Objectives		Potential Countermeasures	Relative Cost to Implement and Operate	Effectiveness	Typical Timeframe for Implementation
		Increase the Size and Letter Height of Roadway Signs	Low	Tried	Short
		Provide Advance-Guide and Street Name Signs	Low	Tried	Short
		Replace Painted Channelization with Raised Channelization	Short	Proven	Medium
		Update Procedures for Assessing Medical Fitness to Drive	Moderate	Proven	Medium
		Increase Seatbelt Use by Older Drivers and Passengers	Low	Proven	Short
		Provide More Protected Left Turn Signal Phases at High-Volume Intersections	Low	Tried	Short
		Encourage External Reporting of At-Risk Drivers to Licensing Authorities	Low	Tried	Medium
4	**Aggressive Driving and Speeding**	Implement Variable Speed Limits	Low	Tried	Short
		Use Targeted Conventional Speed Enforcement Programs at Locations Known to Have Speeding-Related Crashes	Low/Moderate	Proven	Short
		Increase Fines in Special Areas	Low	Tried	Short
		Implement Active Speed Warning Signs (including Truck Rollover Warnings) at High Risk Locations Where Excessive Speeds and Potential Conflicts are Expected	Low	Tried	Short
		Use In-Pavement Measures to Communicate the Need to Reduce Speeds	Moderate	Tried	Short
		Implement Automated Speed Enforcement	Moderate/High	Tried	Medium
		Use Combinations of Geometric Elements to Control Speeds (Horizontal and Vertical Curves, Cross Section), including Providing Design Consistency along Alignments	High	Tried	Long
		Effect Safe Speed Transitions through Design Elements and on Approaches to Lower Speed Areas	High	Tried	Medium
5	**Inattentive, distracted, asleep drivers**	Install Shoulder and/or Centerline Rumble Strips	Low	Tried/Proven	Short
		Encourage Trucking Companies and Other Fleet Operators to Implement Fatigue Management Programs	Low	Tried	Short
		Implement Other Roadway Improvements to Reduce the Likelihood and Severity of Run-Off-Road and/or Head-On Collisions	Moderate/High	Tried/Proven	Medium
		Implement Roadway Improvements to Reduce the Likelihood and Severity of Other Types of Distracted and Drowsy Driver Crashes	Moderate/High	Tried/ Experimental	Medium
		Conduct Education and Awareness Campaigns Targeting the General Driving Public	Moderate	Tried	Medium
		Encourage Employers to Offer Fatigue Management Programs to Employees Working Nighttime or Rotating Shifts	Low	Proven	Short
		Incorporate Information on Distracted/Fatigued Driving into Education Programs and Materials for Young Drivers	Low	Tried	Short
		Implement Targeted Interventions for Other High-Risk Populations	Moderate	Tried/ Experimental	Medium
		Improve Rest Area Security and Services	Low/ Moderate	Tried	Short
		Improve Access to Safe Stopping and Resting Areas	Moderate/ High	Tried	Long

	Objectives	Potential Countermeasures	Relative Cost to Implement and Operate	Effectiveness	Typical Timeframe for Implementation
6	**Intersection Skew (Intersection angle > 15 degrees) on a rural highway**	Realign Intersection Approaches to Reduce or Eliminate Intersection Skews	High	Proven	Medium
		Improve Visibility of Intersections by Providing Lighting	Moderate to High	Proven	Medium
		Clear Sight Triangles on Stop- or Yield-Controlled Approaches to Intersections	Low	Tried	Short
		Call Attention to the Intersection by Installing Rumble Strips on Intersection Approaches	Low	Tried	Short
		Install flashing Beacons at Stop-Controlled Intersections	Low	Tried	Short
		Install Splitter Islands on the Minor-Road Approaches to Intersections	Moderate	Tried	Medium
		Post Appropriate Speed Limit on Intersection Approaches	Low	Tried	Short
		Improve Visibility of Intersections by Providing Enhanced Signing and Delineations	Low	Tried	Short
		Provide Stop Bars (or Provide a Wider Stop Bar) on Minor-Road Approaches	Low	Tried	Short
		Provide an Automated Real-Time System to Inform Drivers of the Suitability of Available Gaps for Making Turning and Crossing Maneuvers	Moderate	Experimental	Medium
7	**Intersection (within 150 ft) on a Curve**	Provide Supplementary Stop Signs Mounted over Roadways	Low	Tried	Short
		Improve Visibility of Intersections by Providing Enhanced Signing and Delineation	Low	Tried	Short
		Post Appropriate Speed Limits on Intersection Approaches	Low	Tried	Short
		Provide Stop Bars (or Provide a Wider Stop Bars) on Minor-Road Approaches	Low	Tried	Short
		Clear Sight Triangles on Stop- or Yield-Controlled Approaches to Intersections	Low	Tried	Short
		Call Attention to Intersections by Installing Rumble Strips on Intersection Approaches	Low	Tried	Short
		Install Flashing Beacons at Stop-Controlled Intersections	Low	Tried	Short
		Install Splitter Islands on the Minor-Road Approaches to Intersections	Moderate	Tried	Medium
		Improve Visibility of Intersections by Providing Lighting	Moderate to High	Proven	Medium
		Provide an Automated Real-Time System to Inform Drivers of the Suitability of Available Gaps for Making Turning and Crossing Maneuvers	Moderate	Experimental	Medium
8	**Intersection within the proximity of a Rail Road Crossing**	Call Attention to Intersections by Installing Rumble Strips on Intersection Approaches	Low	Tried	Short
		Provide Supplementary Stop Signs Mounted over Roadways	Low	Tried	Short
		Improve Visibility of Intersections by Providing Enhanced Signing and Delineations	Low	Tried	Short
		Improve Visibility of Intersections by Providing Lighting	Moderate to High	Proven	Medium
		Install Flashing Beacons at Stop-Controlled Intersections	Low	Tried	Short
		Post Appropriate Speed Limits on Intersection Approaches	Low	Tried	Short
		Provide Stop Bars (or Provide Wider Stop Bars) on Minor-Road Approaches	Low	Tried	Short
		Install Larger Regulatory and Warning Signs at Intersections	Low	Tried	Short

Objectives		Potential Countermeasures	Relative Cost to Implement and Operate	Effectiveness	Typical Timeframe for Implementation
9	**Pedestrian Collisions**	Provide Crosswalk Enhancements (in-pavement flashing lights, inlay tape and thermoplastic)	Low	Proven	Short
		Improve Reflectorizing of Pedestrians	Low	Tried	Short
		Implement Enforcement Campaigns	Moderate	Tried	Short
		Eliminate Screening by Physical Objects (Remove Parking Close to Intersection, Curb Extensions, Installing Advance Yield Markings and Signs)	Moderate	Tried	Medium
		Provide signals to Alert Motorists that Pedestrians are Crossing (Electronic Signs)	Moderate	Tried	Medium
		Implement Road Narrowing Measures	Moderate	Tried	Medium
		Install Traffic Calming-Road Sections	Moderate	Proven	Medium
		Install Traffic Calming-Intersections	Moderate	Proven	Medium
		Provide Education, Outreach, and Training	Moderate	Proven	Medium
		Install or Upgrade Traffic and Pedestrian Signals (Pedestrian Hybrid Beacons)	Moderate to High	Proven	Medium
		Implement Lighting/Crosswalk Illumination Measures	Moderate to High	Proven	Long
		Install Overpasses/Underpasses	High	Proven	Long

US 67 CORRIDOR
MASTER PLAN

Attachment D

At-Risk Segments Project Sheets

February 2020

Texas Department of Transportation

Table 1: Project Sheet for Control Section 0104-08 (Near Shafter)

Control Section 0104-08

Roadway Data

Type:	US Highway
Number:	0104-08
City/Rural:	Rural
County:	Presidio
District:	El Paso
AADT:	1200
Facility Type:	2-lane
Lane Width:	12
Shoulder Width:	6
Shoulder Type:	Paved
Length (miles):	13.1
Rumble Installed:	None
Critical Curve(miles):	3.81

Mobilization, Contingency, Construction Engineering, and Traffic Control 45%

9 - Year Crash Data (2010 to 2018)

	Total	Severe	Road Departure
Crashes	56	12	8
Density (per mile per year)	0.47	0.10	0.07

Ranking Criteria

	Value	Critical Value	Risk Ranking
AADT Range	1200	<1300,>2100	★
Road Departure Density	0.07	>0.07	
Edge Risk(% of the section)	25.57	>12.46	★
Weather/Pavement(ROR crashes caused)	0	>=1 severe crash	
Critical Curve Density	1.68	>0.24	★
Truck Percentages	2.2	>=17.7	
In-the-dark crashes	3	>=1 severe crash	★
			★★★★

Short List of Countermeasures Considered

Time	Cost	Countermeasures	Unit	Quantity	Cost per Unit	Cost
Short	Low	Horizontal Curve Warning Signs	EA	14	$600	$9,000
		Chevrons	EA	11	$600	$7,000
		Advisory Speed Limit Signs	EA	44	$600	$27,000
		Vertical Grade Signs	EA	24	$600	$15,000
		Curve Blocks View Sign	EA	12	$600	$8,000
		Install centerline rumble strip	MILE	13	$2,000	$26,000
		Install shoulder rumble strip	MILE	26	$800	$21,000
		Passing lane ahead and lane ends merge left signs	EA	20	$600	$12,000
		No Passing Zone Signs	EA	82	$600	$50,000
		Tree Trimming/Brush Removal	MILE	4	$2,000	$8,000
						$183,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$266,000
Medium	Moderate to High	Improve design and application of barrier systems	EA	62	$3,000	$186,000
		Add/Extend Guardrail	MILE	8	$167,000	$1,336,000
		Provide guardrail end treatment	EA	122	$3,000	$366,000
		Flashing Beacon Signs	EA	20	$10,000	$200,000
		Sequential Dynamic Curve Warning Sign	EA	3	$26,000	$78,000
		Provide adequate sight distance	CY	19825	$200	$3,965,000
		Provide lighting at intersections	EA	12	$10,000	$120,000
		Raised Pavement Markers	EA	1902	$100	$191,000
		Design safer slopes when fill height is less than 5 feet	CY	4969	$100	$497,000
		Provide Turnouts	SY	9170	$200	$1,834,000
		Superelevation Improvement	TON	14000	$100	$1,400,000
		High Friction Surface Treatment	SY	89668	$50	$4,484,000
						$14,657,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$21,253,000
Long	High	Widen Shoulders from 6 to 10 feet	MILE	26	$750,000	$19,500,000
						$19,500,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$28,275,000

Table 2: Project Sheet for Control Section 0104-07 (North of Shafter)

Control Section 0104-07

Roadway Data

Type:	US Highway
Number:	0104-07
City/Rural:	Rural
County:	Presidio
District:	El Paso
AADT:	1300
Facility Type:	2-lane
Lane Width:	12
Shoulder Width:	6
Shoulder Type:	Paved
Length (miles):	18.3
Rumble Installed:	None
Critical Curve(miles):	2.06

Mobilization, Contingency, Construction Engineering, and Traffic Control 45%

9 - Year Crash Data (2010 to 2018)

	Total	Severe	Road Departure
Crashes	96	20	19
Density (per mile per year)	0.58	0.12	0.12

Ranking Criteria

	Value	Critical Value	Risk Ranking
AADT Range	1300	<1300,>2100	★
Road Departure Density	0.12	>0.07	★
Edge Risk(% of the section)	20.29	>12.46	★
Weather/Pavement(ROR crashes caused)	0	>=1 severe crash	
Critical Curve Density	0.27	>0.24	★
Truck Percentages	2.2	>=17.7	
In-the-dark crashes	3	>=1 severe crash	★
			★★★★★

Short List of Countermeasures Considered

Time	Cost	Countermeasures	Unit	Quantity	Cost per Unit	Cost
Short	Low	Horizontal Curve Warning Signs	EA	14	$600	$9,000
		Chevrons	EA	22	$600	$14,000
		Advisory Speed Limit Signs	EA	10	$600	$6,000
		Vertical Grade Signs	EA	48	$600	$29,000
		Curve Blocks View Sign	EA	3	$600	$2,000
		Install centerline rumble strip	MILE	19	$2,000	$38,000
		Install shoulder rumble strip	MILE	37	$800	$30,000
		Passing lane ahead and lane ends merge left signs	EA	16	$600	$10,000
		No Passing Zone Signs	EA	56	$600	$34,000
		Tree Trimming/Brush Removal	MILE	6	$2,000	$12,000
						$184,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$267,000
Medium	Moderate to High	Improve design and application of barrier systems	EA	10	$3,000	$30,000
		Add/Extend Guardrail	MILE	6	$167,000	$1,002,000
		Provide guardrail end treatment	EA	80	$3,000	$240,000
		Flashing Beacon Signs	EA	6	$10,000	$60,000
		Sequential Dynamic Curve Warning Sign	EA	2	$26,000	$52,000
		Provide adequate sight distance	CY	4952	$200	$991,000
		Provide lighting at intersections	EA	2	$10,000	$20,000
		Raised Pavement Markers	EA	2658	$100	$266,000
		Design safer slopes when fill height is less than 5 feet	CY	42120	$100	$4,212,000
		Provide Rest Area	EA	1	$1,000,000	$1,000,000
		Provide Turnouts	SY	12810	$200	$2,562,000
		Superelevation Improvement	TON	7500	$100	$750,000
		High Friction Surface Treatment	SY	18800	$50	$940,000
						$12,125,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$17,582,000
Long	High	Widen Shoulders from 6 to 10 feet	MILE	36	$750,000	$27,000,000
		Construct Texas Super 2	MILE	16	$2,100,000	$33,600,000
						$60,600,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$87,870,000

Table 3: Project Sheet for Control Section 0020-08 (East of Marfa)

Control Section 0020-08

Roadway Data

Type:	US Highway
Number:	0020-08
City/Rural:	Rural
County:	Presidio
District:	El Paso
AADT:	2200
Facility Type:	2-lane
Lane Width:	13
Shoulder Width:	10
Shoulder Type:	Paved
Length (miles):	13.6
Rumble Installed:	Entire Length
Critical Curve(miles):	0.89

Mobilization, Contingency, Construction Engineering, and Traffic Control 45%

9 - Year Crash Data (2010 to 2018)

	Total	Severe	Road Departure
Crashes	50	15	12
Density (per mile per year)	0.41	0.12	0.10

Ranking Criteria

	Value	Critical Value	Risk Ranking
AADT Range	2200	<1300,>2100	★
Road Departure Density	0.1	>0.07	★
Edge Risk(% of the section)	5.67	>12.46	
Weather/Pavement(ROR crashes caused)	3	>=1 severe crash	★
Critical Curve Density	0.00	>0.24	
Truck Percentages	17.7	>=17.7	★
In-the-dark crashes	4	>=1 severe crash	★
			★★★★★

Short List of Countermeasures Considered

Time	Cost	Countermeasures	Unit	Quantity	Cost per Unit	Cost
Short	Low	Horizontal Curve Warning Signs	EA	14	$600	$9,000
		Chevrons	EA	38	$600	$23,000
		Curve Blocks View Sign	EA	1	$600	$1,000
		Install centerline rumble strip	MILE	14	$2,000	$28,000
		Install shoulder rumble strip	MILE	17	$800	$14,000
		Passing lane ahead and lane ends merge left signs	EA	24	$600	$15,000
		Install Weather Warning Sign	EA	14	$600	$9,000
		No Passing Zone Signs	EA	28	$600	$17,000
		Tree Trimming/Brush Removal	MILE	4	$2,000	$8,000
						$124,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$180,000
Medium	Moderate to High	Improve design and application of barrier systems	EA	3	$3,000	$9,000
		Add/Extend Guardrail	MILE	1	$167,000	$167,000
		Provide guardrail end treatment	EA	16	$3,000	$48,000
		Provide dynamic speed feedback system	EA	4	$10,000	$40,000
		Provide adequate sight distance	CY	3513	$200	$703,000
		Provide lighting at intersections	EA	19	$10,000	$190,000
		Raised Pavement Markers	EA	1975	$100	$198,000
		Design safer slopes when fill height is less than 5 feet	CY	11358	$100	$1,136,000
		Provide Turnouts	SY	9520	$200	$1,904,000
		High Friction Surface Treatment	SY	62250	$50	$3,113,000
						$7,508,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$10,887,000
Long	High	Widen Shoulders from 4 to 10 feet	MILE	12	$1,050,000	$12,600,000
						$12,600,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$18,270,000

Table 4: Project Sheet for Control Section 0020-10 (Near Paisano Pass)

Control Section 0020-10

Roadway Data

Type:	US Highway
Number:	0020-10
City/Rural:	Rural
County:	Brewster
District:	El Paso
AADT:	2100
Facility Type:	4-lane
Lane Width:	13
Shoulder Width:	10
Shoulder Type:	Paved
Length (miles):	1.5
Rumble Installed:	Entire length
Critical Curve(miles):	0.55

Mobilization, Contingency, Construction Engineering, and Traffic Control 45%

9 - Year Crash Data (2010 to 2018)

	Total	Severe	Road Departure
Crashes	7	4	4
Density (per mile per year)	0.52	0.30	0.30

Ranking Criteria

	Value	Critical Value	Risk Ranking
AADT Range	2100	<1300,>2100	★
Road Departure Density	0.3	>0.07	★
Edge Risk(% of the section)	30.81	>12.46	★
Weather/Pavement(ROR crashes caused)	1	>=1 severe crash	★
Critical Curve Density	1.33	>0.24	★
Truck Percentages	17.7	>=17.7	★
In-the-dark crashes	2	>=1 severe crash	★
			★★★★★★★

Short List of Countermeasures Considered

Time	Cost	Countermeasures	Unit	Quantity	Cost per Unit	Cost
Short	Low	Advisory Speed Limit Signs	EA	4	$600	$3,000
		Curve Blocks View Sign	EA	2	$600	$2,000
		Install centerline rumble strip	MILE	2	$2,000	$4,000
		Install shoulder rumble strip	MILE	3	$800	$3,000
		Passing lane ahead and lane ends merge left signs	EA	8	$600	$5,000
		Install Weather Warning Sign	EA	1	$600	$1,000
		Tree Trimming/Brush Removal	MILE	1	$2,000	$2,000
						$20,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$29,000
Medium	Moderate to High	Add/Extend Guardrail	MILE	2	$167,000	$334,000
		Provide guardrail end treatment	EA	10	$3,000	$30,000
		Sequential Dynamic Curve Warning Sign	EA	2	$26,000	$52,000
		Provide lighting at intersections	EA	1	$10,000	$10,000
		Raised Pavement Markers	EA	396	$100	$40,000
		High Friction Surface Treatment	SY	19978	$50	$999,000
		Provide adequate sight distance	CY	5370	$200	$1,074,000
						$2,539,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$3,682,000
Long	High	Widen Shoulders from 6 to 10 feet	MILE	3	$750,000	$2,250,000
						$2,250,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$3,263,000

Table 5: Project Sheet for Control Section 0020-11 (East of Alpine)

Control Section 0020-11

Roadway Data

Type:	US Highway
Number:	0020-11
City/Rural:	Rural
County:	Brewster
District:	El Paso
AADT:	2200
Facility Type:	2-lane
Lane Width:	13
Shoulder Width:	10
Shoulder Type:	Paved
Length (miles):	7.1
Rumble Installed:	Entire length
Critical Curve(miles):	0.58

Mobilization, Contingency, Construction Engineering, and Traffic Control 45%

9 - Year Crash Data (2010 to 2018)

	Total	Severe	Road Departure
Crashes	20	5	4
Density (per mile per year)	0.31	0.08	0.06

Ranking Criteria

	Value	Critical Value	Risk Ranking
AADT Range	2200	<1300,>2100	★
Road Departure Density	0.06	>0.07	
Edge Risk(% of the section)	17.55	>12.46	★
Weather/Pavement(ROR crashes caused)	3	>=1 severe crash	★
Critical Curve Density	0.00	>0.24	
Truck Percentages	17.7	>=17.7	★
In-the-dark crashes	2	>=1 severe crash	★
			★★★★★

Short List of Countermeasures Considered

Time	Cost	Countermeasures	Unit	Quantity	Cost per Unit	Cost
Short	Low	Horizontal Curve Warning Signs	EA	6	$600	$4,000
		Chevrons	EA	20	$600	$12,000
		Curve Blocks View Sign	EA	1	$600	$1,000
		Install centerline rumble strip	MILE	7	$2,000	$14,000
		Install shoulder rumble strip	MILE	14	$800	$12,000
		Passing lane ahead and lane ends merge left signs	EA	8	$600	$5,000
		Install Weather Warning Sign	EA	7	$600	$5,000
		No Passing Zone Signs	EA	21	$600	$13,000
		Tree Trimming/Brush Removal	MILE	2	$2,000	$4,000
						$70,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$102,000
Medium	Moderate to High	Improve design and application of barrier systems	EA	4	$3,000	$12,000
		Add/Extend Guardrail	MILE	3	$167,000	$501,000
		Provide guardrail end treatment	EA	18	$3,000	$54,000
		Provide adequate sight distance	CY	1650	$200	$330,000
		Provide lighting at intersections	EA	14	$10,000	$140,000
		Raised Pavement Markers	EA	1031	$100	$104,000
		Provide Turnouts	SY	4970	$200	$994,000
		Design safer slopes when fill height is less than 5 feet	CY	10467	$100	$1,047,000
		Add left turn lanes to existing rest area	EA	1	$396,000	$396,000
						$3,578,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$5,189,000
Long	High	Widen Shoulders from 6 to 10 feet	MILE	1	$750,000	$750,000
		Construct Texas Super 2	MILE	6	$2,100,000	$12,600,000
						$13,350,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$19,358,000

Table 6: Project Sheet for Control Section 0075-02 (North of Brewster/ Pecos County Line)

Control Section 0075-02

Roadway Data

Type:	US Highway
Number:	0075-02
City/Rural:	Rural
County:	Pecos
District:	Odessa
AADT:	1300
Facility Type:	2-lane
Lane Width:	12
Shoulder Width:	6
Shoulder Type:	Paved
Length (miles):	11.9
Rumble Installed:	None
Critical Curve(miles):	0.65

Mobilization, Contingency, Construction Engineering, and Traffic Control 45%

9 - Year Crash Data (2010 to 2018)

	Total	Severe	Road Departure
Crashes	42	12	10
Density (per mile per year)	0.39	0.11	0.09

Ranking Criteria

	Value	Critical Value	Risk Ranking
AADT Range	1300	<1300,>2100	★
Road Departure Density	0.09	>0.07	★
Edge Risk(% of the section)	3.24	>12.46	
Weather/Pavement(ROR crashes caused)	1	>=1 severe crash	★
Critical Curve Density	0.00	>0.24	
Truck Percentages	12.3	>=17.7	
In-the-dark crashes	3	>=1 severe crash	★
			★★★★

Short List of Countermeasures Considered

Time	Cost	Countermeasures	Unit	Quantity	Cost per Unit	Cost
Short	Low	Horizontal Curve Warning Signs	EA	2	$600	$2,000
		Chevrons	EA	40	$600	$24,000
		Install advanced warning signs for railroad crossing	EA	2	$600	$2,000
		Flashing beacon for railroad crossing	EA	2	$6,000	$12,000
		Install Weather Warning Sign	EA	11	$600	$7,000
		Install centerline rumble strip	MILE	12	$2,000	$24,000
		Install shoulder rumble strip	MILE	24	$800	$20,000
		Passing lane ahead and lane ends merge left signs	EA	8	$600	$5,000
		No Passing Zone Signs	EA	10	$600	$6,000
		Tree Trimming/Brush Removal	MILE	4	$2,000	$8,000
						$110,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$160,000
Medium	Moderate to High	Improve design and application of barrier systems	EA	12	$3,000	$36,000
		Highway Rail Grade Crossing Safety System	EA	2	$10,000	$20,000
		Provide lighting at intersections	EA	6	$10,000	$60,000
		Raised Pavement Markers	EA	1728	$100	$173,000
		Design safer slopes when fill height is less than 5 feet	CY	7528	$100	$753,000
		Provide Rest Area	EA	1	$1,000,000	$1,000,000
		Provide Turnouts	SY	8330	$200	$1,666,000
		High Friction Surface Treatment	SY	36560	$50	$1,828,000
						$5,536,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$8,028,000
Long	High	Widen Shoulders from 4 to 10 feet	MILE	3	$1,050,000	$3,150,000
		Construct Texas Super 2	MILE	11	$2,100,000	$23,100,000
		Grade Separation at Old Alpine Highway	EACH	1	$5,200,000	$5,200,000
						$31,450,000
TOTAL (Including Mobilization, Contingency, Construction Engineering and Traffic Control)						$45,603,000

Table 7: Project Sheet for Control Section 0075-03 (South of US 67/I-10 Interchange)

Control Section 0075-03

Roadway Data

Type:	US Highway
Number:	0075-03
City/Rural:	Rural
County:	Pecos
District:	Odessa
AADT:	1300
Facility Type:	2-lane
Lane Width:	12
Shoulder Width:	10
Shoulder Type:	Paved
Length (miles):	15.8
Rumble Installed:	None
Critical Curve(miles):	0.00

Mobilization, Contingency, Construction Engineering, and Traffic Control 45%

9 - Year Crash Data (2010 to 2018)

	Total	Severe	Road Departure
Crashes	43	12	11
Density (per mile per year)	0.30	0.08	0.08

Ranking Criteria

	Value	Critical Value	Risk Ranking
AADT Range	1300	<1300,>2100	★
Road Departure Density	0.08	>0.07	★
Edge Risk(% of the section)	20.84	>12.46	★
Weather/Pavement(ROR crashes caused)	0	>=1 severe crash	
Critical Curve Density	0.00	>0.24	
Truck Percentages	12.3	>=17.7	
In-the-dark crashes	4	>=1 severe crash	★
			★★★★

Short List of Countermeasures Considered

Time	Cost	Countermeasures	Unit	Quantity	Cost per Unit	Cost
Short	Low	Horizontal Curve Warning Signs	EA	4	$600	$3,000
		Chevrons	EA	13	$600	$8,000
		Install centerline rumble strip	MILE	16	$2,000	$32,000
		Install shoulder rumble strip	MILE	32	$800	$26,000
		Passing lane ahead and lane ends merge left signs	EA	16	$600	$10,000
		No Passing Zone Signs	EA	16	$600	$10,000
		Tree Trimming/Brush Removal	MILE	5	$2,000	$10,000
						$99,000
TOTAL (Including Mobilization, Contingency, Construction Engineering, and Traffic Control)						$144,000
Medium	Moderate to High	Provide lighting at intersections	EA	2	$10,000	$20,000
		Raised Pavement Markers	EA	2295	$100	$230,000
		Design safer slopes when fill height is less than 5 feet	CY	64786	$100	$6,479,000
		Provide Turnouts	SY	11060	$200	$2,212,000
						$8,941,000
TOTAL (Including Mobilization, Contingency, Construction Engineering, and Traffic Control)						$12,965,000
Long	High	Widen Shoulders from 4 to 10 feet	MILE	6	$1,050,000	$6,300,000
		Construct Texas Super 2	MILE	13	$2,100,000	$27,300,000
						$33,600,000
TOTAL (Including Mobilization, Contingency, Construction Engineering, and Traffic Control)						$48,720,000

US 67 CORRIDOR
MASTER PLAN

Attachment E

At-Risk Intersection Analysis

February 2020

Texas Department of Transportation

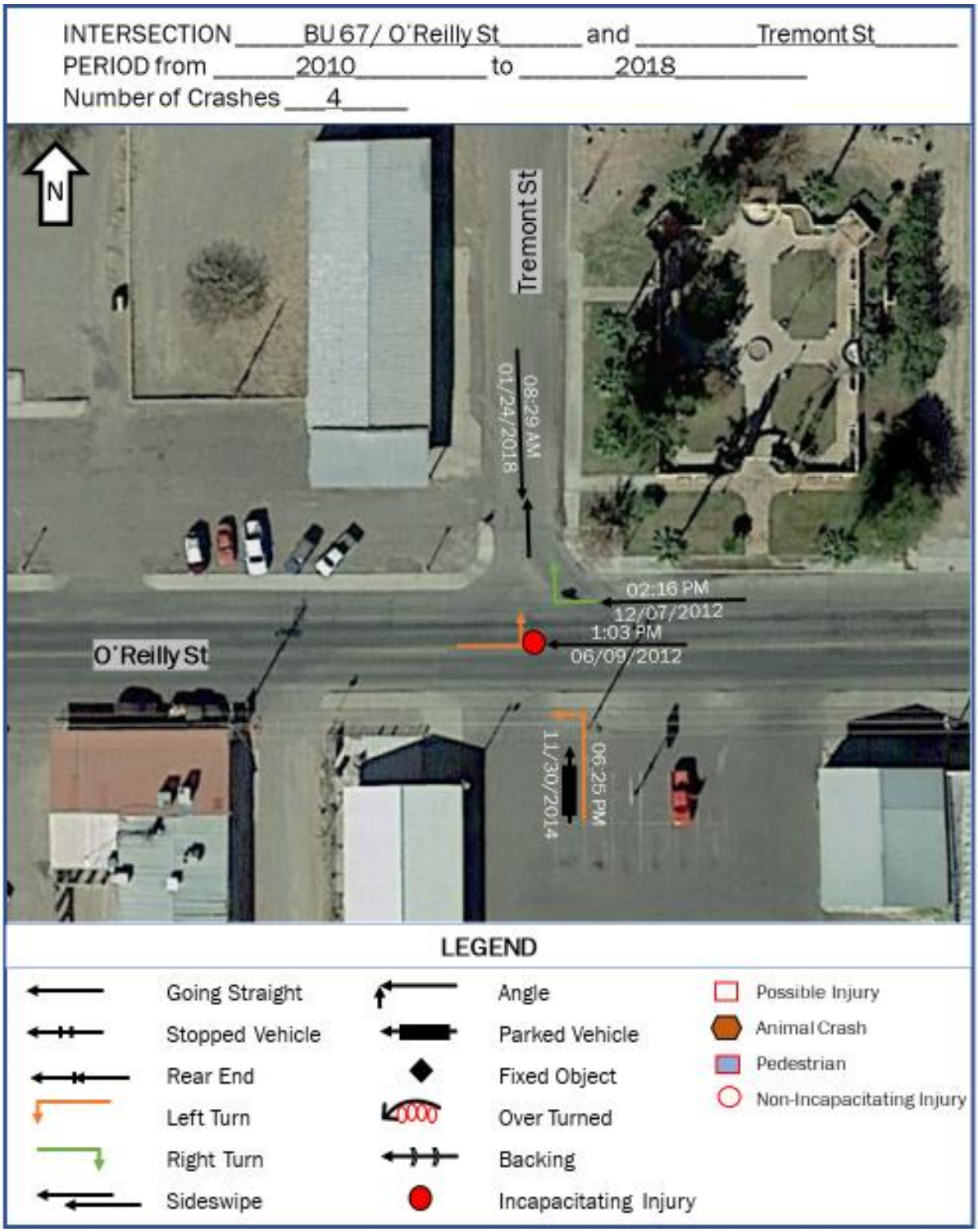
1. BUS 67/ O'Reilly St and Howard Street

This intersection was analyzed as a system with the neighboring intersection near the Presidio Port of Entry (POE). In nine years, there were only four crashes and all of them were property damage only crashes; one of them is likely a congestion related crash. However, there is a known operational issue, due to the recurrent queue that forms in the southbound direction approaching the Presidio POE.

- **Short-term:** Provide striping and signage changes within the existing pavement blueprint.
- **Mid- to long-term:** Propose improvements including shoulders and crash attenuator. Additional details are provided in the US 67 Corridor Master Plan Alternatives Analysis Technical Memorandum.

2. BUS 67/O'Reilly St and Tremont Street

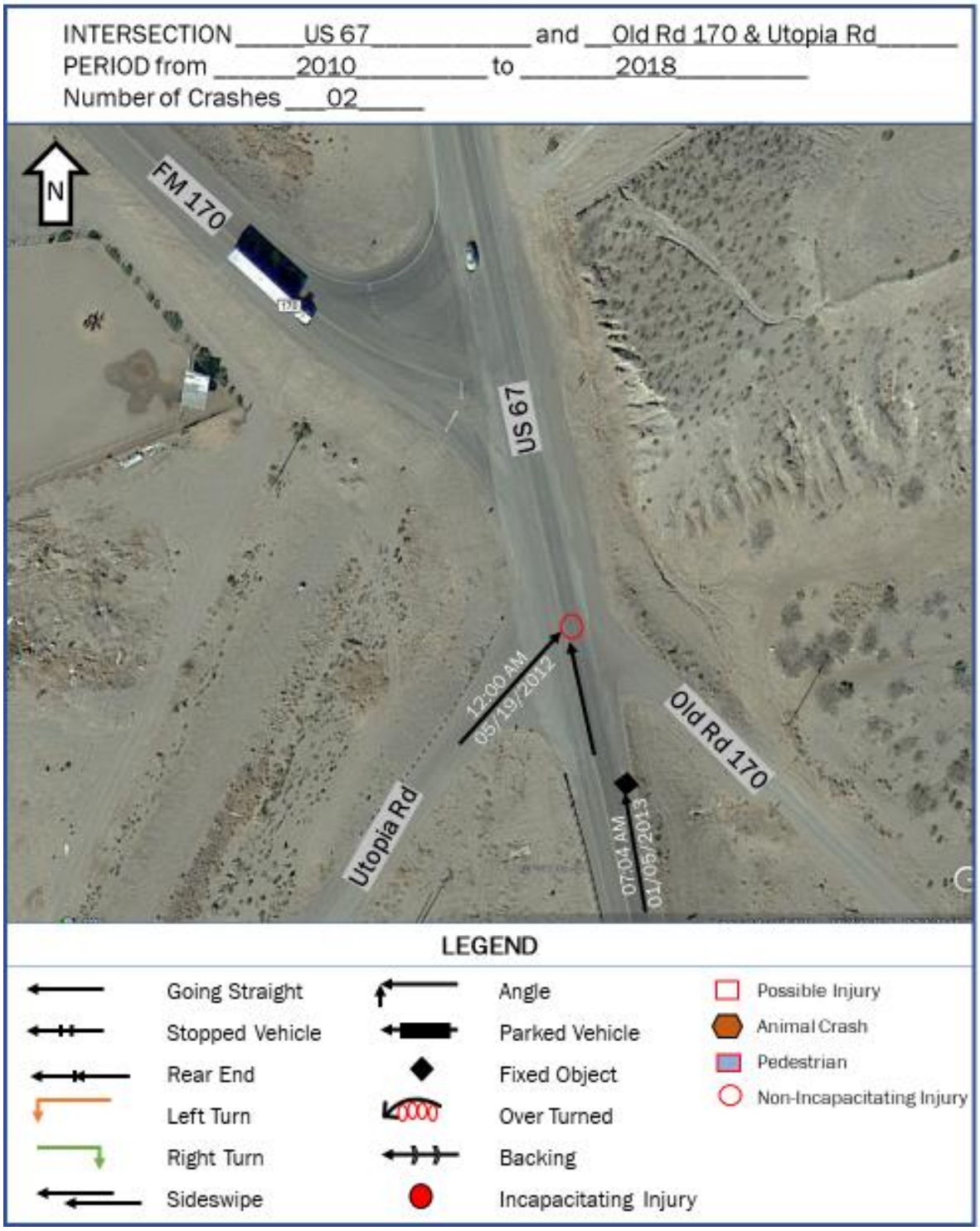
This intersection is located between BUS 67 (O'Reilly Street) and Tremont Street. In the last nine years, one incapacitating injury occurred in 2012. The other three were property damage crashes, one of which appears to have occurred at the parking lot with a stationary vehicle.



- **Short-term:** Improve striping, signing and pavement marking. The stop bar looks faded, and there is presence of two stop signs next to each other, one is temporary.
- **Mid- to long-term:** None.

3. US 67 and Old Rd 170 and Utopia Road

This intersection is located north of Presidio and is a five-leg intersection, all with skewed angles. There were two crashes in the past nine years. One was a property damage only and the second a non-incapacitating crash.



- **Short-term:** Improve striping, signing and pavement marking.
- **Mid- to long-term:** Realign approaches and provide two-way-left-turn lane. Additional details are provided in the US 67 Corridor Master Plan Alternatives Analysis Technical Memorandum.

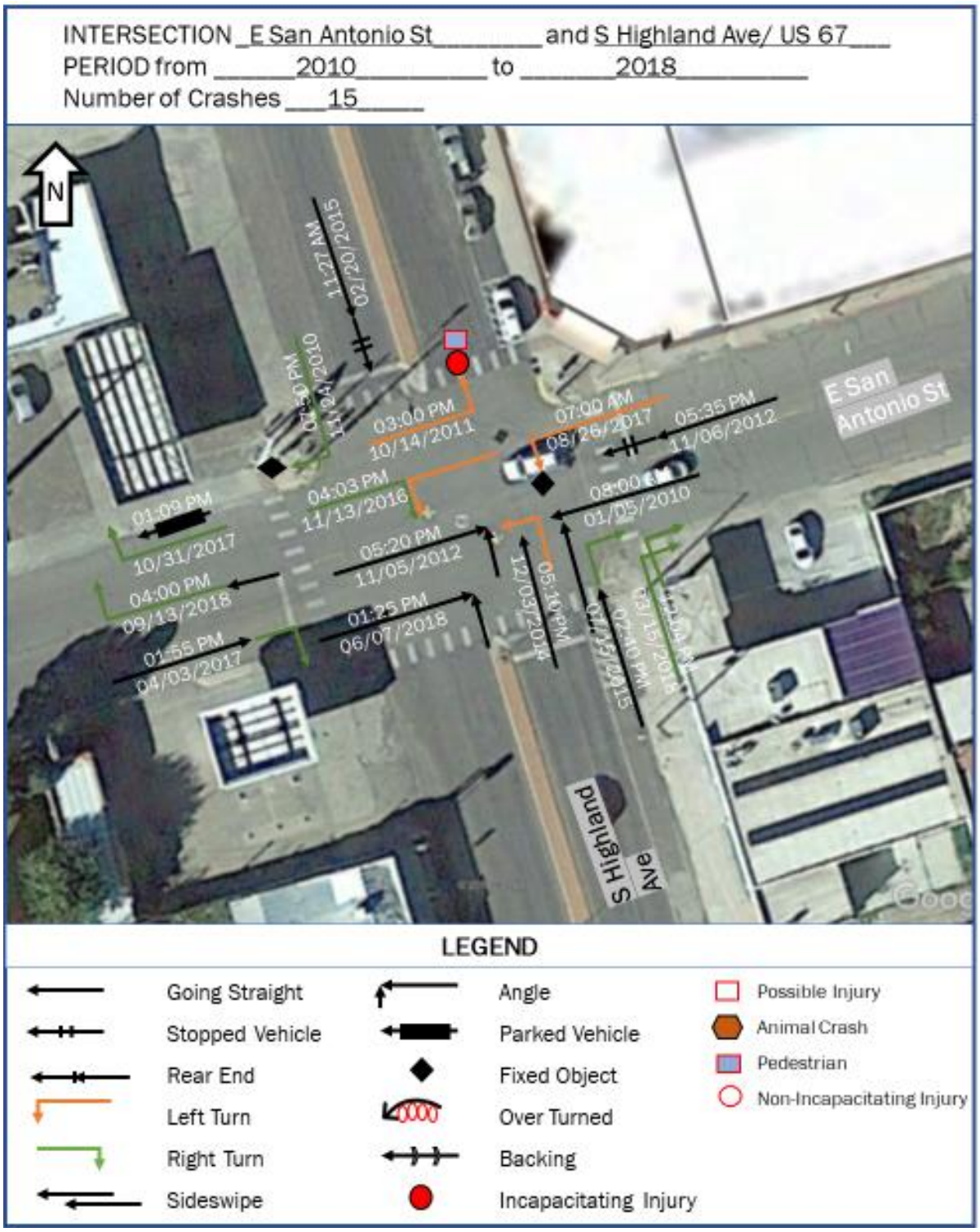
4. US 67 and Cibolo Creek Rd

This intersection is in Shafter. There were four crashes in the past nine years - one possible injury, one animal crash and two property damage only crashes. Out of the four, two were fixed object crashes. There isn't an apparent obstruction for the fixed objects crashes.

- **Short-term:** Install smart LED lighting at the intersection.
- **Mid- to long-term**: None.

5. Highland Avenue and San Antonio Street

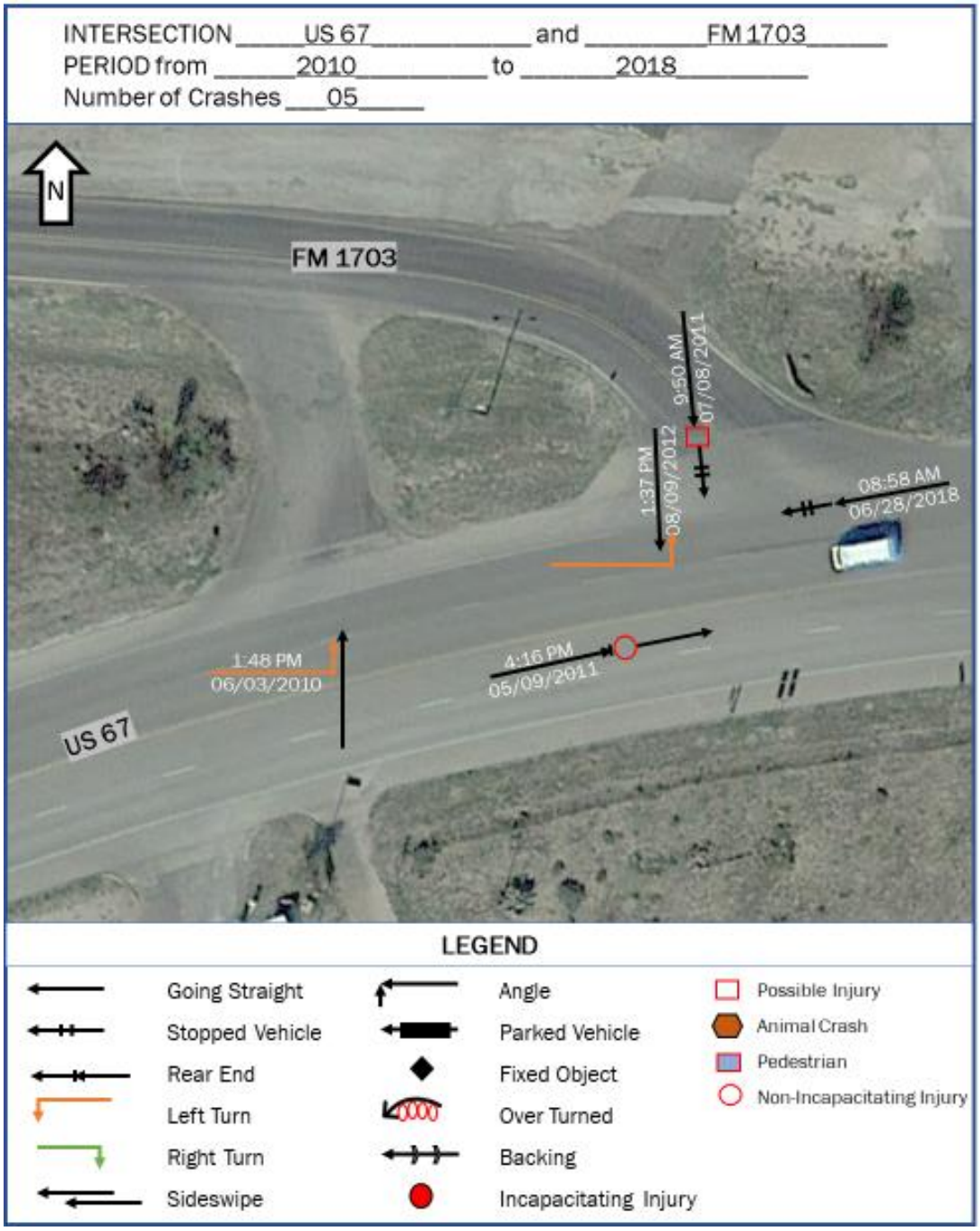
This intersection is four way stop sign located in the Marfa. There were 15 crashes in the past nine years. Two fixed objects, one incapacitating (pedestrian), one parked vehicle and rest are property damage only crashes. Four out of 15 crashes involved a vehicle turning left.



- **Short-term**: Install a flashing beacon altering drivers of pedestrians entering crosswalks.
- **Mid- to long-term**: Revise intersection geometry. Additional details are provided in the US 67 Corridor Master Plan Alternatives Analysis Technical Memorandum.

6. US 67 and FM 1703

This intersection is located on the west side of Alpine. This intersection was identified as an at-risk intersection due to the skewed angle of the FM 1703 approach and its proximity to a curve. There were five crashes in the past nine years. Two out of the five crashes involved a vehicle turning left.



- **Short-term:** Restripe and close access for tuning left from/to US 67 from one of the intersection approaches. Also, the northbound left lane on US 67 could be turned into a left turn only lane approaching this intersection.

- **Mid- to long-term:** Realign approaches and completely close one of the two access points to US 67. Additional details are provided in the US 67 Corridor Master Plan Alternatives Analysis Technical Memorandum.

7. US 67 and Orange Street

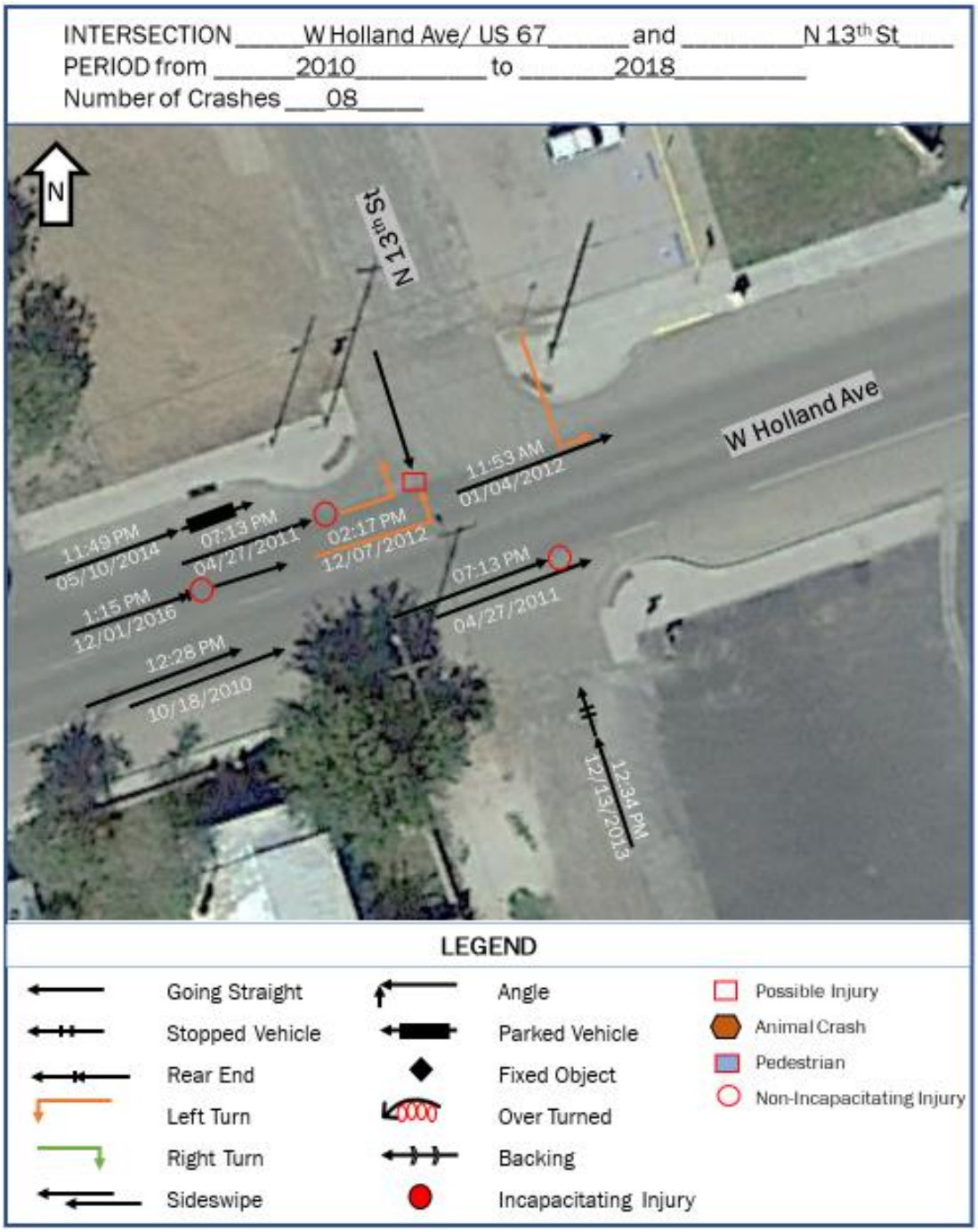
This intersection has five legs and is located in the west side of Alpine. It was identified as an at-risk intersection due to the skewed angle and its proximity to a curve. There were two crashes involved in the past nine years, both non-incapacitating injuries.

- **Short-term:** Improve and maintain pavement marking in general. Stop bars are either faded or absent for the stop-controlled approaches.

- **Mid- to long-term:** Realign approaches to meet at 90 degrees and close one of the additional access points to US 67. Additional details are provided in the US 67 Corridor Master Plan Alternatives Analysis Technical Memorandum.

8. Holland Avenue and 13th Street

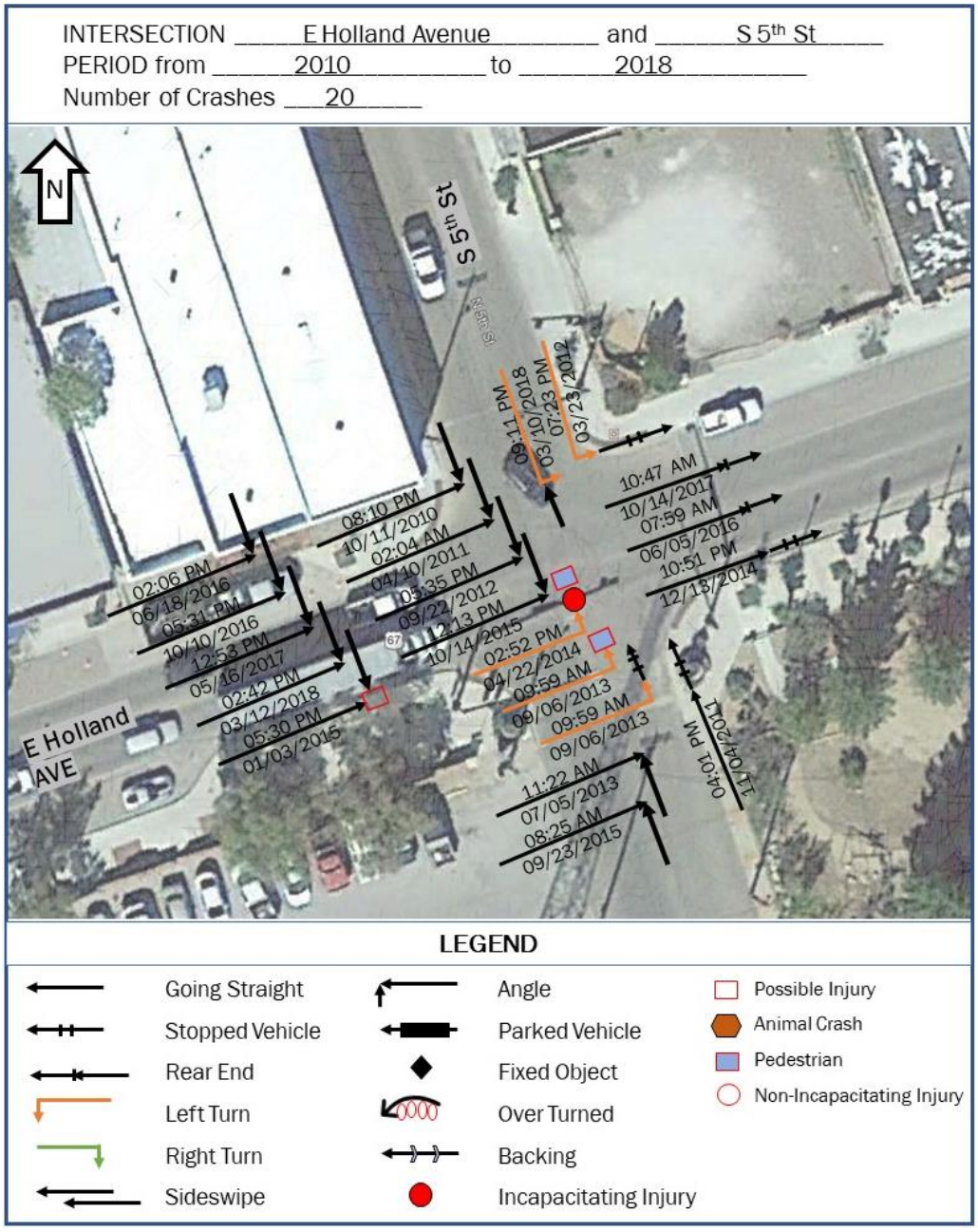
This intersection is in Alpine. Eight crashes occurred in the past nine years. Four of them were injury crashes. Five out of the eight crashes involved vehicles that were both traveling in the eastbound direction. This could indicate a speeding issue or vehicle trying to pass each other.



- **Short-term:**
  - Enhance speed limit signing by adding a speed feedback that reminds users to lower their speed. These are commercially available stand-alone products.
  - Improve pavement marking.
- **Mid- to long-term:** Widen shoulder and provide channelization. Additional details are provided in the US 67 Corridor Master Plan Alternatives Analysis Technical Memorandum.

9. Holland Avenue and 5th Street

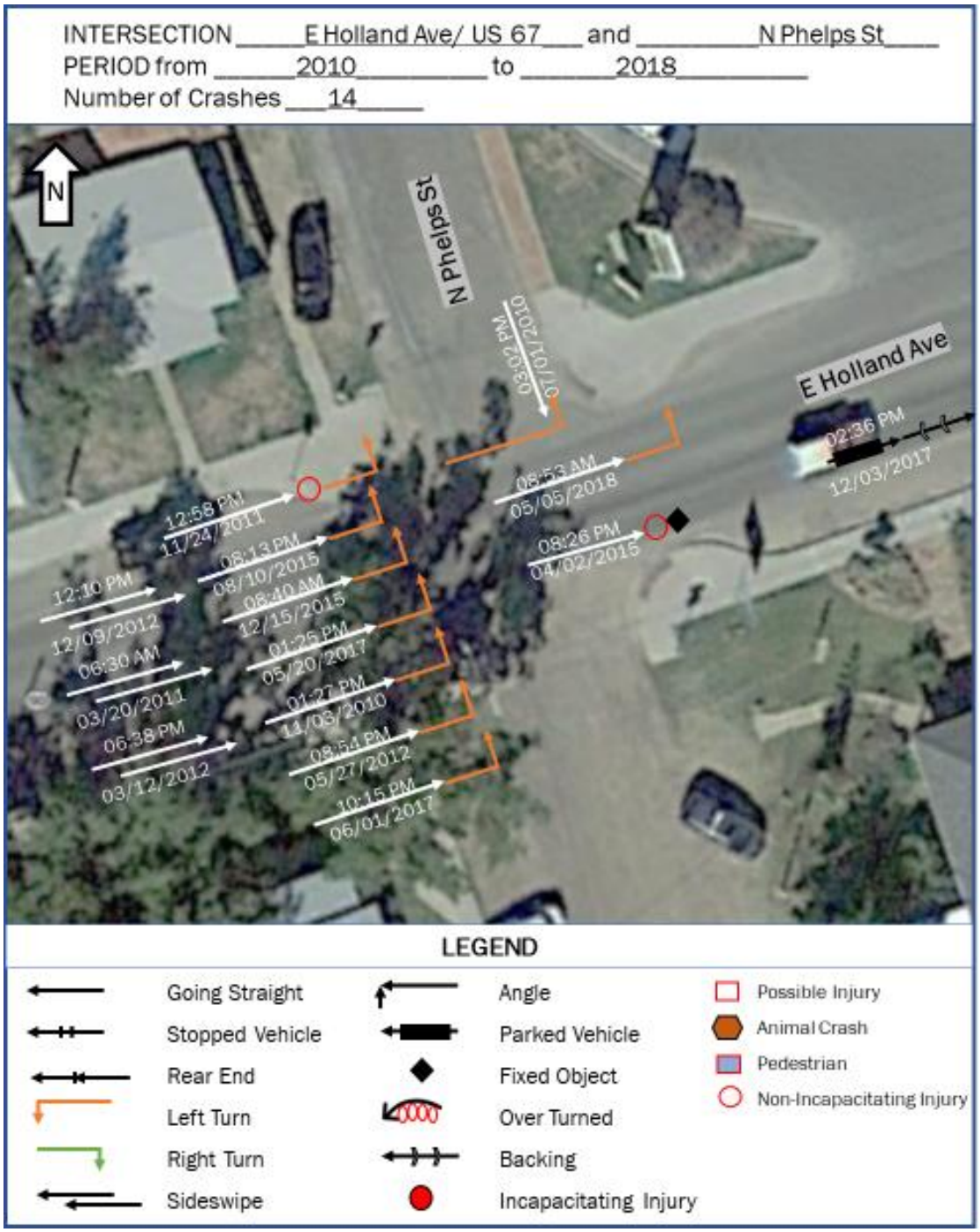
This intersection is located in downtown Alpine. Out of the 20 crashes in the past 9 years, 11 were angle collisions, four were left turn related, and two hit pedestrians. Other crashes include rear-end collisions.



- **Short-term:** Improve striping, signing and pavement marking.
- **Mid- to long-term:**
    - Propose improvements including curb extensions and channelization. Additional details are provided in the US 67 Corridor Master Plan Alternatives Analysis Technical Memorandum.
    - Signalize intersection and ensure adequate pedestrian phase.

10. Holland Avenue and Phelps Street

This intersection is in Alpine. There were 14 crashes in the past nine years. One was a non-incapacitating injury crash. Nine out of the 14 crashes involved a vehicle turning left from US 67.

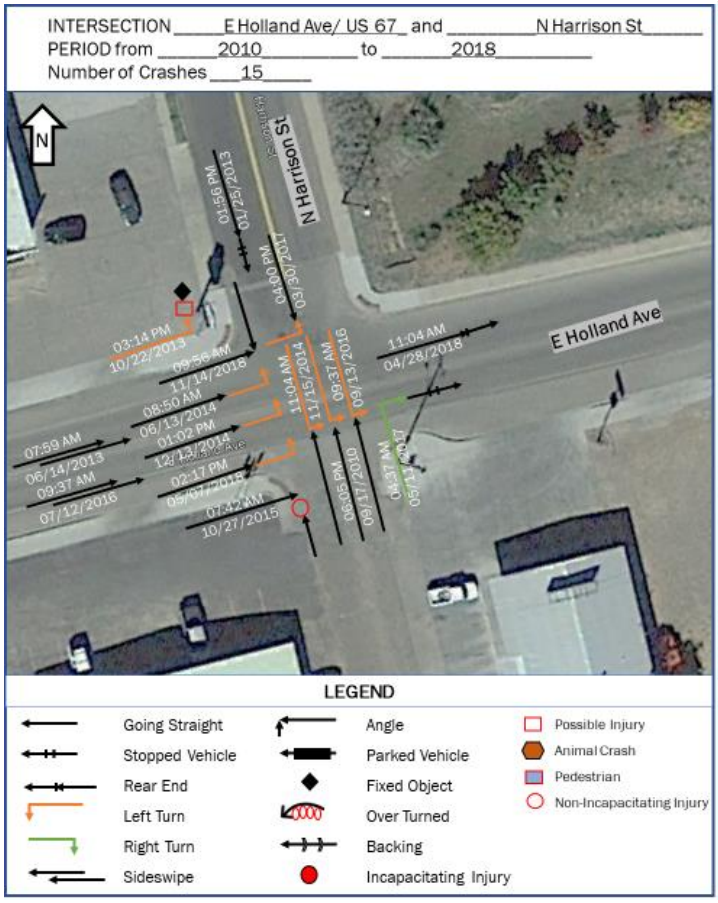


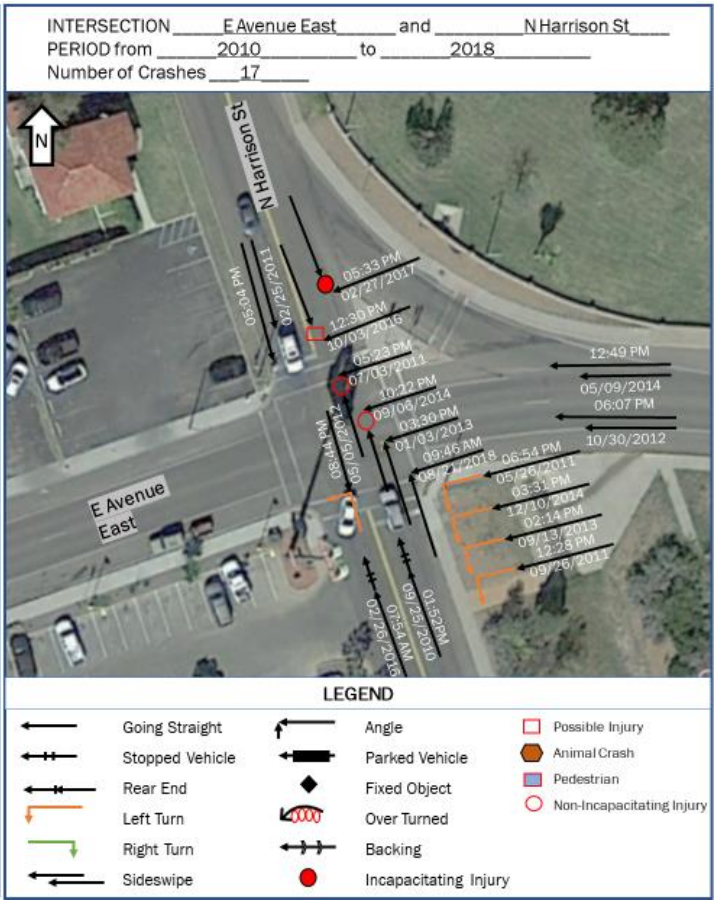
- **Short-term:**
  - There are two "stops sign ahead" signs – one on either side of US 67 – just before N. Phelps Street. It is possible drivers think they have stop at N. Phelps Street. Consider moving these signs to the far side of the intersection.
  - Consider adding advance signage for the gas station for driver to stay left, to create awareness of the upcoming decision point.
- **Mid- to long-term:** None.

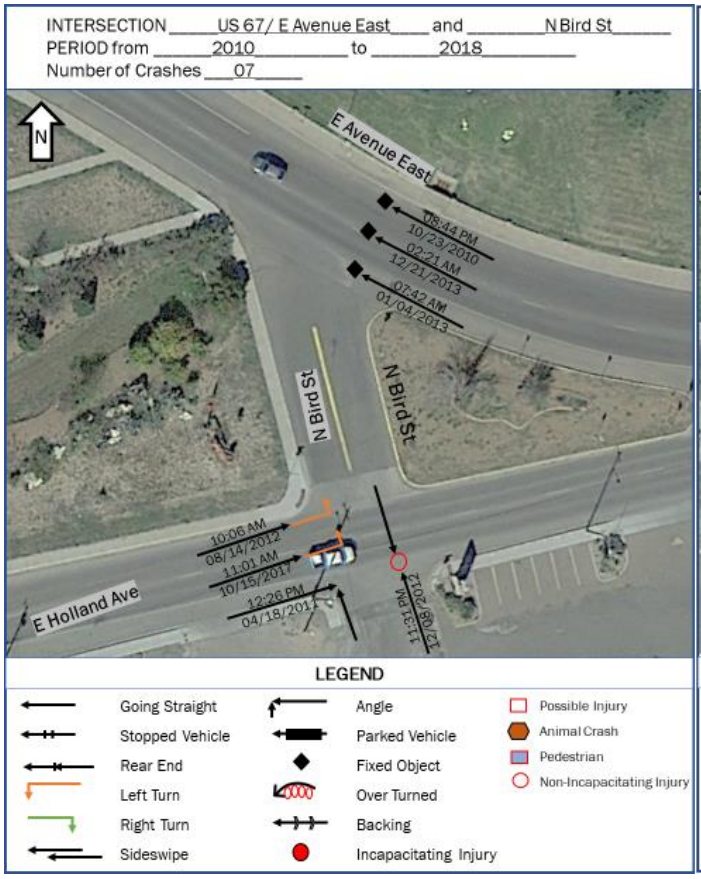
11. Holland Avenue and Harrison Street
12. E Avenue and Harrison Street
13. E Avenue and Bird Street
14. US 67 and Lackey Street

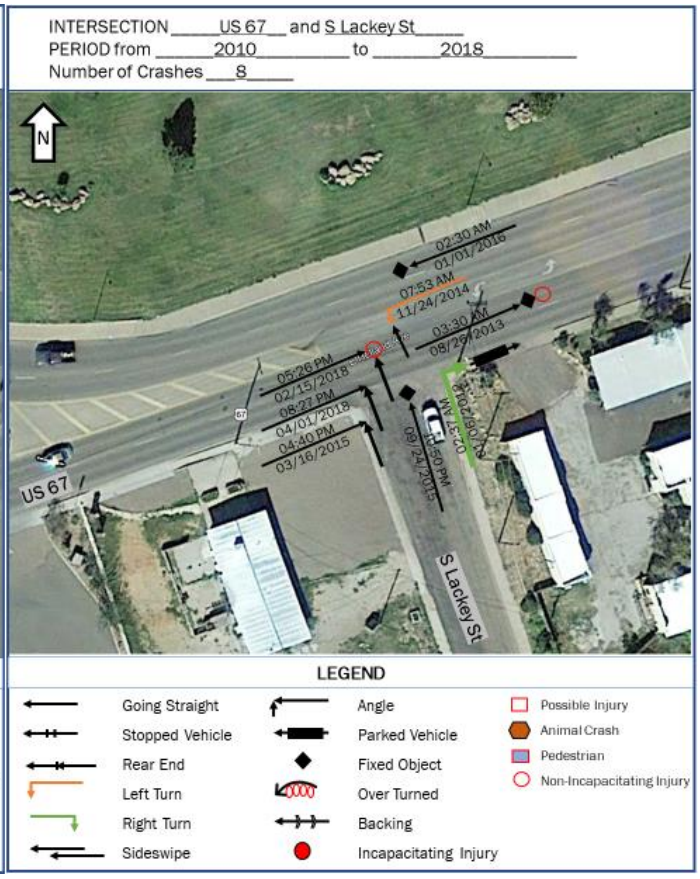
These four intersections should be analyzed as a system due to their close proximity to each other. Crashes involving a left turning vehicle are prominent.

- At Holland Avenue and N Harrison Street, there were 15 crashes at this intersection in the past nine years. Eight out of the 15 crashes involved a vehicle turning left.
- At E Avenue East and N Harrison Street, there were 17 crashes at this intersection in the past nine years. Four crashes involved a vehicle turning left from E. Avenue East to Harrison Street.
- At US 67 and Bird Street, there were seven crashes at this intersection in the past nine years. Three were fixed object crashes along E. Avenue East. Two involved vehicles turning left on US 67.
- At US 67 and S Lackey Street, there were 8 crashes at this intersection in the past nine years. Three crashes involved were angle collision crashes.









- **Short-term:**
  - Improve signage and pavement marking. Add a plaque underneath the stop signs for "Cross Traffic Does Not Stop".
  - Remove the hanging lights. Replace by adding sensors/LED lights for the stop signs.
  - Add the zebra pedestrian crosswalks, add pedestrian crossing signs, and a pedestrian crossing ahead sign upstream of the intersection.
  - Convert Harrison Street to a southbound only between E Avenue East and Holland Avenue.
  - Convert Bird Street to a northbound only street.
  - At the intersection of E Avenue East and N Harrison Street, provide a channelized left turn for the eastbound direction.
  - Consider traffic calming measures including dropping the speed limit westbound further east of the intersection.

- **Mid- to long-term:** Convert multiple intersections in this area into a roundabout. Additional details are provided in the US 67 Corridor Master Plan Alternatives Analysis Technical Memorandum.

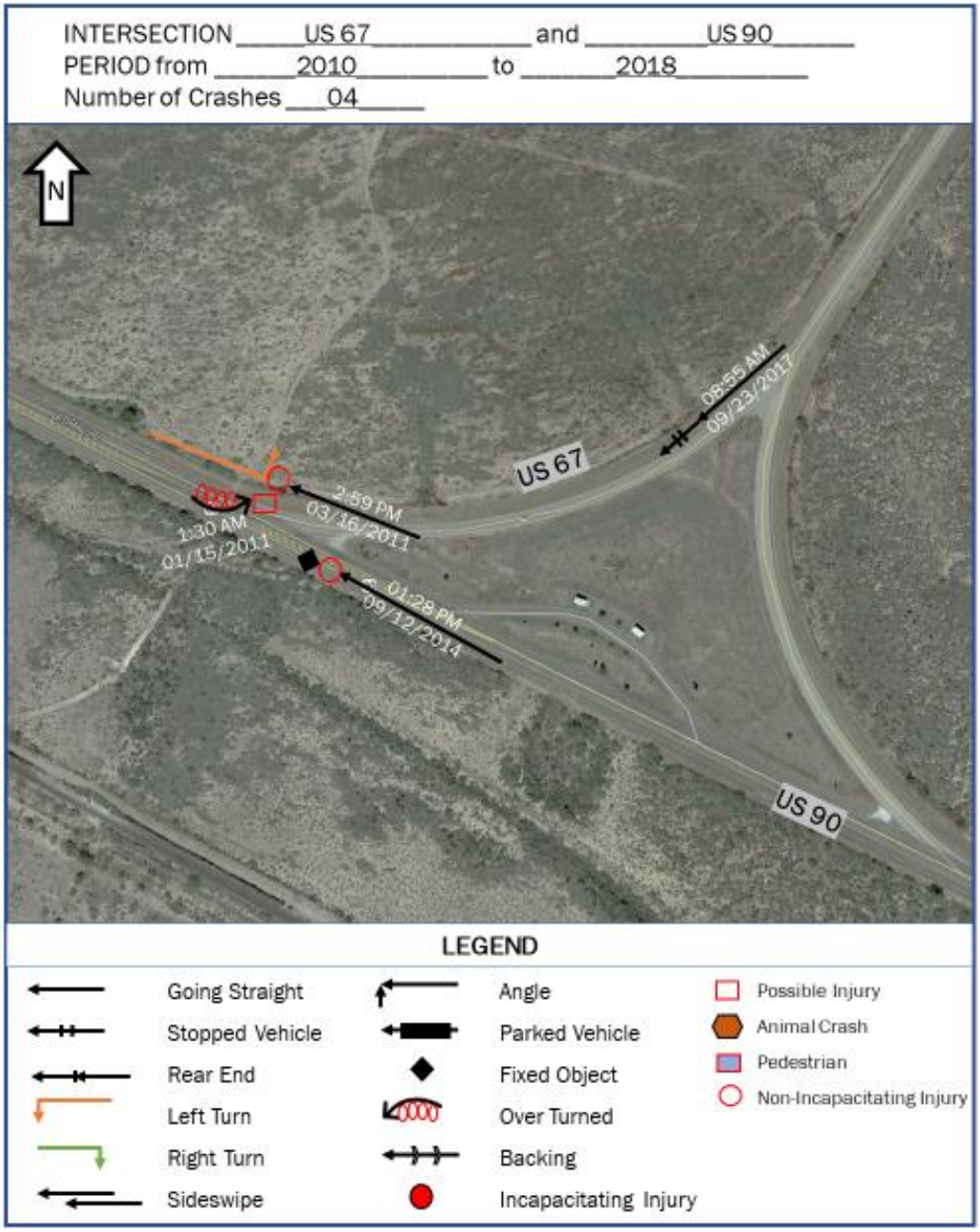
15. US 67 and Harmon Street

This intersection is located at the south entrance of the Sul Ross State University with US 67. There was only one crash that happened in 2018. The crash involved two vehicles and a pedestrian.

- **Short-term:** Provide pedestrian crossing warning sign. The sidewalks on both sides of US 67 suggest pedestrian activity from/to the Sul Ross State University.
- **Mid- to long-term**: None.

16. US 67 and US 90 Interchange – East of Alpine

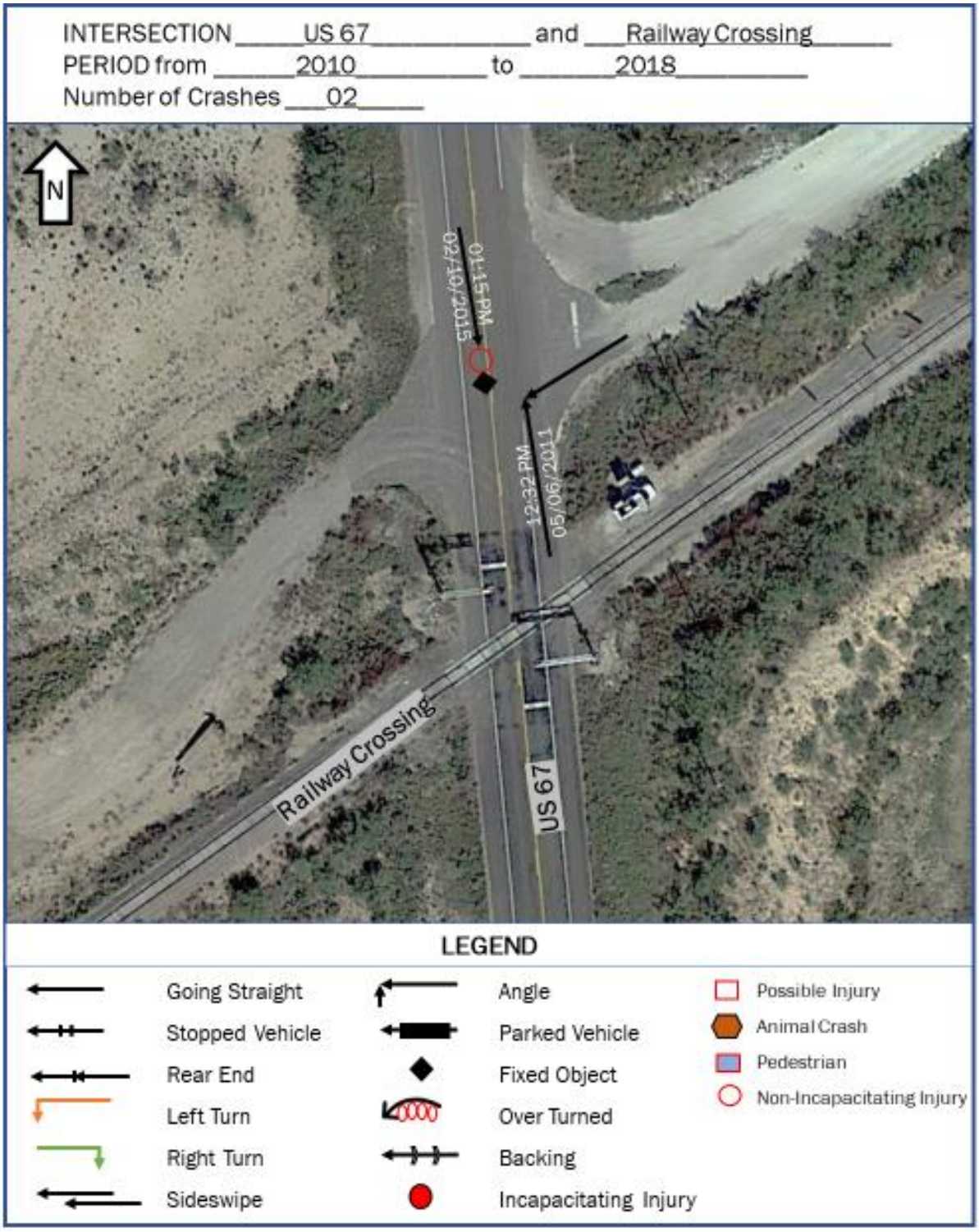
This interchange is located east of Alpine. Four crashes occurred in the last nine years. Three crashes were injury crashes. Three of them occurred in the left quadrant of the Y intersection, but there is no apparent correlation between them. The skewed left turning movements would benefit from some reconfiguration.



- **Short-term:**
  - Remove obstacles – short marker posts along US 90 near the picnic area.
  - Maintain pavement marking.
- **Mid- to long-term:** Revise interchange geometry including shoulder widening. Additional details are provided in the US 67 Corridor Master Plan Alternatives Analysis Technical Memorandum.

17. US 67 at Old Alpine Highway – Railway Crossing North of US 90 interchange

This intersection is a railway crossing located about 20 miles south of I-10 and north of US 67/US 90 intersection. There were two crashes on the last nine years. One of them was a fixed object crash and the other a right-angled crash. The public raised some concerns about the sudden speed drop to give priority to the train which caused the safety concern.



- **Short-term:** Add a stopped vehicle warning system.
- **Mid- to long-term:** The stopped vehicle warning system should be re-evaluated after stopped vehicle warning system has been operational.

18. US 67 and I-10 Interchange

This interchange is located in the north end of the study area, west of Fort Stockton. There were three property damage only crashes and one possible injury crash in the past nine years. This interchange lacks adequate taper length for ramps and lacks proper signage.

- **Short-term:**
  - Add LED lights for the stop signs and banner to alert that main traffic does not stop.
- **Mid- to long-term:**
  - Recommend removal of the redundant northbound exit ramp from US 67 to I-10 to avoid merge conflict.
  - Recommend increasing the exit ramp deceleration and taper lengths to 780 feet per TxDOT Roadway Design Manual's recommended value for speed change lane length.
  - Recommend increasing the entrance ramp acceleration and taper lengths to 1,110 feet per TxDOT Roadway Design Manual's recommended value for speed change lane length.

US 67 CORRIDOR
MASTER PLAN

Attachment F

IHSDM Analysis Summary Tables

February 2020

Texas Department of Transportation

Table 1: Predicted Crash Frequency for Control Section 0104-07 (North of Shafter)

Statistic	Existing (2010-2017)	No-Build (2020-2045)	Build (2020-2045)	Difference between Build & No-Build (2020-2045)
First Year of Analysis	2010	2020	2020	
Last Year of Analysis	2017	2045	2045	
Evaluated Length (mi)	17.14	17.14	17.14	
Average Future Road AADT (vpd)	1,300	2,400	2,400	
Predicted Crashes				
Total Crashes	61	352	244	108 (31%)
Fatal and Injury Crashes (FI)	20	113	78	35
Property-Damage-Only Crashes	41	239	165	74
Percent of Total Predicted Crashes				
Percent Fatal and Injury Crashes (%)	32	32	32	
Percent Property-Damage-Only Crashes (%)	68	68	68	
Predicted Crash Rate				
Crash Rate (crashes/mi/yr)	0.44	0.79	0.55	0.24
FI Crash Rate (crashes/mi/yr)	0.14	0.25	0.18	0.07
PDO Crash Rate (crashes/mi/yr)	0.30	0.54	0.37	0.17
Predicted Travel Crash Rate				
Total Travel (million veh-mi)	66	384	384	
Travel Crash Rate (per 100 million veh-mi)	92	92	64	28

Table 2: Predicted Crash Frequency for Control Section 0104-08 (Near Shafter)

Statistic	Existing (2010-2017)	No-Build (2020-2045)	Build (2020-2045)	Difference between Build & No-Build (2020-2045)
First Year of Analysis	2010	2020	2020	
Last Year of Analysis	2017	2045	2045	
Evaluated Length (mi)	14.63	14.63	14.63	
Average Future Road AADT (vpd)	1,300	2,100	2,100	
Predicted Crashes				
Total Crashes	52	274	191	83 (30%)
Fatal and Injury Crashes (FI)	17	88	61	27
Property-Damage-Only Crashes	35	186	130	56
Percent of Total Predicted Crashes				
Percent Fatal and Injury Crashes (%)	32	32	32	
Percent Property-Damage-Only Crashes (%)	68	68	68	
Predicted Crash Rate				
Crash Rate (crashes/mi/yr)	0.44	0.72	0.50	0.22
FI Crash Rate (crashes/mi/yr)	0.14	0.23	0.16	0.07
PDO Crash Rate (crashes/mi/yr)	0.30	0.49	0.34	0.15
Predicted Travel Crash Rate				
Total Travel (million veh-mi)	55	290	290	
Travel Crash Rate (per 100 million veh-mi)	95	95	66	29

Table 3: Predicted Crash Frequency for Control Section 0020-08 (East of Marfa)

Statistic	Existing (2010-2017)	No-Build (2020-2045)	Build (2020-2045)	Difference between Build & No-Build (2020-2045)
First Year of Analysis	2010	2020	2020	
Last Year of Analysis	2017	2045	2045	
Evaluated Length (mi)	14.12	14.12	14.12	
Average Future Road AADT (vpd)	2,300	3,900	3,900	
Predicted Crashes				
Total Crashes	57	314	243	71 (23%)
Fatal and Injury Crashes (FI)	18	101	78	23
Property-Damage-Only Crashes	39	213	165	48
Percent of Total Predicted Crashes				
Percent Fatal and Injury Crashes (%)	32	32	32	
Percent Property-Damage-Only Crashes (%)	68	68	68	
Predicted Crash Rate				
Crash Rate (crashes/mi/yr)	0.50	0.85	0.66	0.19
FI Crash Rate (crashes/mi/yr)	0.16	0.27	0.21	0.06
PDO Crash Rate (crashes/mi/yr)	0.34	0.58	0.45	0.13
Predicted Travel Crash Rate				
Total Travel (million veh-mi)	95	521	521	
Travel Crash Rate (per 100 million veh-mi)	60	60	47	13

Table 4: Predicted Crash Frequency for Control Section 0020-10 (Near Paisano Pass)

Statistic	Existing (2010-2017)	No-Build (2020-2045)	Build (2020-2045)	Difference between Build & No-Build (2020-2045)
First Year of Analysis	2010	2020	2020	
Last Year of Analysis	2017	2045	2045	
Evaluated Length (mi)	1.53	1.53	1.53	
Average Future Road AADT (vpd)	2,200	3,900	3,900	
Predicted Crashes				
Total Crashes	6	36	25	11 (31%)
Fatal and Injury Crashes (FI)	2	11	8	3
Property-Damage-Only Crashes	4	24	17	7
Percent of Total Predicted Crashes				
Percent Fatal and Injury Crashes (%)	32	32	32	
Percent Property-Damage-Only Crashes (%)	68	68	68	
Predicted Crash Rate				
Crash Rate (crashes/mi/yr)	0.50	0.89	0.63	0.26
FI Crash Rate (crashes/mi/yr)	0.16	0.29	0.20	0.09
PDO Crash Rate (crashes/mi/yr)	0.34	0.61	0.43	0.18
Predicted Travel Crash Rate				
Total Travel (million veh-mi)	10	57	57	
Travel Crash Rate (per 100 million veh-mi)	63	63	45	18

Table 5: Predicted Crash Frequency for Control Section 0020-11 (East of Alpine)

Statistic	Existing (2010-2017)	No-Build (2020-2045)	Build (2020-2045)	Difference between Build & No-Build (2020-2045)
First Year of Analysis	2010	2020	2020	
Last Year of Analysis	2017	2045	2045	
Evaluated Length (mi)	7.38	7.38	7.38	
Average Future Road AADT (vpd)	2,300	3,900	3,900	
Predicted Crashes				
Total Crashes	41	232	145	87 (38%)
Fatal and Injury Crashes (FI)	13	74	47	27
Property-Damage-Only Crashes	28	157	99	58
Percent of Total Predicted Crashes				
Percent Fatal and Injury Crashes (%)	32	32	32	
Percent Property-Damage-Only Crashes (%)	68	68	68	
Predicted Crash Rate				
Crash Rate (crashes/mi/yr)	0.70	1.21	0.76	0.45
FI Crash Rate (crashes/mi/yr)	0.22	0.39	0.24	0.15
PDO Crash Rate (crashes/mi/yr)	0.48	0.82	0.51	0.31
Predicted Travel Crash Rate				
Total Travel (million veh-mi)	49	274	274	
Travel Crash Rate (per 100 million veh-mi)	85	85	53	32

Table 6: Predicted Crash Frequency for Control Section 0075-02 (North of Brewster/Pecos County Line)

Statistic	Existing (2010-2017)	No-Build (2020-2045)	Build (2020-2045)	Difference between Build & No-Build (2020-2045)
First Year of Analysis	2010	2020	2020	
Last Year of Analysis	2017	2045	2045	
Evaluated Length (mi)	11.94	11.94	11.94	
Average Future Road AADT (vpd)	1,300	2,100	2,100	
Predicted Crashes				
Total Crashes	32	162	106	56 (35%)
Fatal and Injury Crashes (FI)	10	52	34	18
Property-Damage-Only Crashes	22	110	72	38
Percent of Total Predicted Crashes				
Percent Fatal and Injury Crashes (%)	32	32	32	
Percent Property-Damage-Only Crashes (%)	68	68	68	
Predicted Crash Rate				
Crash Rate (crashes/mi/yr)	0.33	0.52	0.34	0.18
FI Crash Rate (crashes/mi/yr)	0.11	0.17	0.11	0.06
PDO Crash Rate (crashes/mi/yr)	0.23	0.35	0.23	0.12
Predicted Travel Crash Rate				
Total Travel (million veh-mi)	45	237	237	
Travel Crash Rate (per 100 million veh-mi)	70	69	45	24

Table 7: Predicted Crash Frequency for Control Section 0075-03 (South of US 67/I-10 Interchange)

Statistic	Existing (2010-2017)	No-Build (2020-2045)	Build (2020-2045)	Difference between Build & No-Build (2020-2045)
First Year of Analysis	2010	2020	2020	
Last Year of Analysis	2017	2045	2045	
Evaluated Length (mi)	15.63	15.63	15.63	
Average Future Road AADT (vpd)	1,400	2,400	2,400	
Predicted Crashes				
Total Crashes	51	278	213	65 (23%)
Fatal and Injury Crashes (FI)	16	89	68	21
Property-Damage-Only Crashes	35	189	145	44
Percent of Total Predicted Crashes				
Percent Fatal and Injury Crashes (%)	32	32	32	
Percent Property-Damage-Only Crashes (%)	68	68	68	
Predicted Crash Rate				
Crash Rate (crashes/mi/yr)	0.41	0.68	0.52	0.16
FI Crash Rate (crashes/mi/yr)	0.13	0.22	0.17	0.05
PDO Crash Rate (crashes/mi/yr)	0.28	0.46	0.36	0.10
Predicted Travel Crash Rate				
Total Travel (million veh-mi)	63	352	352	
Travel Crash Rate (per 100 million veh-mi)	81	79	61	18

US 67 CORRIDOR
MASTER PLAN

Attachment G

ISATe Analysis Summary Tables

February 2020

Texas Department of Transportation

Table 1: Predicted Crash Frequency for US 67 and I-10 Interchange Components for No-Build Scenario

Output Summary

General Information

Project description:	US67 and I-10 Interchange				
Analyst:	Houssam	Date:	3/19/2019	Area type:	Rural
First year of analysis:	2020				
Last year of analysis:	2040				

Crash Data Description

Freeway segments	Segment crash data available?	No	First year of crash data:	
	Project-level crash data available?	No	Last year of crash data:	
Ramp segments	Segment crash data available?	No	First year of crash data:	
	Project-level crash data available?	No	Last year of crash data:	
Ramp terminals	Segment crash data available?	No	First year of crash data:	
	Project-level crash data available?	No	Last year of crash data:	

Estimated Crash Statistics

Crashes for Entire Facility		Total	K	A	B	C	PDO
Estimated number of crashes during Study Period, crashes:		56.5	0.7	2.2	9.8	11.7	32.1
Estimated average crash freq. during Study Period, crashes/yr:		2.7	0.0	0.1	0.5	0.6	1.5
Crashes by Facility Component	Nbr. Sites	Total	K	A	B	C	PDO
Freeway segments, crashes:	3	33.3	0.4	1.2	5.4	6.9	19.4
Ramp segments, crashes:	5	14.6	0.2	0.7	3.6	2.2	7.9
Crossroad ramp terminals, crashes:	2	8.6	0.0	0.2	0.8	2.7	4.9
Crashes for Entire Facility by Year	Year	Total	K	A	B	C	PDO
Estimated number of crashes during the Study Period, crashes:	2020	2.2	0.0	0.1	0.4	0.5	1.3
	2021	2.3	0.0	0.1	0.4	0.5	1.3
	2022	2.3	0.0	0.1	0.4	0.5	1.3
	2023	2.4	0.0	0.1	0.4	0.5	1.3
	2024	2.4	0.0	0.1	0.4	0.5	1.4
	2025	2.5	0.0	0.1	0.4	0.5	1.4
	2026	2.5	0.0	0.1	0.4	0.5	1.4
	2027	2.6	0.0	0.1	0.4	0.5	1.4
	2028	2.6	0.0	0.1	0.5	0.5	1.5
	2029	2.6	0.0	0.1	0.5	0.5	1.5
	2030	2.7	0.0	0.1	0.5	0.6	1.5
	2031	2.7	0.0	0.1	0.5	0.6	1.6
	2032	2.8	0.0	0.1	0.5	0.6	1.6
	2033	2.8	0.0	0.1	0.5	0.6	1.6
	2034	2.9	0.0	0.1	0.5	0.6	1.6
	2035	2.9	0.0	0.1	0.5	0.6	1.7
	2036	3.0	0.0	0.1	0.5	0.6	1.7
	2037	3.0	0.0	0.1	0.5	0.6	1.7
	2038	3.1	0.0	0.1	0.5	0.6	1.7
	2039	3.1	0.0	0.1	0.5	0.6	1.8
	2040	3.1	0.0	0.1	0.5	0.6	1.8
	2041						
	2042						
	2043						

Distribution of Crashes for Entire Facility

Crash Type	Crash Type Category	Estimated Number of Crashes During the Study Period					
		Total	K	A	B	C	PDO
Multiple vehicle	Head-on crashes:	0.3	0.0	0.0	0.1	0.1	0.1
	Right-angle crashes:	4.3	0.0	0.2	0.5	1.6	2.0
	Rear-end crashes:	10.5	0.1	0.4	1.8	2.7	5.4
	Sideswipe crashes:	5.2	0.0	0.1	0.6	0.8	3.7
	Other multiple-vehicle crashes:	1.1	0.0	0.0	0.1	0.2	0.7
	Total multiple-vehicle crashes:	21.4	0.2	0.7	3.1	5.4	12.0
Single vehicle	Crashes with animal:	1.1	0.0	0.0	0.1	0.1	0.9
	Crashes with fixed object:	19.6	0.2	0.7	3.3	3.3	12.1
	Crashes with other object:	1.8	0.0	0.0	0.1	0.1	1.6
	Crashes with parked vehicle:	1.1	0.0	0.0	0.2	0.2	0.7
	Other single-vehicle crashes	11.5	0.2	0.7	3.1	2.7	4.8
	Total single-vehicle crashes:	35.1	0.5	1.5	6.7	6.4	20.1
	Total crashes:	56.5	0.7	2.2	9.8	11.7	32.1

(K=Killed; A=Incapacitating; B=Non-Incapacitating; C=Possible Injury; O=No Injury, or Property-Damage-Only).

Table 2: Predicted Crash Frequency for US 67 and I-10 Interchange Components for Build Scenario

Output Summary

General Information

Project description:	US67 and I-10 Interchange				
Analyst:	Houssam	Date:	3/19/2019	Area type:	Rural
First year of analysis:	2020				
Last year of analysis:	2040				

Crash Data Description

Freeway segments	Segment crash data available?	No	First year of crash data:	
	Project-level crash data available?	No	Last year of crash data:	
Ramp segments	Segment crash data available?	No	First year of crash data:	
	Project-level crash data available?	No	Last year of crash data:	
Ramp terminals	Segment crash data available?	No	First year of crash data:	
	Project-level crash data available?	No	Last year of crash data:	

Estimated Crash Statistics

Crashes for Entire Facility	Total	K	A	B	C	PDO
Estimated number of crashes during Study Period, crashes:	54.5	0.6	2.0	9.0	11.1	31.7
Estimated average crash freq. during Study Period, crashes/yr:	2.6	0.0	0.1	0.4	0.5	1.5

Crashes by Facility Component	Nbr. Sites	Total	K	A	B	C	PDO
Freeway segments, crashes:	3	33.3	0.4	1.2	5.1	6.5	20.1
Ramp segments, crashes:	4	12.6	0.2	0.6	3.1	1.9	6.8
Crossroad ramp terminals, crashes:	2	8.6	0.0	0.2	0.8	2.7	4.9

Crashes for Entire Facility by Year	Year	Total	K	A	B	C	PDO
Estimated number of crashes during the Study Period, crashes:	2020	2.2	0.0	0.1	0.4	0.4	1.2
	2021	2.2	0.0	0.1	0.4	0.5	1.3
	2022	2.2	0.0	0.1	0.4	0.5	1.3
	2023	2.3	0.0	0.1	0.4	0.5	1.3
	2024	2.3	0.0	0.1	0.4	0.5	1.3
	2025	2.4	0.0	0.1	0.4	0.5	1.4
	2026	2.4	0.0	0.1	0.4	0.5	1.4
	2027	2.5	0.0	0.1	0.4	0.5	1.4
	2028	2.5	0.0	0.1	0.4	0.5	1.5
	2029	2.5	0.0	0.1	0.4	0.5	1.5
	2030	2.6	0.0	0.1	0.4	0.5	1.5
	2031	2.6	0.0	0.1	0.4	0.5	1.5
	2032	2.7	0.0	0.1	0.4	0.5	1.6
	2033	2.7	0.0	0.1	0.4	0.6	1.6
	2034	2.8	0.0	0.1	0.5	0.6	1.6
	2035	2.8	0.0	0.1	0.5	0.6	1.6
	2036	2.9	0.0	0.1	0.5	0.6	1.7
	2037	2.9	0.0	0.1	0.5	0.6	1.7
	2038	2.9	0.0	0.1	0.5	0.6	1.7
	2039	3.0	0.0	0.1	0.5	0.6	1.8
	2040	3.0	0.0	0.1	0.5	0.6	1.8
	2041						
	2042						
	2043						

Distribution of Crashes for Entire Facility

Crash Type	Crash Type Category	Estimated Number of Crashes During the Study Period					
		Total	K	A	B	C	PDO
Multiple vehicle	Head-on crashes:	0.3	0.0	0.0	0.1	0.1	0.1
	Right-angle crashes:	4.3	0.0	0.2	0.5	1.6	2.0
	Rear-end crashes:	11.6	0.1	0.4	1.9	2.9	6.3
	Sideswipe crashes:	6.0	0.0	0.1	0.6	0.8	4.4
	Other multiple-vehicle crashes:	1.1	0.0	0.0	0.1	0.2	0.8
	Total multiple-vehicle crashes:	23.4	0.2	0.8	3.2	5.5	13.6
Single vehicle	Crashes with animal:	1.0	0.0	0.0	0.1	0.1	0.9
	Crashes with fixed object:	17.3	0.2	0.6	2.8	2.8	10.8
	Crashes with other object:	1.7	0.0	0.0	0.1	0.1	1.5
	Crashes with parked vehicle:	1.0	0.0	0.0	0.1	0.1	0.7
	Other single-vehicle crashes	10.1	0.2	0.6	2.7	2.4	4.3
	Total single-vehicle crashes:	31.1	0.4	1.2	5.8	5.5	18.2
	Total crashes:	54.5	0.6	2.0	9.0	11.1	31.7

(K=Killed; A=Incapacitating; B=Non-Incapacitating; C=Possible Injury; O=No Injury, or Property-Damage-Only).

US 67 CORRIDOR
MASTER PLAN

Attachment H

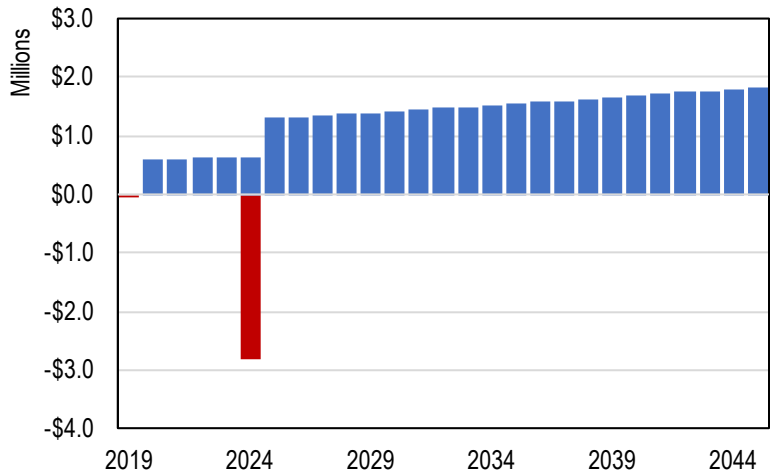
Benefit-Cost Analysis Results

February 2020

Texas Department of Transportation

Table 1: Segment 2 (0104-08) BCA Results

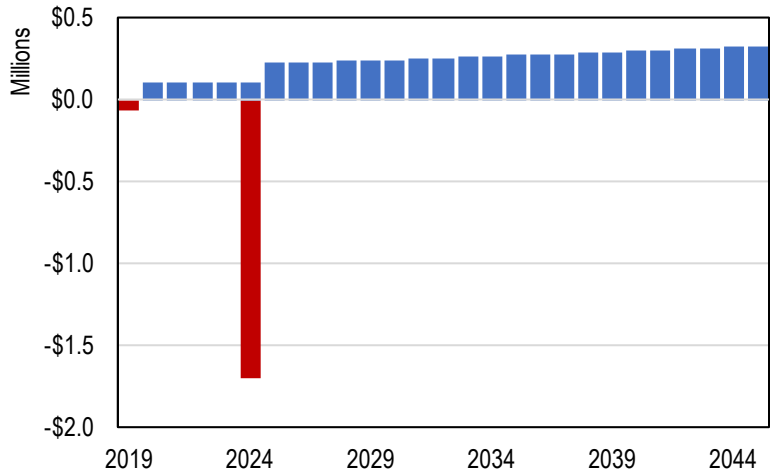
Years		Accidents Δ (Savings)					Costs	Benefits	Total
CY	Analysis	K	A	B	C	O	Subtotal	Subtotal	
2019	0	0.00	0.00	0.00	0.00	0.00	-$42,575	$0	-$42,575
2020	1	0.05	0.10	0.30	0.10	1.07	$0	$599,299	$599,299
2021	2	0.05	0.11	0.30	0.11	1.08	$0	$609,611	$609,611
2022	3	0.05	0.11	0.31	0.11	1.10	$0	$620,100	$620,100
2023	4	0.06	0.11	0.31	0.11	1.12	$0	$630,770	$630,770
2024	5	0.06	0.11	0.32	0.11	1.14	-$2,800,000	$641,624	-$2,158,376
2025	6	0.11	0.23	0.65	0.23	2.33	$0	$1,305,328	$1,305,328
2026	7	0.12	0.23	0.66	0.23	2.37	$0	$1,327,788	$1,327,788
2027	8	0.12	0.24	0.67	0.24	2.41	$0	$1,350,635	$1,350,635
2028	9	0.12	0.24	0.68	0.24	2.45	$0	$1,373,875	$1,373,875
2029	10	0.12	0.24	0.69	0.24	2.49	$0	$1,397,515	$1,397,515
2030	11	0.12	0.25	0.71	0.25	2.54	$0	$1,421,562	$1,421,562
2031	12	0.13	0.25	0.72	0.25	2.58	$0	$1,446,023	$1,446,023
2032	13	0.13	0.26	0.73	0.26	2.63	$0	$1,470,904	$1,470,904
2033	14	0.13	0.26	0.74	0.26	2.67	$0	$1,496,213	$1,496,213
2034	15	0.13	0.27	0.76	0.27	2.72	$0	$1,521,958	$1,521,958
2035	16	0.14	0.27	0.77	0.27	2.77	$0	$1,548,146	$1,548,146
2036	17	0.14	0.28	0.78	0.28	2.82	$0	$1,574,785	$1,574,785
2037	18	0.14	0.28	0.79	0.28	2.86	$0	$1,601,882	$1,601,882
2038	19	0.14	0.29	0.81	0.29	2.91	$0	$1,629,445	$1,629,445
2039	20	0.15	0.29	0.82	0.29	2.97	$0	$1,657,483	$1,657,483
2040	21	0.15	0.30	0.84	0.30	3.02	$0	$1,686,003	$1,686,003
2041	22	0.15	0.30	0.85	0.30	3.07	$0	$1,715,013	$1,715,013
2042	23	0.15	0.31	0.87	0.31	3.12	$0	$1,744,523	$1,744,523
2043	24	0.16	0.31	0.88	0.31	3.18	$0	$1,774,541	$1,774,541
2044	25	0.16	0.32	0.90	0.32	3.24	$0	$1,805,075	$1,805,075
2045	26	0.16	0.32	0.91	0.32	3.29	$0	$1,836,134	$1,836,134
Total		3.13	6.27	17.76	6.27	63.94	-$2,842,575	$35,786,236	$32,943,661



NPV @ 3%	$20,697,859
NPV @ 7%	$12,035,307
BCR @ 3%	9.421
BCR @ 7%	6.903

Table 2: Segment 3 (0104-07) BCA Results

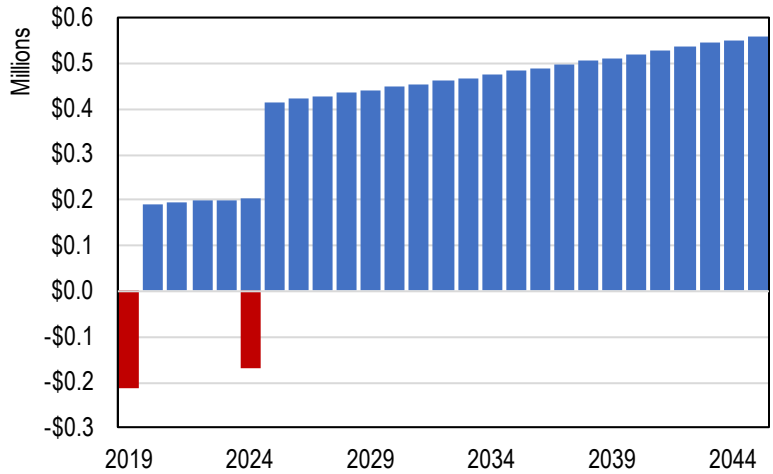
Years		Accidents Δ (Savings)					Costs	Benefits	Total
CY	Analysis	K	A	B	C	O	Subtotal	Subtotal	
2019	0	0.00	0.00	0.00	0.00	0.00	-$59,475	$0	-$59,475
2020	1	0.00	0.14	0.22	0.05	1.13	$0	$100,213	$100,213
2021	2	0.00	0.15	0.22	0.06	1.15	$0	$102,229	$102,229
2022	3	0.00	0.15	0.23	0.06	1.17	$0	$104,286	$104,286
2023	4	0.00	0.15	0.23	0.06	1.20	$0	$106,385	$106,385
2024	5	0.00	0.15	0.24	0.06	1.22	-$1,700,000	$108,525	-$1,591,475
2025	6	0.00	0.32	0.49	0.12	2.49	$0	$221,417	$221,417
2026	7	0.00	0.32	0.50	0.12	2.54	$0	$225,872	$225,872
2027	8	0.00	0.33	0.51	0.13	2.59	$0	$230,417	$230,417
2028	9	0.00	0.34	0.52	0.13	2.64	$0	$235,052	$235,052
2029	10	0.00	0.34	0.53	0.13	2.70	$0	$239,782	$239,782
2030	11	0.00	0.35	0.54	0.13	2.75	$0	$244,606	$244,606
2031	12	0.00	0.36	0.55	0.14	2.81	$0	$249,528	$249,528
2032	13	0.00	0.36	0.56	0.14	2.86	$0	$254,548	$254,548
2033	14	0.00	0.37	0.57	0.14	2.92	$0	$259,670	$259,670
2034	15	0.00	0.38	0.58	0.15	2.98	$0	$264,894	$264,894
2035	16	0.00	0.39	0.59	0.15	3.04	$0	$270,224	$270,224
2036	17	0.00	0.39	0.60	0.15	3.10	$0	$275,661	$275,661
2037	18	0.00	0.40	0.62	0.15	3.17	$0	$281,207	$281,207
2038	19	0.00	0.41	0.63	0.16	3.23	$0	$286,865	$286,865
2039	20	0.00	0.42	0.64	0.16	3.29	$0	$292,637	$292,637
2040	21	0.00	0.43	0.65	0.16	3.36	$0	$298,525	$298,525
2041	22	0.00	0.43	0.67	0.17	3.43	$0	$304,531	$304,531
2042	23	0.00	0.44	0.68	0.17	3.50	$0	$310,658	$310,658
2043	24	0.00	0.45	0.70	0.17	3.57	$0	$316,908	$316,908
2044	25	0.00	0.46	0.71	0.18	3.64	$0	$323,285	$323,285
2045	26	0.00	0.47	0.72	0.18	3.71	$0	$329,789	$329,789
Total		0.00	8.90	13.68	3.42	70.21	-$1,759,475	$6,237,713	$4,478,238



NPV @ 3%	$2,493,631
NPV @ 7%	$1,158,602
BCR @ 3%	2.634
BCR @ 7%	1.911

Table 3: Segment 5 (0020-08) BCA Results

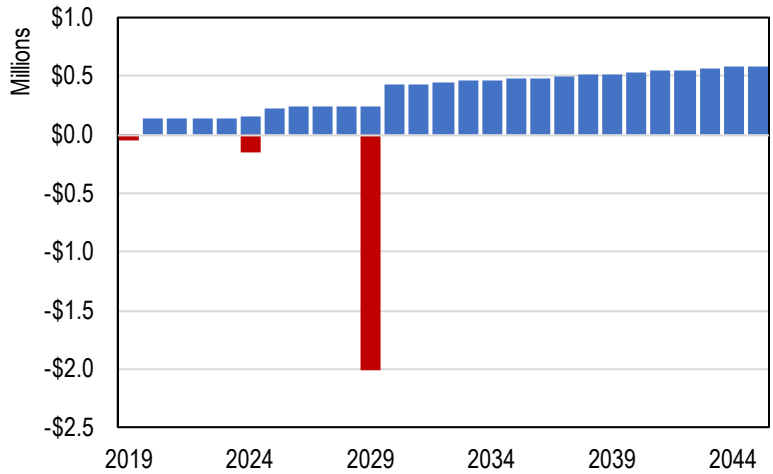
Years		Accidents Δ (Savings)					Costs	Benefits	Total
CY	Analysis	K	A	B	C	O	Subtotal	Subtotal	
2019	0	0.00	0.00	0.00	0.00	0.00	-$212,440	$0	-$212,440
2020	1	0.01	0.09	0.19	0.09	0.51	$0	$192,457	$192,457
2021	2	0.01	0.09	0.19	0.09	0.52	$0	$195,362	$195,362
2022	3	0.01	0.09	0.19	0.09	0.53	$0	$198,311	$198,311
2023	4	0.01	0.09	0.20	0.09	0.54	$0	$201,304	$201,304
2024	5	0.01	0.09	0.20	0.09	0.55	-$168,000	$204,343	$36,343
2025	6	0.03	0.19	0.41	0.19	1.12	$0	$414,855	$414,855
2026	7	0.03	0.19	0.41	0.19	1.15	$0	$421,117	$421,117
2027	8	0.03	0.20	0.42	0.20	1.17	$0	$427,473	$427,473
2028	9	0.03	0.20	0.43	0.20	1.19	$0	$433,926	$433,926
2029	10	0.03	0.20	0.43	0.20	1.21	$0	$440,476	$440,476
2030	11	0.03	0.20	0.44	0.20	1.24	$0	$447,126	$447,126
2031	12	0.03	0.21	0.45	0.21	1.26	$0	$453,875	$453,875
2032	13	0.03	0.21	0.45	0.21	1.29	$0	$460,727	$460,727
2033	14	0.03	0.21	0.46	0.21	1.31	$0	$467,682	$467,682
2034	15	0.03	0.22	0.47	0.22	1.34	$0	$474,742	$474,742
2035	16	0.03	0.22	0.47	0.22	1.37	$0	$481,909	$481,909
2036	17	0.03	0.22	0.48	0.22	1.39	$0	$489,184	$489,184
2037	18	0.03	0.23	0.49	0.23	1.42	$0	$496,569	$496,569
2038	19	0.03	0.23	0.49	0.23	1.45	$0	$504,066	$504,066
2039	20	0.03	0.23	0.50	0.23	1.48	$0	$511,676	$511,676
2040	21	0.03	0.24	0.51	0.24	1.51	$0	$519,401	$519,401
2041	22	0.03	0.24	0.52	0.24	1.54	$0	$527,243	$527,243
2042	23	0.04	0.25	0.53	0.25	1.57	$0	$535,203	$535,203
2043	24	0.04	0.25	0.53	0.25	1.60	$0	$543,283	$543,283
2044	25	0.04	0.25	0.54	0.25	1.63	$0	$551,486	$551,486
2045	26	0.04	0.26	0.55	0.26	1.66	$0	$559,812	$559,812
Total		0.73	5.11	10.95	5.11	31.54	-$380,440	$11,153,609	$10,773,169



NPV @ 3%	$6,881,365
NPV @ 7%	$4,084,519
BCR @ 3%	20.256
BCR @ 7%	13.295

Table 4: Segment 7 (0020-10) BCA Results

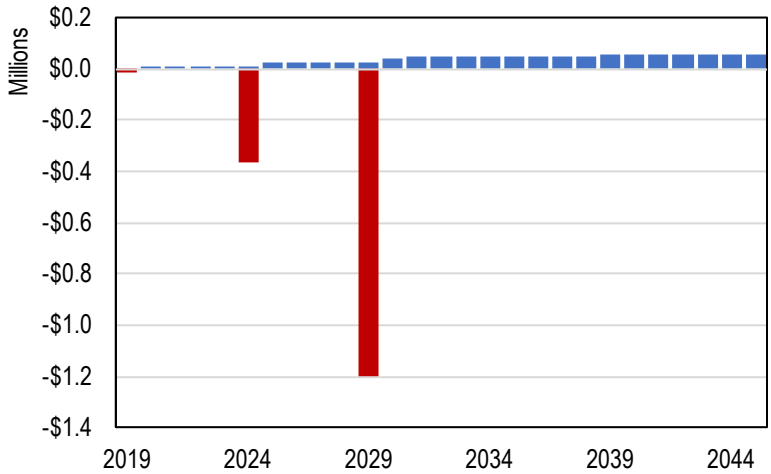
Years		Accidents Δ (Savings)					Costs	Benefits	Total
CY	Analysis	K	A	B	C	O	Subtotal	Subtotal	
2019	0	0.00	0.00	0.00	0.00	0.00	-$42,475	$0	-$42,475
2020	1	0.01	0.01	0.03	0.06	0.04	$0	$137,507	$137,507
2021	2	0.01	0.01	0.03	0.07	0.04	$0	$140,520	$140,520
2022	3	0.01	0.01	0.03	0.07	0.04	$0	$143,599	$143,599
2023	4	0.01	0.01	0.03	0.07	0.04	$0	$146,745	$146,745
2024	5	0.01	0.01	0.03	0.07	0.04	-$144,000	$149,961	$5,961
2025	6	0.02	0.02	0.04	0.11	0.07	$0	$229,870	$229,870
2026	7	0.02	0.02	0.04	0.11	0.07	$0	$234,906	$234,906
2027	8	0.02	0.02	0.05	0.11	0.07	$0	$240,053	$240,053
2028	9	0.02	0.02	0.05	0.12	0.07	$0	$245,313	$245,313
2029	10	0.02	0.02	0.05	0.12	0.07	-$2,000,000	$250,688	-$1,749,312
2030	11	0.04	0.04	0.08	0.20	0.12	$0	$426,969	$426,969
2031	12	0.04	0.04	0.08	0.21	0.13	$0	$436,324	$436,324
2032	13	0.04	0.04	0.08	0.21	0.13	$0	$445,885	$445,885
2033	14	0.04	0.04	0.09	0.21	0.13	$0	$455,655	$455,655
2034	15	0.04	0.04	0.09	0.22	0.13	$0	$465,639	$465,639
2035	16	0.04	0.04	0.09	0.22	0.14	$0	$475,841	$475,841
2036	17	0.05	0.05	0.09	0.23	0.14	$0	$486,268	$486,268
2037	18	0.05	0.05	0.09	0.23	0.14	$0	$496,922	$496,922
2038	19	0.05	0.05	0.10	0.24	0.14	$0	$507,811	$507,811
2039	20	0.05	0.05	0.10	0.24	0.15	$0	$518,937	$518,937
2040	21	0.05	0.05	0.10	0.25	0.15	$0	$530,308	$530,308
2041	22	0.05	0.05	0.10	0.25	0.15	$0	$541,928	$541,928
2042	23	0.05	0.05	0.10	0.26	0.16	$0	$553,802	$553,802
2043	24	0.05	0.05	0.11	0.27	0.16	$0	$565,937	$565,937
2044	25	0.05	0.05	0.11	0.27	0.16	$0	$578,337	$578,337
2045	26	0.06	0.06	0.11	0.28	0.17	$0	$591,009	$591,009
Total		0.94	0.94	1.88	4.70	2.85	-$2,186,475	$9,996,733	$7,810,259



NPV @ 3%	$4,604,721
NPV @ 7%	$2,476,408
BCR @ 3%	3.783
BCR @ 7%	3.131

Table 5: Segment 8 (0020-11) BCA Results

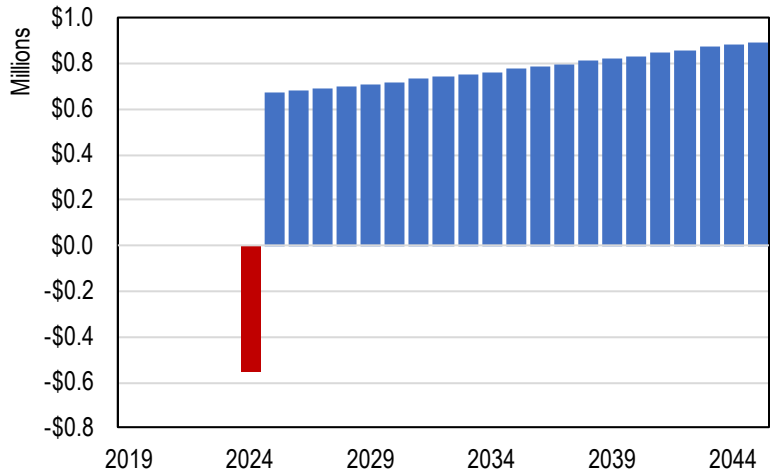
Years		Accidents Δ (Savings)					Costs	Benefits	Total
CY	Analysis	K	A	B	C	O	Subtotal	Subtotal	
2019	0	0.00	0.00	0.00	0.00	0.00	-$11,715	$0	-$11,715
2020	1	0.00	0.00	0.04	0.03	0.06	$0	$7,241	$7,241
2021	2	0.00	0.00	0.04	0.03	0.07	$0	$7,386	$7,386
2022	3	0.00	0.00	0.04	0.03	0.07	$0	$7,535	$7,535
2023	4	0.00	0.00	0.04	0.03	0.07	$0	$7,687	$7,687
2024	5	0.00	0.00	0.04	0.03	0.07	-$362,000	$7,842	-$354,158
2025	6	0.00	0.00	0.13	0.10	0.21	$0	$24,001	$24,001
2026	7	0.00	0.00	0.14	0.11	0.22	$0	$24,484	$24,484
2027	8	0.00	0.00	0.14	0.11	0.22	$0	$24,978	$24,978
2028	9	0.00	0.00	0.14	0.11	0.22	$0	$25,481	$25,481
2029	10	0.00	0.00	0.14	0.11	0.23	-$1,200,000	$25,995	-$1,174,005
2030	11	0.00	0.00	0.25	0.19	0.39	$0	$44,198	$44,198
2031	12	0.00	0.00	0.25	0.20	0.40	$0	$45,089	$45,089
2032	13	0.00	0.00	0.26	0.20	0.41	$0	$45,998	$45,998
2033	14	0.00	0.00	0.26	0.20	0.41	$0	$46,925	$46,925
2034	15	0.00	0.00	0.27	0.21	0.42	$0	$47,871	$47,871
2035	16	0.00	0.00	0.27	0.21	0.43	$0	$48,836	$48,836
2036	17	0.00	0.00	0.28	0.22	0.44	$0	$49,820	$49,820
2037	18	0.00	0.00	0.28	0.22	0.45	$0	$50,824	$50,824
2038	19	0.00	0.00	0.29	0.22	0.46	$0	$51,849	$51,849
2039	20	0.00	0.00	0.29	0.23	0.47	$0	$52,894	$52,894
2040	21	0.00	0.00	0.30	0.23	0.48	$0	$53,960	$53,960
2041	22	0.00	0.00	0.31	0.24	0.49	$0	$55,048	$55,048
2042	23	0.00	0.00	0.31	0.24	0.49	$0	$56,157	$56,157
2043	24	0.00	0.00	0.32	0.25	0.50	$0	$57,289	$57,289
2044	25	0.00	0.00	0.33	0.25	0.51	$0	$58,444	$58,444
2045	26	0.00	0.00	0.33	0.26	0.53	$0	$59,622	$59,622
Total		0.00	0.00	5.49	4.27	8.70	-$1,573,715	$987,456	-$586,259



NPV @ 3%	-$607,969
NPV @ 7%	-$535,513
BCR @ 3%	0.500
BCR @ 7%	0.391

Table 6: Segment 11 (0075-02) BCA Results

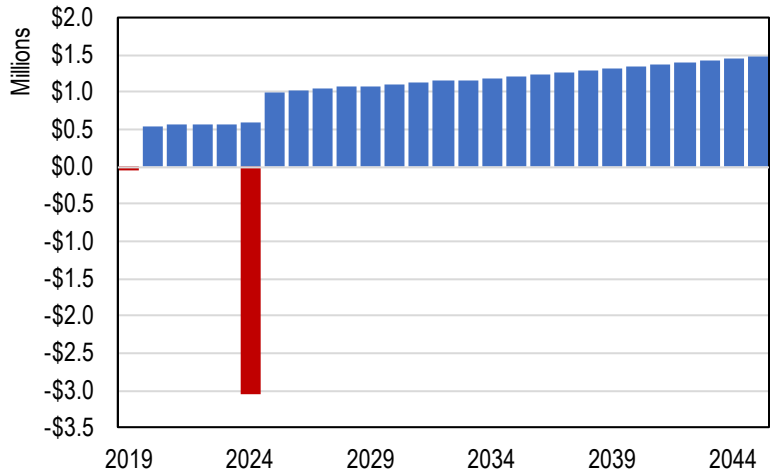
Years		Accidents Δ (Savings)					Costs	Benefits	Total
CY	Analysis	K	A	B	C	O	Subtotal	Subtotal	
2019	0	0.00	0.00	0.00	0.00	0.00	$0	$0	$0
2020	1	0.00	0.00	0.00	0.00	0.00	$0	$0	$0
2021	2	0.00	0.00	0.00	0.00	0.00	$0	$0	$0
2022	3	0.00	0.00	0.00	0.00	0.00	$0	$0	$0
2023	4	0.00	0.00	0.00	0.00	0.00	$0	$0	$0
2024	5	0.00	0.00	0.00	0.00	0.00	-$556,500	$0	-$556,500
2025	6	0.06	0.06	0.19	0.16	0.57	$0	$668,505	$668,505
2026	7	0.06	0.06	0.19	0.16	0.57	$0	$678,326	$678,326
2027	8	0.06	0.06	0.19	0.16	0.58	$0	$688,291	$688,291
2028	9	0.07	0.07	0.20	0.16	0.59	$0	$698,403	$698,403
2029	10	0.07	0.07	0.20	0.17	0.60	$0	$708,663	$708,663
2030	11	0.07	0.07	0.20	0.17	0.61	$0	$719,074	$719,074
2031	12	0.07	0.07	0.21	0.17	0.62	$0	$729,638	$729,638
2032	13	0.07	0.07	0.21	0.17	0.63	$0	$740,357	$740,357
2033	14	0.07	0.07	0.21	0.18	0.64	$0	$751,234	$751,234
2034	15	0.07	0.07	0.22	0.18	0.65	$0	$762,270	$762,270
2035	16	0.07	0.07	0.22	0.18	0.66	$0	$773,469	$773,469
2036	17	0.07	0.07	0.22	0.18	0.67	$0	$784,832	$784,832
2037	18	0.07	0.07	0.22	0.19	0.68	$0	$796,362	$796,362
2038	19	0.08	0.08	0.23	0.19	0.69	$0	$808,062	$808,062
2039	20	0.08	0.08	0.23	0.19	0.70	$0	$819,933	$819,933
2040	21	0.08	0.08	0.23	0.20	0.72	$0	$831,979	$831,979
2041	22	0.08	0.08	0.24	0.20	0.73	$0	$844,201	$844,201
2042	23	0.08	0.08	0.24	0.20	0.74	$0	$856,604	$856,604
2043	24	0.08	0.08	0.25	0.20	0.75	$0	$869,188	$869,188
2044	25	0.08	0.08	0.25	0.21	0.76	$0	$881,957	$881,957
2045	26	0.08	0.08	0.25	0.21	0.77	$0	$894,914	$894,914
Total		1.54	1.54	4.61	3.84	13.96	-$556,500	$16,306,262	$15,749,762



NPV @ 3%	$9,683,628
NPV @ 7%	$5,393,800
BCR @ 3%	21.172
BCR @ 7%	14.594

Table 7: Segment 12 (0075-03) BCA Results

Years		Accidents Δ (Savings)					Costs	Benefits	Total
CY	Analysis	K	A	B	C	O	Subtotal	Subtotal	
2019	0	0.00	0.00	0.00	0.00	0.00	-$51,350	$0	-$51,350
2020	1	0.05	0.05	0.22	0.12	0.67	$0	$548,612	$548,612
2021	2	0.05	0.05	0.22	0.12	0.68	$0	$559,156	$559,156
2022	3	0.05	0.05	0.23	0.12	0.70	$0	$569,903	$569,903
2023	4	0.05	0.05	0.23	0.13	0.71	$0	$580,857	$580,857
2024	5	0.05	0.05	0.24	0.13	0.72	-$3,050,350	$592,021	-$2,458,329
2025	6	0.09	0.09	0.40	0.22	1.23	$0	$1,005,666	$1,005,666
2026	7	0.09	0.09	0.41	0.22	1.25	$0	$1,024,995	$1,024,995
2027	8	0.10	0.10	0.42	0.23	1.28	$0	$1,044,696	$1,044,696
2028	9	0.10	0.10	0.43	0.23	1.30	$0	$1,064,775	$1,064,775
2029	10	0.10	0.10	0.44	0.23	1.33	$0	$1,085,240	$1,085,240
2030	11	0.10	0.10	0.44	0.24	1.36	$0	$1,106,099	$1,106,099
2031	12	0.10	0.10	0.45	0.24	1.38	$0	$1,127,358	$1,127,358
2032	13	0.11	0.11	0.46	0.25	1.41	$0	$1,149,026	$1,149,026
2033	14	0.11	0.11	0.47	0.25	1.44	$0	$1,171,110	$1,171,110
2034	15	0.11	0.11	0.48	0.26	1.46	$0	$1,193,619	$1,193,619
2035	16	0.11	0.11	0.49	0.26	1.49	$0	$1,216,560	$1,216,560
2036	17	0.11	0.11	0.50	0.27	1.52	$0	$1,239,943	$1,239,943
2037	18	0.12	0.12	0.51	0.27	1.55	$0	$1,263,775	$1,263,775
2038	19	0.12	0.12	0.52	0.28	1.58	$0	$1,288,064	$1,288,064
2039	20	0.12	0.12	0.53	0.28	1.61	$0	$1,312,821	$1,312,821
2040	21	0.12	0.12	0.54	0.29	1.64	$0	$1,338,054	$1,338,054
2041	22	0.13	0.13	0.55	0.29	1.67	$0	$1,363,771	$1,363,771
2042	23	0.13	0.13	0.56	0.30	1.71	$0	$1,389,983	$1,389,983
2043	24	0.13	0.13	0.57	0.31	1.74	$0	$1,416,699	$1,416,699
2044	25	0.13	0.13	0.58	0.31	1.77	$0	$1,443,928	$1,443,928
2045	26	0.14	0.14	0.59	0.32	1.81	$0	$1,471,680	$1,471,680
Total		2.65	2.65	11.47	6.18	35.04	-$3,101,700	$28,568,412	$25,466,712



NPV @ 3%	$15,878,245
NPV @ 7%	$9,139,215
BCR @ 3%	6.919
BCR @ 7%	5.105

Curve Control Section	Radius (ft)	Length (ft)	Existing Super (%)	Super based on emax= 6%	Difference with 6% Criteria	Super based on emax = 8%	Difference with 8% Criteria
0020-11-C4	5,730	995	3.7%	3.4%	0.3%	3.6%	0.1%
0020-11-C5	5,730	855	4.1%	3.4%	0.7%	3.6%	0.5%
0020-11-C6	2,865	1,572	5.5%	5.4%	0.1%	6.4%	-0.9%
0020-11-C7	5,730	892	4.0%	3.4%	0.6%	3.6%	0.4%
0075-01-C1	5,730	1,469	2.7%	3.4%	-0.7%	3.6%	-0.9%
0075-01-C2	2,865	1,254	5.0%	5.4%	-0.4%	6.4%	-1.4%
0075-01-C3	2,865	790	4.5%	5.4%	-0.9%	6.4%	-1.9%
0075-01-C4	5,730	977	2.5%	3.4%	-0.9%	3.6%	-1.1%
0075-01-C5	5,730	344	1.7%	3.4%	-1.7%	3.6%	-1.9%
0075-02-C1	2,865	1,191	6.1%	5.4%	0.7%	6.4%	-0.3%
0075-02-C2	2,865	1,412	6.5%	5.4%	1.1%	6.4%	0.1%
0075-02-C3	5,730	998	3.8%	3.4%	0.4%	3.6%	0.2%
0075-02-C4	2,865	2,839	6.3%	5.4%	0.9%	6.4%	-0.1%
0075-02-C5	2,865	2,037	5.9%	5.4%	0.5%	6.4%	-0.5%
0075-03-C1	5,730	983	3.8%	3.4%	0.4%	3.6%	0.2%
0075-03-C2	5,730	2,543	3.7%	3.4%	0.3%	3.6%	0.1%
0075-03-C3	5,730	1,990	3.7%	3.4%	0.3%	3.6%	0.1%
0075-03-C4	11,460	1,243	2.5%	2.0%	0.5%	2.0%	0.5%
0075-03-C5	5,730	1,802	3.1%	3.4%	-0.3%	3.6%	-0.5%
0075-03-C6	11,460	2,903	2.5%	2.0%	0.5%	2.0%	0.5%
0075-03-C7	5,730	848	2.8%	3.4%	-0.6%	3.6%	-0.8%

13 FT 7 IN
Texas Department of Transportation
PRESIDIO TEXAS
CITY of ALPINE
BREWSTER COUNTY
1882
THE CITY OF MARFA
MARFA TEXAS
OUR 67
US 67 CORRIDOR
MASTER PLAN