Appendix B

Existing Safety Analysis

FM 76 (North Loop Drive) Feasibility Study

November 2023

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Appendix B.1 – Existing Conditions Analysis

Appendix B.2 – Existing Safety Analysis

1. Introduction

1.1 Purpose

The Farm to Market (FM) 76 (North Loop Drive) Safety Analysis Report is a component of the Farm to Market Road (FM) 76 (North Loop Drive) Feasibility Study conducted by the El Paso District (the District) of the Texas Department of Transportation (TxDOT). The feasibility study includes the evaluation of the feasibility of improvements to the FM 76 Corridor from Horizon Boulevard (Blvd.) to Fabens Road (Rd.). As part of this evaluation, a study of the safety of the FM 76 corridor as well as all the FM roads in El Paso County was conducted to understand site-specific and regional crash patterns of fatal injury (K), suspected serious injury (A), and suspected minor injury (B) crashes according to the KABCO classification of crash injury severity[1]. This data driven analysis provides useful insights on the existing road safety conditions in the study corridor as well as all FM roads in El Paso County. **Figure 1** shows the FM 76 study corridor.

This study was conducted in two parts: a site-specific analysis and systemic analysis. The site-specific analysis provides insights regarding the locations within the study corridor with high concentrations of KAB crashes that could be candidates for potential infrastructure improvements that could subsequently improve roadway safety. As part of the Site-Specific Analysis in **Section 4**, the KAB crash data was further divided into segment and intersection related crashes. The systemic analysis is used to proactively identify roadway or traffic characteristics as risk factors associated with KA crashes and results in the proposal of countermeasures to reduce risk at locations with the identified characteristics. The site-specific analysis was applied to the study corridor and the systemic analysis was applied to all the FM roads in the county (further explanation is illustrated in **Section 5**). This analysis will result in the identification of potential near- and long-term safety improvements to address the high crash locations or risk factors. These insights and improvements will serve the alternative development and evaluation process by indicating what types of safety improvements are recommended at high-crash locations or as part of new proposed typical sections.

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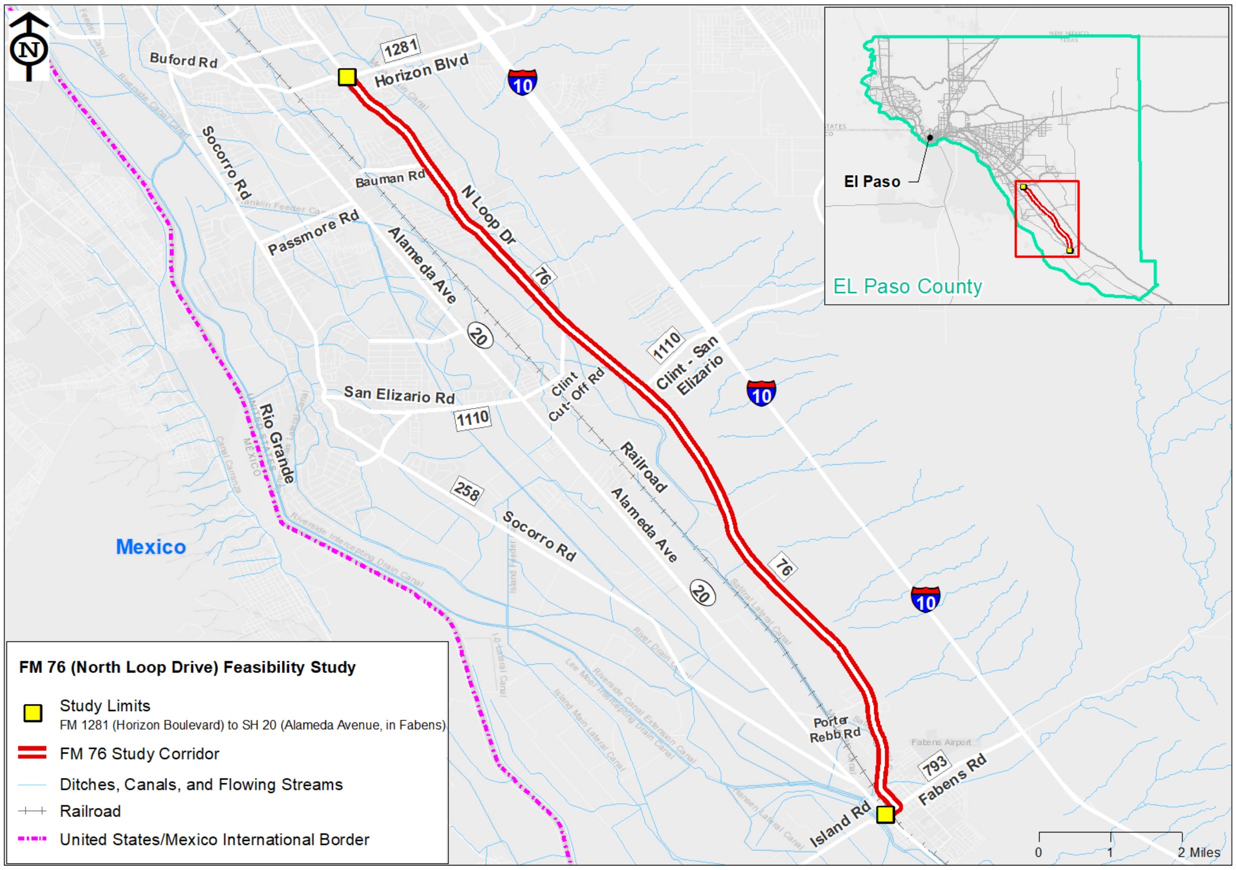
[1] Manual on Classification of Motor Vehicle Traffic Crashes, 8th ed. (ANSI D.16-2017); Available at: https://www.nhtsa.gov/sites/nhtsa.gov/files/documents/ansi_d16-2017.pdf



Source: CDM Smith, 2022

Figure 1: FM 76 (North Loop Drive) Feasibility Study Safety Analysis Study Area

1.2 Guiding Documents

The FM 76 safety analysis was guided by several publications listed and described below:

1.2.1 Texas Strategic Highway Safety Plan (SHSP) [2]

The SHSP plan outlines fatal and serious injury crash emphasis areas that have been identified as the state's focus for improving safety on public roads. The FM 76 safety analysis is focused on identifying infrastructure-related contributing factors and therefore was focused on the following three emphasis areas as defined in the SHSP:

[2] Available at https://www.texasshsp.com

- **Roadway and Lane Departures:** "The Roadway and Lane Departures (RLD) emphasis area encompasses two crash types pertaining to difficulties with lane keeping: single motor vehicles that run off the road (SVROR) and head-on collisions. SVROR describes a crash where only one vehicle is involved and the first harmful event impact occurred on the shoulder, beyond the shoulder, or in the median of the roadway. Head-on crashes involve two motor vehicles traveling straight and in opposite directions prior to impact."

- **Pedestrian Safety:** "The Pedestrian Safety emphasis area encompasses crashes that involve at least one pedestrian and one motor vehicle." For the purposes of this report, in the FM 76 safety analysis, bicyclist crashes were combined with the Pedestrian emphasis area and referred to as PED/BIKE.

- **Intersection Safety:** "An intersection crash is one that occurs within the boundaries of an intersection or in which the first harmful event occurred on an approach to or an exit from an intersection and is related to movement through the intersection."

1.2.2 TxDOT 2022 Highway Safety Improvement Program (HSIP) Guidelines[3]

The key component used from the 2022 HSIP guidance was the work code list that were considered as potential near- and long-term strategies for safety improvements. The document also provides descriptive attributes for work codes, such as the crash reduction factors referenced throughout the document.

1.3 Organization of Report

This report is divided into six sections described below:

- Section 1 introduced the purpose of the safety analysis and the guiding documents of the study. This subsection concludes with the organization of the report.

- Section 2 describes the methods associated with data collection, acquisition, and assumptions made when cleaning the acquired data.

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[3] Available at Highway Safety Improvement Program Guidelines (state.tx.us)

- Section 3 consists of Descriptive Statistics that provide a general overview of crashes in the FM 76 corridor between Horizon Boulevard and Fabens Road for the years of 2015 to 2019.

- Section 4 describes the Site-Specific Analysis that was conducted in this study. This section includes the methods of the analysis as well as assumptions made. Problem areas within the study corridor will be assessed and identified. Near-term (0-5 years) and long-term (>5 years) strategies to address problem areas are then presented.

- Section 5 describes the Systemic Analysis. This section includes methods and assumptions of the analysis. Additionally, the systemic safety section includes identification of focus crash types, risk factors associated with roadway or traffic features, and near- and long-term strategies addressing the risk factors.

- Section 6 concludes the report with a summary of the analysis and recommendations.

- Finally, this report is supplemented with **Appendix B.1: Collision and Condition Diagrams** that were created to support site-specific analysis and **Appendix B.2: Systemic Collision Tree Diagrams** that were created as part of the systemic analysis.

2. Data

2.1 Data Collection and Acquisition

The crash and roadway data used in this study were derived from multiple sources. The crash data was acquired from the TxDOT Crash Records Information System (CRIS) [4]. Five years of crash data from 2015 to 2019 in El Paso County were downloaded. Note that the crash records for years 2020 and 2021 were excluded in this analysis because of the global COVID-19 pandemic which has been observed to have had anomalous impacts on crash patterns that the study team does not expect to sustain as traffic patterns return to normal. This crash data includes attributes such as the context, conditions, and outcomes of crashes within the FM 76 corridor. These attributes include severity of

[4] Available at: https://cris.dot.state.tx.us/

the crash and manner of collision. The roadway data, used primarily for the Systemic Analysis, included TxDOT Roadway Inventory data from the year 2019. Aerial imagery from Google Earth provided further context for roadway conditions that may have been contributing factors to crashes. Additionally, ArcGIS was used to visualize and present data for analysis.

2.2 Data Cleaning

After acquiring the CRIS data, ArcGIS was used to visualize the data for further cleaning to ensure crashes in the study corridor are selected properly. A total of 40 KAB crashes were observed in the study corridor. Crash records that have missing information about location and/or severity were excluded from the site-specific and systemic analyses as there is insufficient information to determine where the crashes occurred or what was the resulting severity.

2.3 Data Processing and Segregation

There were 491 total crashes within the study corridor for the years between 2015 and 2019. This crash data was then used in developing the descriptive statistics in Section 3 of this report. The data includes crashes of all severities and not only KA or KAB crashes, which are typically the focus of data-driven safety studies.

3. Descriptive Statistics

The following descriptive statistics were generated for the corridor of FM 76 spanning from Horizon Blvd. to Fabens Rd between 2015 and 2019.

Figure 2 shows the yearly trend of crashes within the corridor between 2015 and 2019. The trend indicates a fairly consistent number of crashes from 2015 to 2017 with a decline in the years 2018 and 2019.

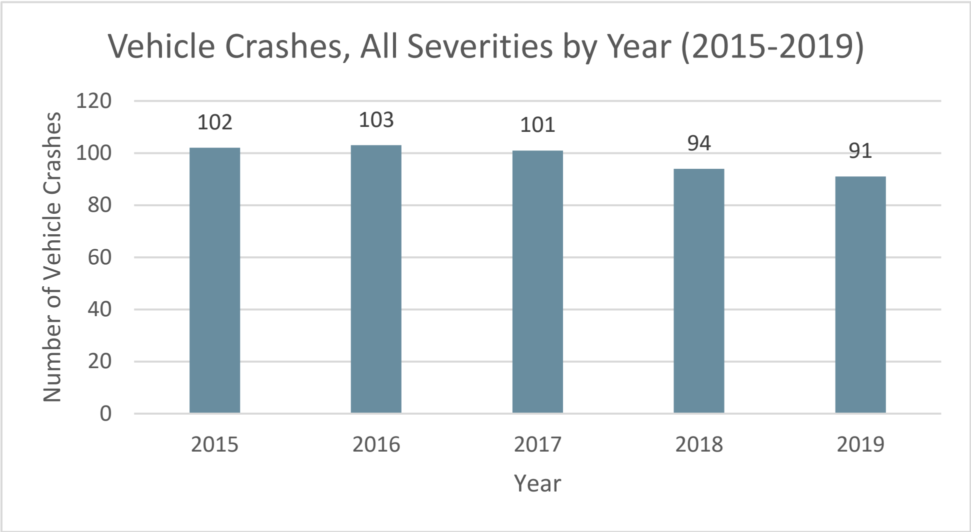

Figure 2: Crashes by Year

Figure 3 shows that between 2015 and 2019, the month with the highest number of crashes on the FM 76 corridor from Horizon Blvd. to Fabens Rd. was March.

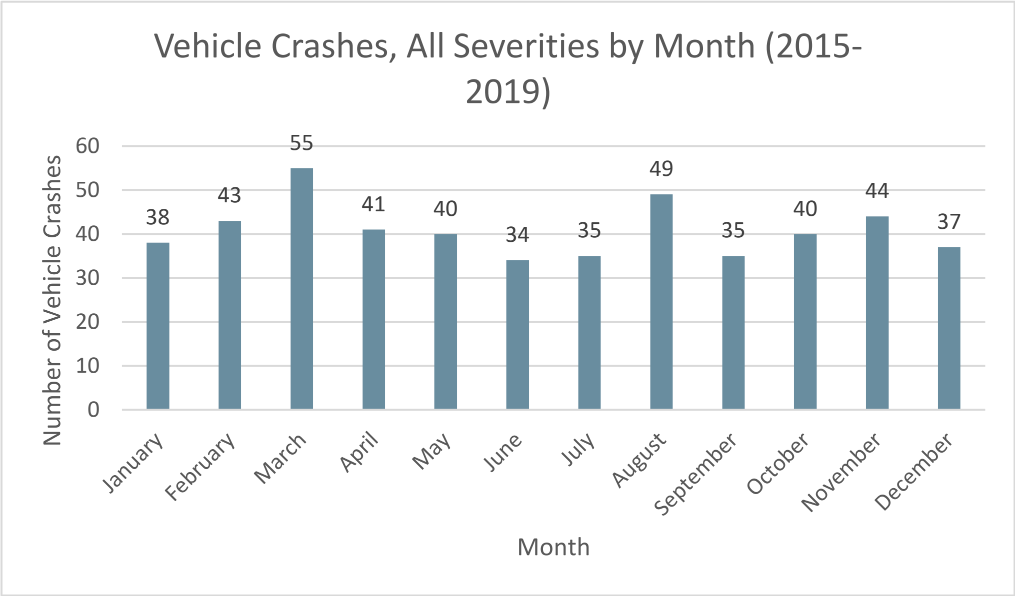

Figure 3: Crashes by Month

Figure 4 shows that Fridays and Saturdays witnessed the highest number of crashes among all the days of the week, about 23 and 24 percent more than the weekday average, respectively.

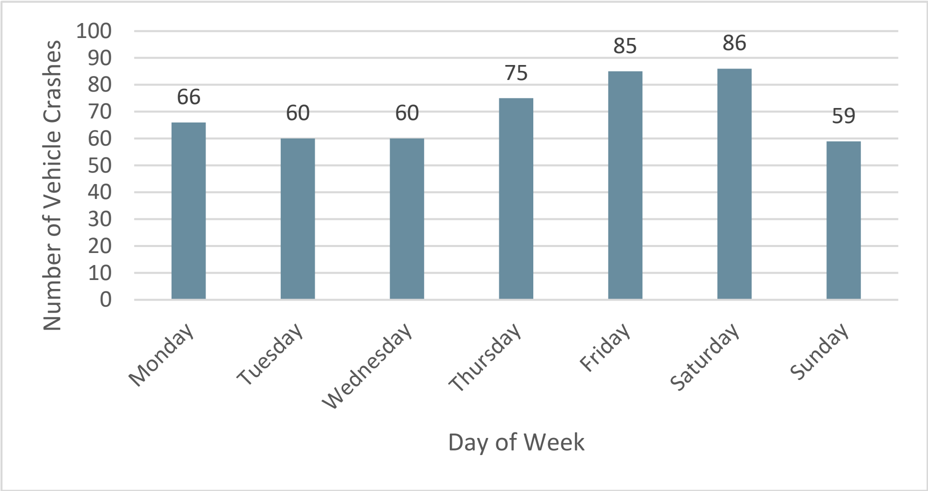

Figure 4: Crashes by Day of Week

Figure 5 shows that of the 491 crashes on FM 76 between Horizon Blvd. and Fabens Rd., approximately 70% did not result in an apparent injury and approximately 24% resulted in a suspected minor or possible injury. Suspected serious injury and fatal injury crashes represent less than 3% of total crashes.

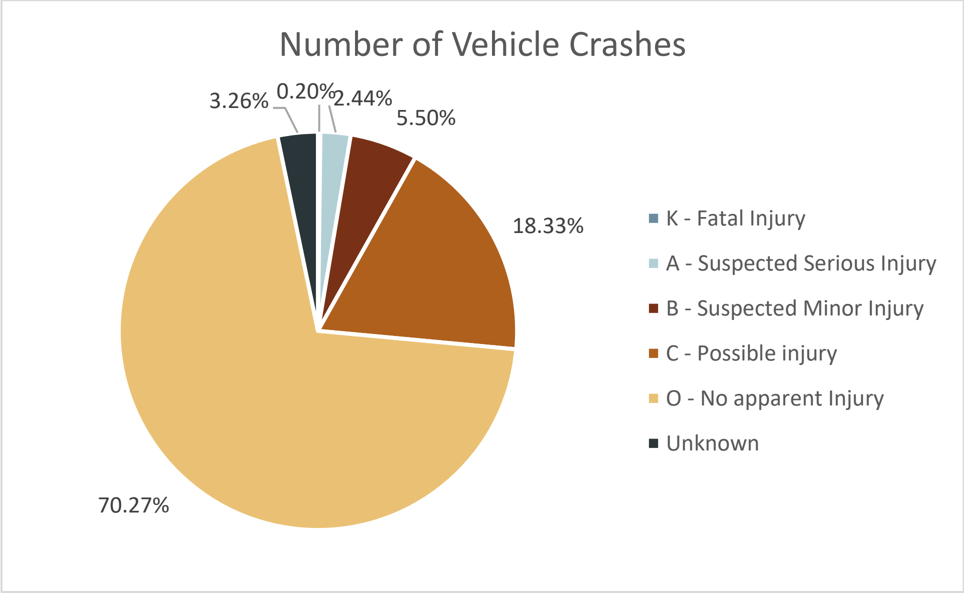

Figure 5: Crashes by Injury Severity

Figure 6 shows that between 2015 and 2019 more crashes on FM 76 between Horizon Blvd. and Fabens Rd. occurred during the morning peak hour (7:00 AM to 8:00 AM) and the afternoon peak period (3:00 PM to 7:00 PM). Afternoon peak period had larger timeframe of crashes than morning peak period.

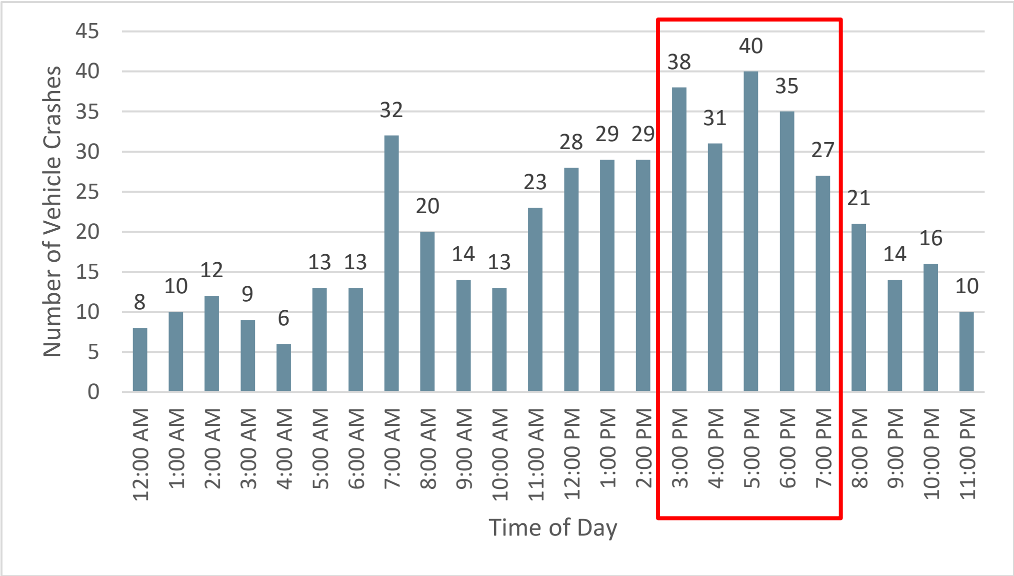

Figure 6: Crashes by Time of Day

Figure 7 shows that the Commercial Motor Vehicle (CMV) related crashes on FM 76 between Horizon Blvd and Fabens Rd between 2015 and 2019 remained steady with an average of about 3 crashes per year summing a total of 14 crashes in five years.

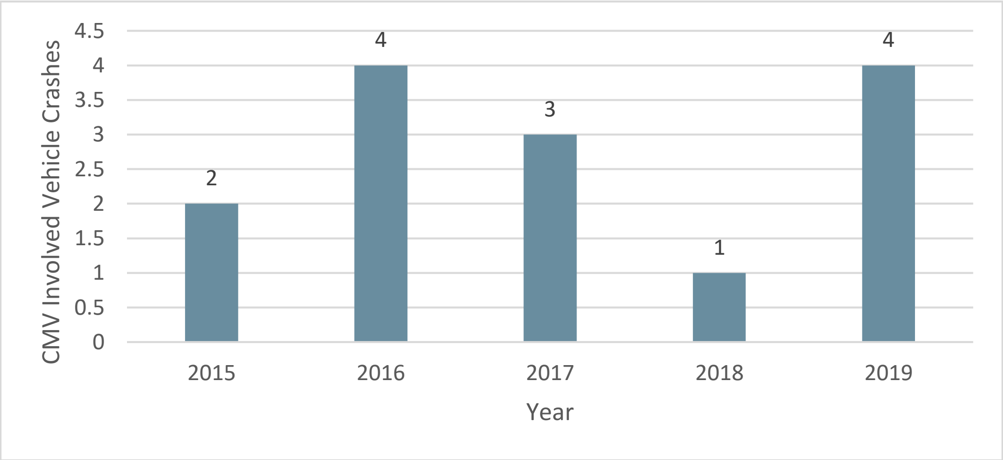

Figure 7: Commercial Motor Vehicle Related Crashes by Year

Out of 14 CMV involved crashes, two crashes had a suspected minor injury, all crashes were either property damage only or involved possible injury. Out of two suspected minor injury crashes, one occurred at an intersection and the other one occurred on a segment.

Figure 8 shows that the most common type of crash (38%) on FM 76 between Horizon Blvd. and Fabens Rd. between 2015 and 2019 occurred in the same direction. Approximately 2% involved only one motor vehicle. Twenty-four percent of the vehicle crashes studied occurred at an angle and 23% occurred were because of Roadway and Lane Departures.

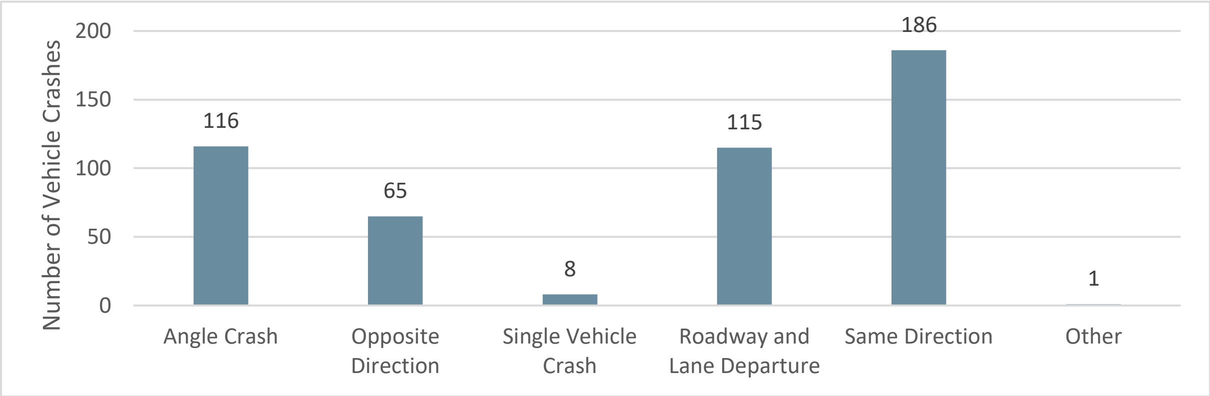

Figure 8: Crashes by Types

Figure 9 shows out of the total crashes that occurred, majority (64%) occurred during daylight followed by dark, lighted conditions (20%), and dark, not lighted conditions (13%).

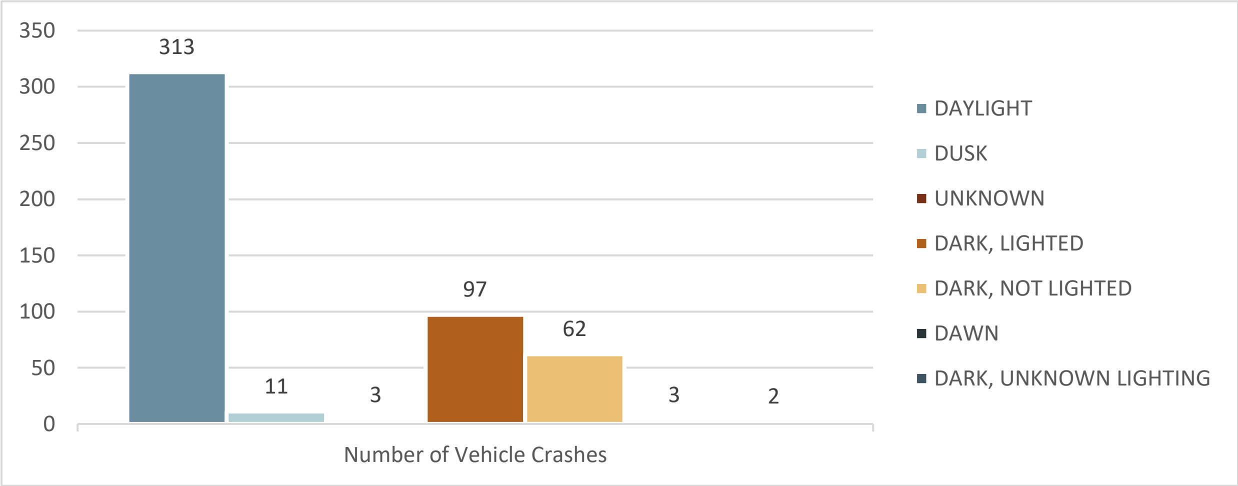

Figure 9: Crashes by Light Conditions

4. Site - Specific Analysis

4.1 Methods and Assumptions

The Site-Specific Analysis was conducted first by generating maps with the acquired and cleaned data for analysis with ArcGIS using Kernel Density. The Kernel Density tool calculates and illustrates the density of features within a given area, in this case, crashes. High density crash locations, or "hotspots", were used to identify specific sites for potential safety improvements. Hotspots were identified for crashes occurring within intersections and crashes occurring along roadway segments separately. For each analysis, all KAB crashes occurring in the study corridor were used. Diagnosis was performed at each site within the study corridor using aerial imagery and Street View imagery from Google Earth to examine roadway conditions relevant to the dominant characteristics of crashes occurring at the site.

4.2 Site Identification and Diagnosis

4.2.1 Intersection Analysis

The following visualizations were prepared with ArcGIS using the acquired and cleaned crash data to identify hotspots within the study corridor for the intersection analysis. **Figure 10** illustrates the 26 KAB intersection related crashes within the study corridor.

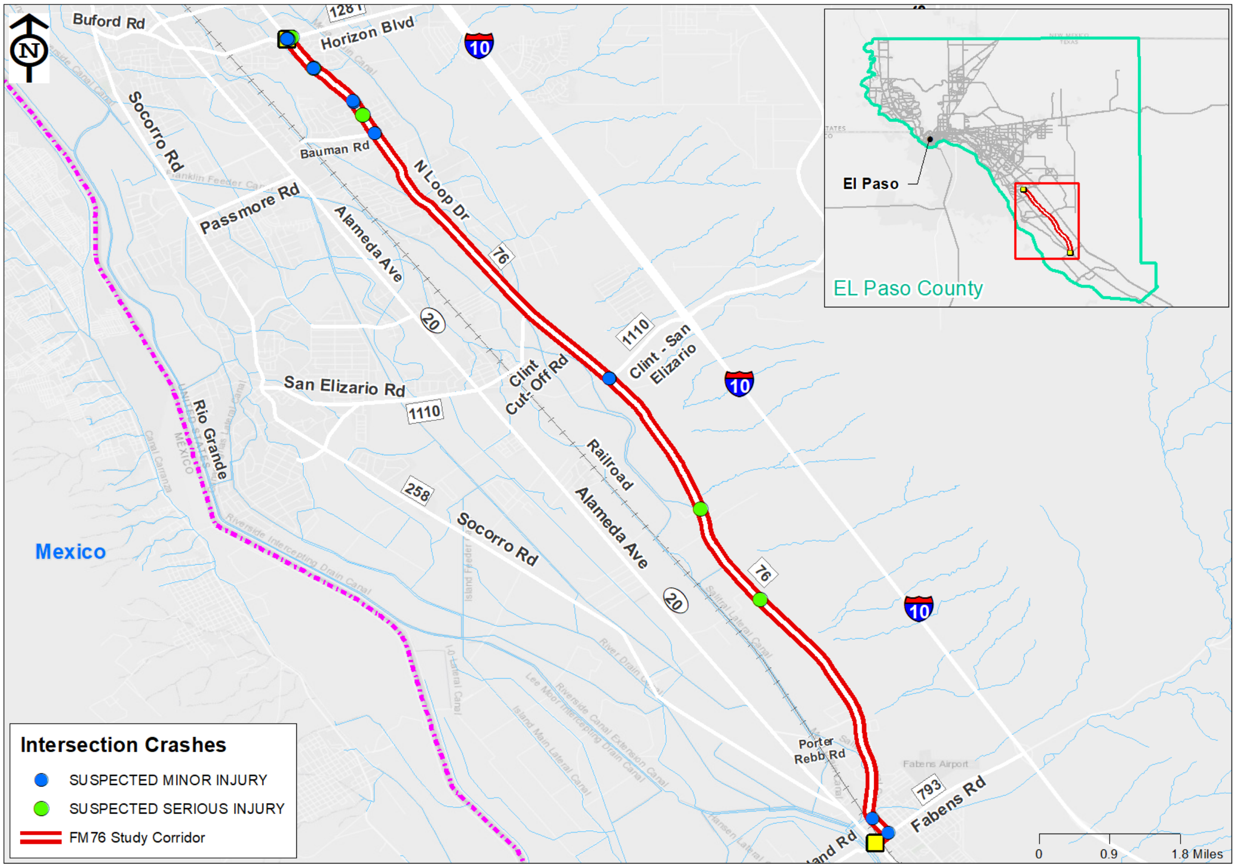

Figure 10: Intersection KAB Crashes

Figure 11 illustrates major hotspots (orange or red color) within the study corridor.

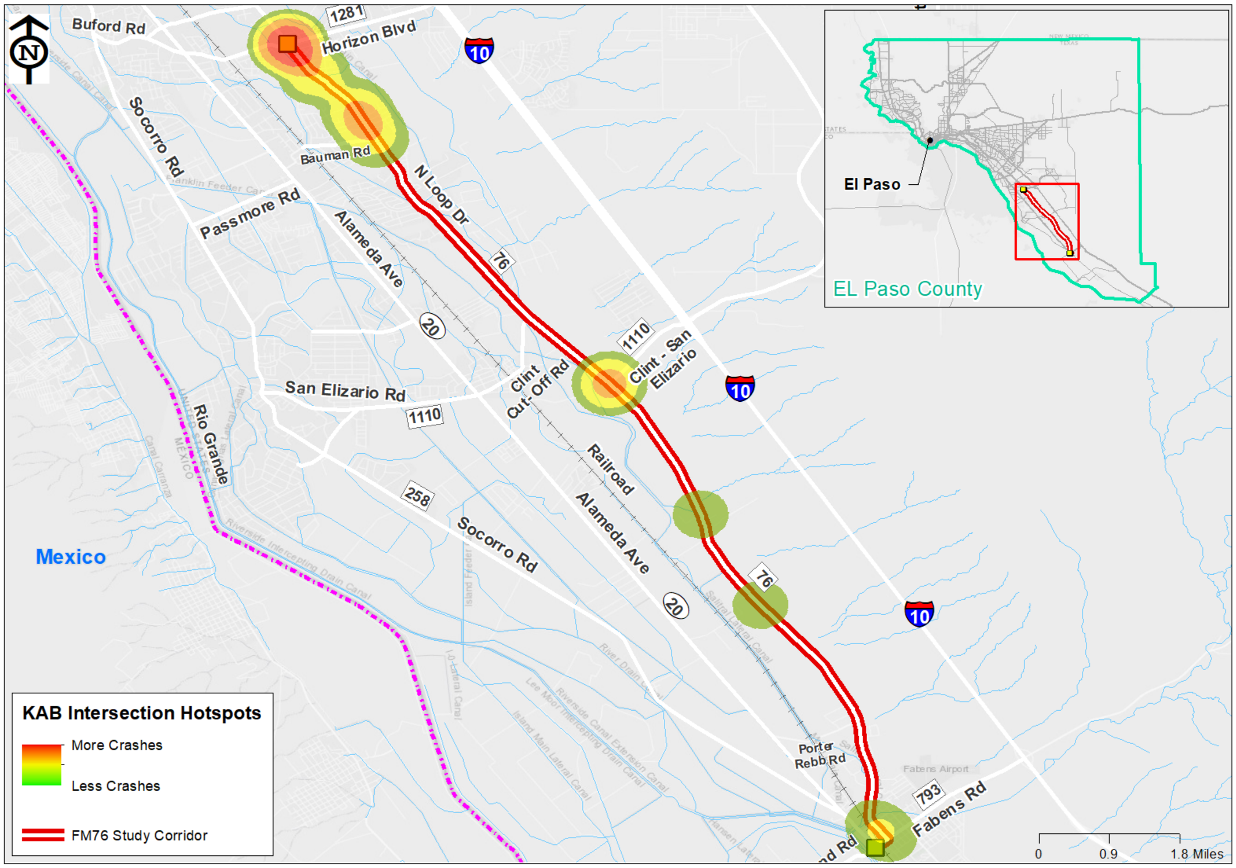

Figure 11: Intersection Hotspot Map

All 26 intersection related crashes occurred at 10 intersections. **Figure 12** shows 3 site locations (intersections 1, 2 and 6 shown in red) that were identified using the intersection crash hotspot map.

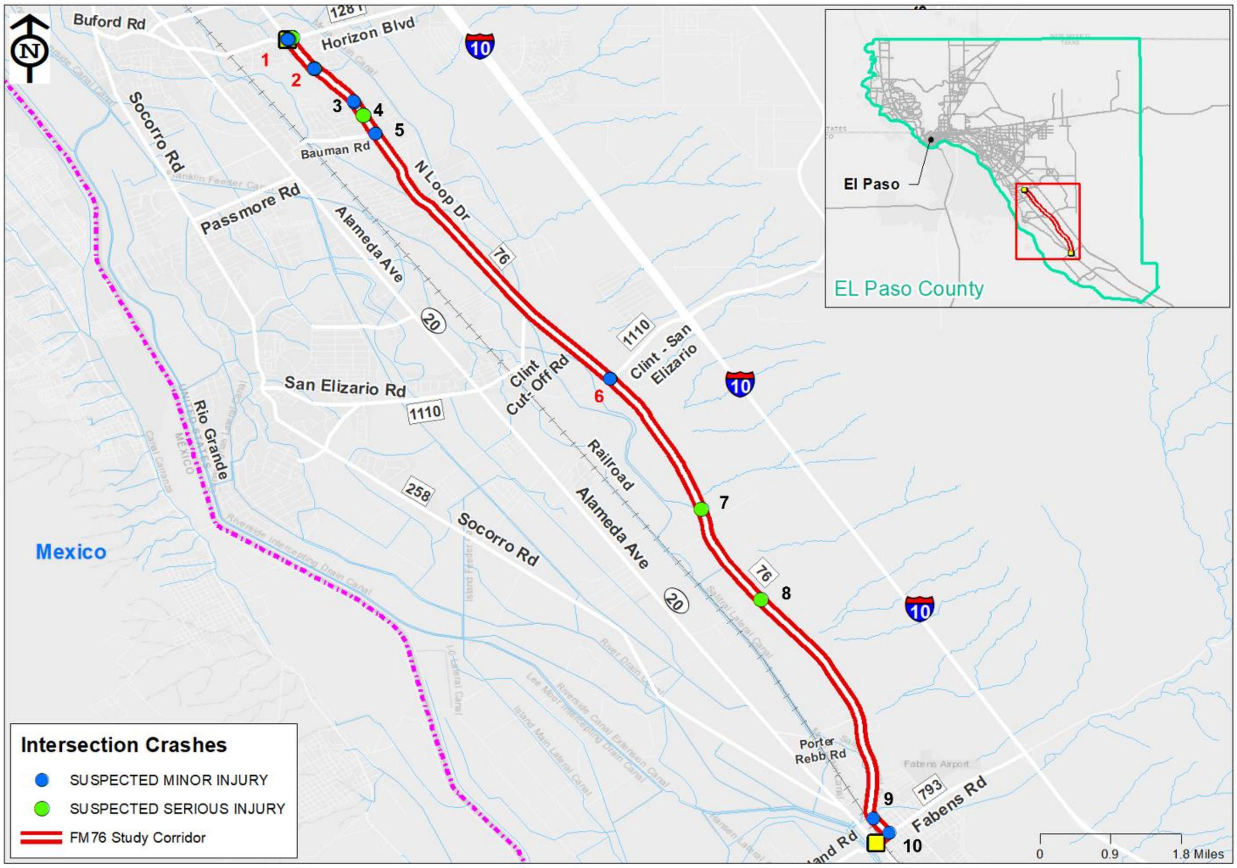

Figure 12: Intersection Site for Potential Safety Improvement

The characteristics of each identified site location are detailed in **Table 1**. Roadway striping was assessed as either good, fair, worn, or no striping. 'Good' indicates that the roadway has proper striping which is clearly visible and without breaks. 'Fair' indicates that the roadway striping is faded. 'Worn' indicates that the roadway striping has faded and poor visibility. 'No striping' indicates that the roadway does not have any striping. The "on curve" indicates if the intersection along the FM 76 is on curve or not. A site adjacent to a curve but not on curve is considered as not on curve. Traffic sign category indicates if the site has traffic signs such as traffic control signs, lanes for turning movements, pedestrian crossing, etc.

Table 1: Intersection Site Conditions

Inter. Site No.	Intersection Name	On Curve	Intersection Control	Striping	Traffic Signs	Median Type	No. of KAB Crashes
1	FM 76 and Horizon Blvd	No	Signalized	Fair	Present	Raised Median	9
2	FM 76 and Sudan Dr	No	One-Way Stop Control	Fair	Present	No Median	3
3	FM 76 and Liahona Dr	No	One-Way Stop Control	Good	Present	No Median	2
4	FM 76 and Barnhart Dr	No	One-Way Stop Control	Good	Present	No Median	2
5	FM 76 and Bauman Rd	No	One-Way Stop Control	Worn	Present	No Median	2
6	FM 76 and Clint - San Elizario	No	Signalized	Good	Present	No Median	4
7	FM 76 and Ruffian Way	No	No Control	Good	Present	No Median	1
8	FM 76	No	No Control	Good	Present	No Median	1
9	FM 76 and 3rd St NW	No	One-Way Stop Control	Good	Present	No Median	1
10	FM 76 and Fabens Rd	No	Signalized	Good	Present	No Median	1
Total	N/A	N/A	N/A	N/A	N/A	N/A	26

Table 2 shows the crash severity at intersections. There were no fatal injury crashes at study corridor intersections between 2015 and 2019. The highest number of suspected serious injury crashes occurred at intersection 1 and intersection 4. However, the highest number of suspected minor injuries was observed at intersection 1 only. Intersection 6 experienced the second highest number of suspected minor injuries.

Table 2: Intersection Site by Crash Severity

Intersection Site No.	Suspected Minor Injury	Suspected Serious Injury	Fatal Injury	Total
1	7	2	0	9
2	2	1	0	3
3	2	0	0	2
4	0	2	0	2
5	2	0	0	2
6	4	0	0	4
7	0	1	0	1
8	0	1	0	1
9	1	0	0	1
10	1	0	0	1
Total	**19**	**7**	**0**	**26**

Table 3 shows the manner of collision for the intersection locations. The most common crash type was angle collisions (35%) followed by same direction (31%) and opposite direction (27%). Intersection site 1 had four (44%) opposite direction crashes and two (22%) same direction and angle crashes. The least common crash type was roadway and lane departure crashes.

Table 3: Intersection Site by Collision Type

Intersection Site No.	Angle Crash	Opposite Direction	Roadway and Lane Departure	Same Direction	Total
1	2	4	1	2	9
2	1	1	0	1	3
3	0	0	0	2	2
4	1	0	0	1	2
5	2	0	0	0	2
6	2	1	1	0	4
7	0	0	0	1	1
8	0	0	0	1	1
9	0	1	0	0	1
10	1	0	0	0	1
Total	**9**	**7**	**2**	**8**	**26**

Table 4 shows the first harmful events of crashes at each intersection. The majority of the crashes (92%) were indicated as motor vehicle in transport, meaning no pedestrian, cyclist, or fixed object was struck, and the vehicle did not overturn. One crash at intersection 6 hit a fixed object and one crash at intersection 1 was a vehicle overturned. No crash was observed involving pedestrians or bicyclists.

Table 4: Intersection Site by First Harmful Event

Intersection Site No.	Fixed Object	Motor Vehicle in Transport	Overturned	Total
1	0	8	1	9
2	0	3	0	3
3	0	2	0	2
4	0	2	0	2
5	0	2	0	2
6	1	3	0	4
7	0	1	0	1
8	0	1	0	1
9	0	1	0	1
10	0	1	0	1
Total	**1**	**24**	**1**	**26**

4.2.2 Segment Analysis

The following visualizations were prepared with ArcGIS using the acquired crash data to identify hotspots within the study corridor for the segment analysis. **Figure 13** illustrates the segment related crashes which occurred on the FM 76 between Horizon Blvd. and Fabens Rd.

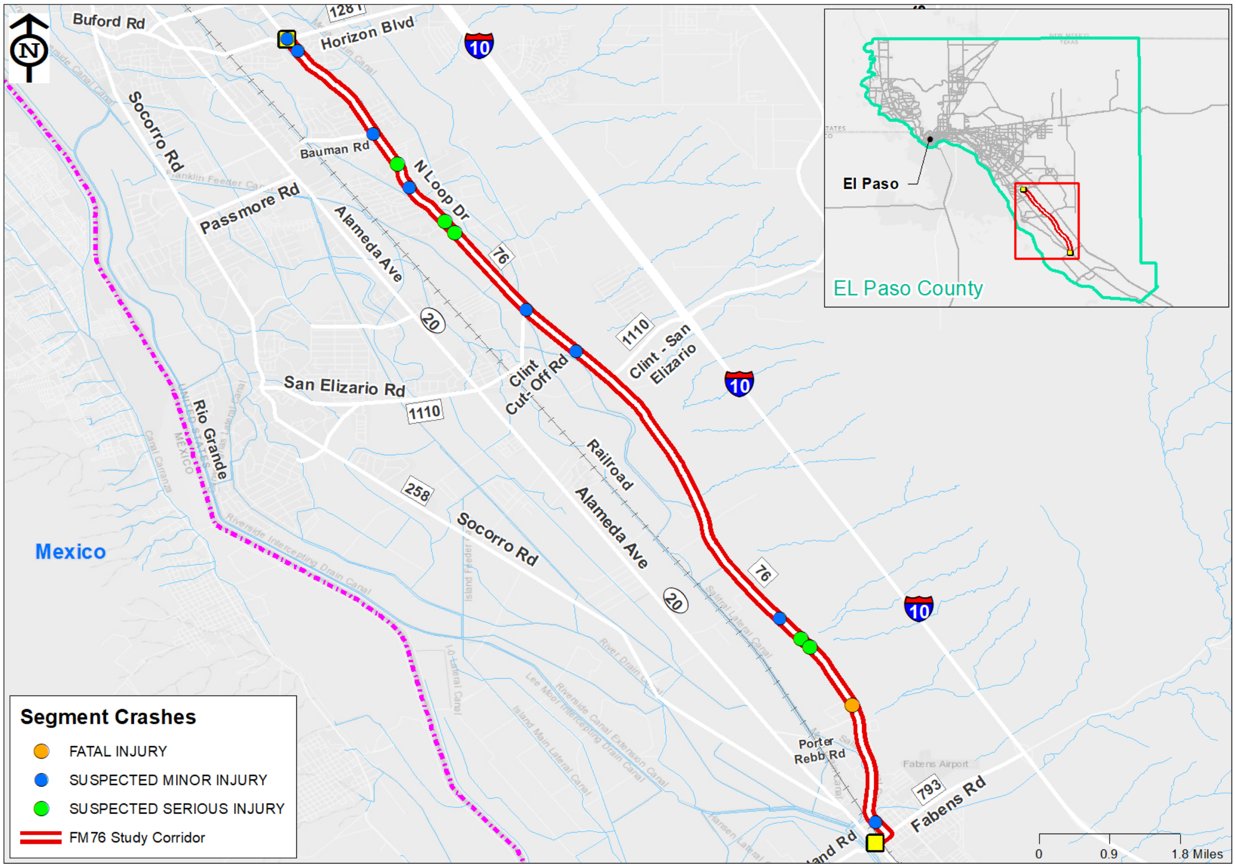

Figure 13: Roadway Segment KAB Crashes

Figure 14 illustrates the roadway segment hotspot locations within study corridor. The roadway segment hotspot locations which are defined as locations with the highest crash density (red and orange color) within the study area were then coded as segments in **Figure 15**. Segments with at least two crashes or one fatal crash were considered in the site-specific analysis. Segments with less than two crashes and no fatal crash were excluded from the analysis.

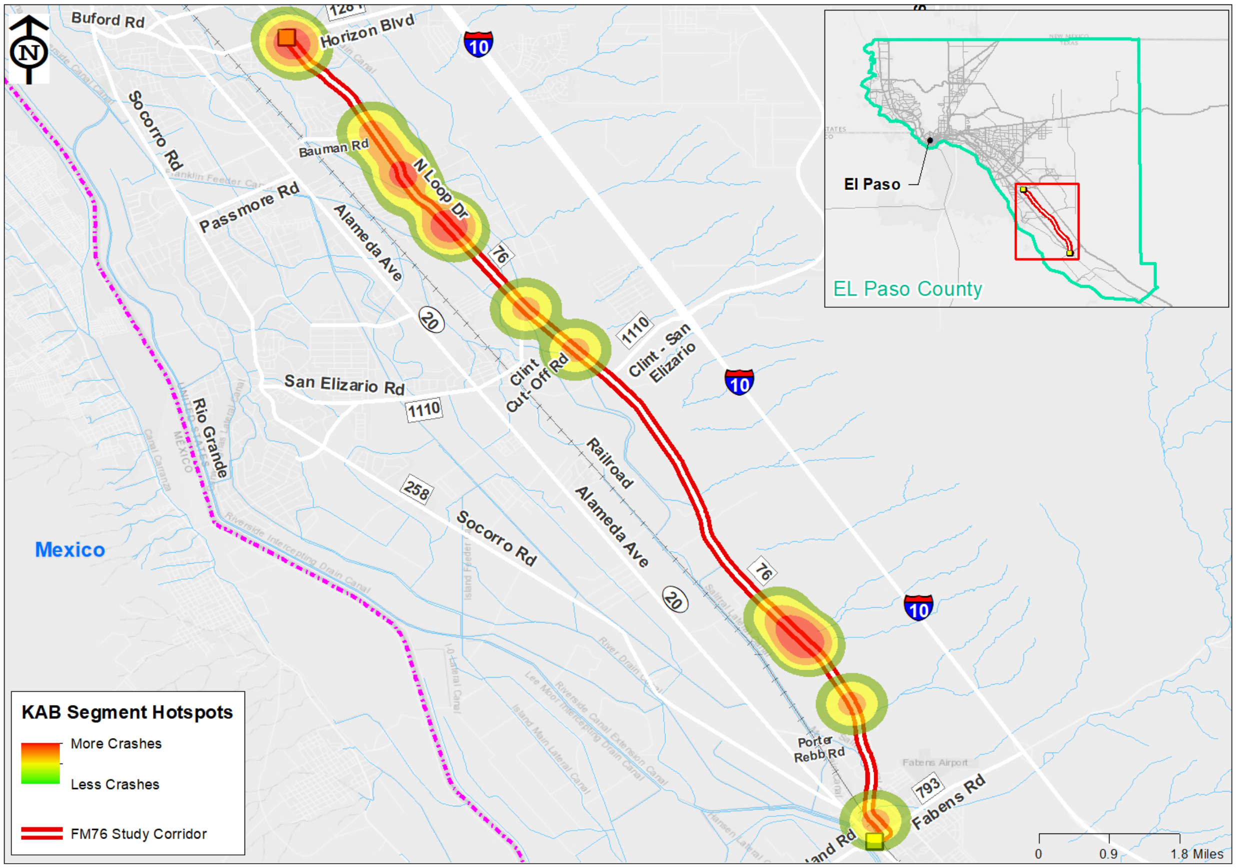

Figure 14: Roadway Segment KAB Hotspot Map

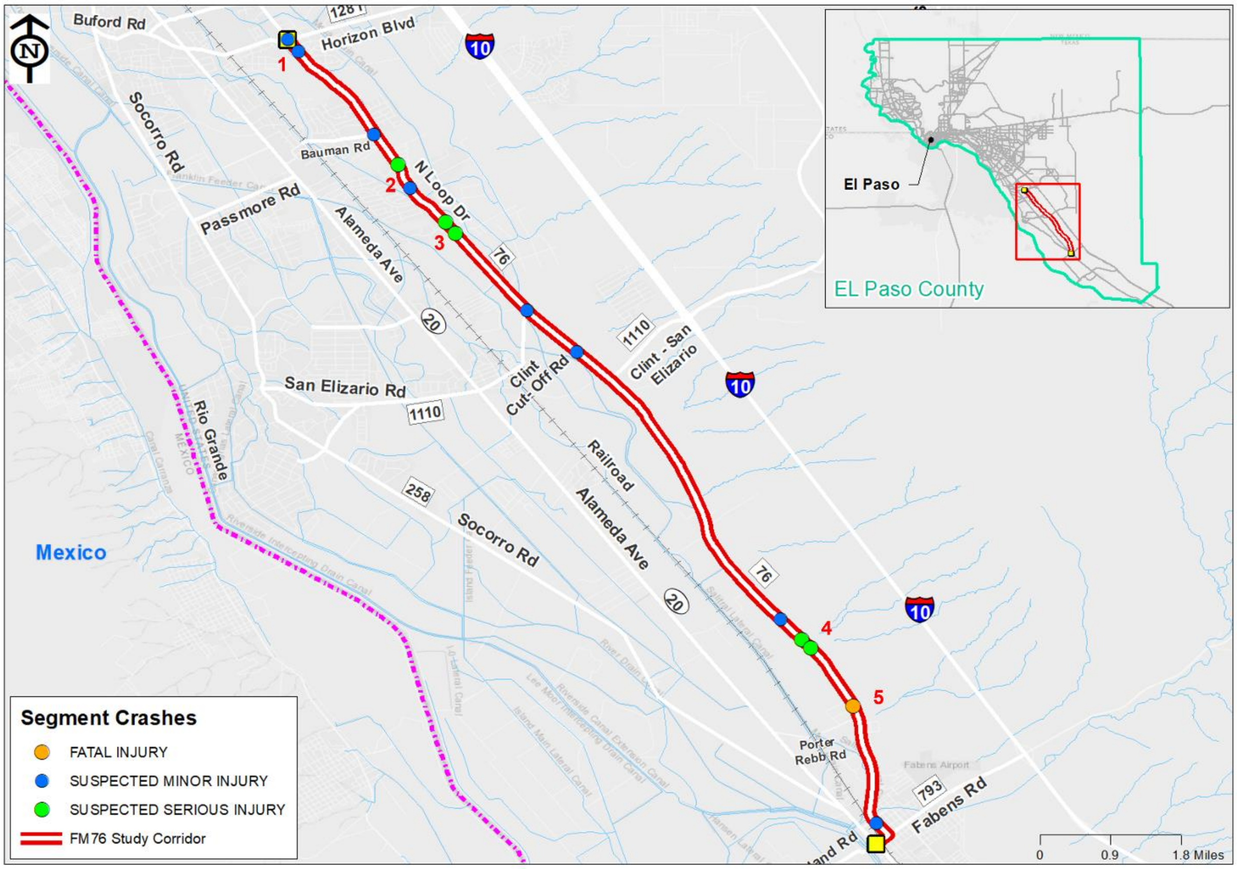

Figure 15: Roadway Segment Site for Potential Safety Improvement

Each of the five identified segment's (four red circles and one orange circle with fatal crash in **Figure 14**) roadway characteristics are detailed in **Table 5** which includes the segment length, site description, curve presence, striping condition, signage presence, number of lanes, lane width, shoulder width, median width, presence of shoulder/centerline rumble strips, and number of KAB crashes.

Table 5: Roadway Segment Conditions

Seg. No.	Length(mi)	Description (FM 76)	On Curve	Striping	Traffic Signs	No. of Through Lanes	Lane Width (ft)	Shoulder Width Average (ft)	Shoulder/ Centerline Rumble Strips	Median Width (ft)	Number of KAB Crashes
1	0.531	From Horizon Boulevard to Milo Dr	No	Good	Yes	2	12	0	No	18	2
2	0.915	From Bauman Rd to Worsham Rd	Yes	Good	Yes	2	12	3	No	0	3
3	0.581	From Richardson Rd to Young John Rd	No	Good	Yes	2	12	3	No	0	2
4	0.765	From Webb Rd to Tata Dr	No	Good	Yes	2	12	3	No	0	3
5	0.297	From Tata Dr to Gina Dr	No	Good	Yes	2	12	3	No	0	1

Table 6 illustrates that no KAB crashes along the five hotspots involved a truck. The truck percentage on these locations is low (about 3.5%).

Table 6: Roadway Segment by CMV Involved

Segment No.	Truck % of total AADT (2019)	Not Tuck-Related	Truck-Related	Total
1	2.8	2	0	2
2	3.8	3	0	3
3	3.8	2	0	2
4	3.4	3	0	3
5	3.4	1	0	1
Total	-	**10**	**0**	**11**

Table 7 shows the manner of collision for crashes occurring within segment hotspots. Most of the crashes observed in the hotspots were roadway and lane departure crashes (91%).

Table 7: Roadway Segment by Crash Type

Segment No.	Angle Crash	Roadway and Lane Departure	Single Vehicle Crash	Total
1	0	2	0	2
2	0	2	1	3
3	0	2	0	2
4	0	3	0	3
5	0	1	0	1
Total	**0**	**10**	**1**	**11**

Table 8 illustrates the road-related crashes within segment hotspots. Nine out of eleven crashes occurred off the roadway. Segment 4 has the highest number of KAB crashes leaving the roadway (total of off-roadway, shoulder, and median crashes), whereas segment 2 and segment 3 had two KAB crashes leaving the roadway. Segment 5 had one off roadway fatal crash.

Table 8: Roadway Segment by Road Related

Segment No	On Roadway	Off Roadway	Shoulder	Median	Total
1	1	1	0	0	2
2	1	2	0	0	3
3	0	2	0	0	2
4	0	3	0	0	3
5	0	1	0	0	1
Total	**2**	**9**	**0**	**0**	**11**

4.3 Site-Specific Contributing Factors and Countermeasures

Based on review of crash patterns and roadway features of all intersection and segment site locations, the study team summarized the identified problems, relevant roadway characteristics, and recommended near- and long-term strategies for safety improvement as shown in **Table 9** and **Table 10** for intersection and segment sites respectively. Strategies were selected from the TxDOT HSIP guidance and are identified via their work code number and accompanied with the crash reduction factor. Note that only site locations where a dominant crash pattern or roadway characteristic that can be addressed by a safety countermeasure were reported in the summary tables. Also, additional site characteristics such as presence of rumble strips was checked for site locations where the identified problem may be relevant.

Note that for the observed crash patterns, no applicable long-term strategies were identified for segments.

Table 9: Site-Specific Intersection Near- and Long-Term Strategies

Intersection No	Identified Problems	Description	Near-Term Strategies	Long-Term Strategies
1	44% of KAB crashes at intersection were opposite direction	Traffic signal with fair striping and raised median.	401 - Install Pavement Markings (Reduction Factor - 20%) 108 - Improve Traffic Signals (Reduction Factor - 24%)	-
2	One angle, one opposite direction and one same direction KAB crash	One-Way Stop Control with fair striping on main road and no striping on the crossroad, no median.	401 - Install Pavement Markings (Reduction Factor - 20%)	203- Install Raised median where it doesn't exist (Reduction Factor - 25%)
4	One angle and one same direction KAB crash	One-Way Stop Control with good striping on main road and no striping on the crossroad, no median.	401 - Install Pavement Markings (Reduction Factor - 20%) for the crossroad	203- Install Raised median where it doesn't exist (Reduction Factor - 25%)
5	100% of KAB crashes are angle crashes	One-Way Stop Control with worn striping on main road and no striping on the crossroad, no median.	401 - Install Pavement Markings (Reduction Factor - 20%)	203- Install Raised median where it doesn't exist (Reduction Factor - 25%)
6	50% of KAB crashes are angle crashes, 25% each for opposite direction and roadway and lane departure crashes	Traffic Signal with good striping on main road and fair striping on the crossroad, no median.	401 - Install Pavement Markings for the crossroad (Reduction Factor - 20%) 108 - Improve Traffic Signals (Reduction Factor - 24%) 532 - Milled Edgeline Rumble Strips (Reduction Factor - 15%) where it currently doesn't exist	203- Install Raised median where it doesn't exist (Reduction Factor - 25%)

Table 10: Site-Specific Segment Near-Term Strategies

Segment No	Identified Problems	Description	Near-Term Strategies
1	100% of crashes were roadway and lane departure crashes	Striping is in good condition and median is present for some part of the segment. No centerline or shoulder rumble strips.	532 – Install Milled Edgeline Rumble Strips where they currently do not exist (Reduction Factor – 15%) 542 – Install Milled Centerline Rumble Strips where they currently do not exist (Reduction Factor 26%)
2	67% of crashes were roadway and lane departure crashes and 33% were single vehicle crashes	Striping is in good condition and no median is present. No centerline or shoulder rumble strips.	532 – Install Milled Edgeline Rumble Strips where they currently do not exist (Reduction Factor – 15%) 542 – Install Milled Centerline Rumble Strips where they currently do not exist (Reduction Factor 26%)
3	100% of crashes were roadway and lane departure crashes	Striping is in good condition and no median is present. No centerline or shoulder rumble strips.	532 – Install Milled Edgeline Rumble Strips (where they currently do not exist Reduction Factor – 15%) 542 – Install Milled Centerline Rumble Strips where they currently do not exist (Reduction Factor 26%)
4	100% of crashes were roadway and lane departure crashes	Striping is in good condition and no median is present. No centerline or shoulder rumble strips.	532 – Install Milled Edgeline Rumble Strips where they currently do not exist (Reduction Factor – 15%) 542 – Install Milled Centerline Rumble Strips where they currently do not exist (Reduction Factor 26%)

Segment No	Identified Problems	Description	Near-Term Strategies
5	100% of crashes were roadway and lane departure crashes	Striping is in good condition and no median is present. No centerline or shoulder rumble strips.	532 – Install Milled Edgeline Rumble Strips where they currently do not exist (Reduction Factor – 15%) 542 – Install Milled Centerline Rumble Strips where they currently do not exist (Reduction Factor 26%)

5. Systemic Analysis

5.1 Methods and Assumptions

The study team conducted a review of existing methodologies used by other agencies and established a systemic safety analysis method to identify near- and long-term strategies for safety improvements. The proposed method is based on review of the Texas A&M Transportation Institute Report *Developing Methodology for Identifying, Evaluating, and Prioritizing Systemic Improvements*[5] and the *FHWA Systemic Safety Project Selection Tool*[6].

The proposed methodology included 3-steps:

- Step 1: Identification of focus crash types
- Step 2: Identification and analysis of contributing factors
- Step 3: Selecting near- and long-term strategies for safety improvements

Note that the study corridor had only 40 KAB observed crashes over the five years from 2015 to 2019 out of which 15 crashes were roadway and lane departure crashes. This is the most common focus crash type in this corridor. This number of crashes was deemed too small to adequately derive systemic insights specific to the FM 76 corridor. Therefore, the team decided to conduct the systemic analysis for all the similar roadway facilities, specifically all FM roads in El Paso County.

For the systemic analysis, all KAB crashes (135) that occurred on all FM roads from 2015 to 2019 in El Paso County were considered. The goal of the proposed process is to identify high-risk roadway characteristics associated with the potential for KAB crashes and propose countermeasures to reduce the risk. Studying all FM roads in El Paso County provides a wider system context to support systemic analysis.

[5] Available at: https://ftp.txdot.gov/pub/txdot-info/trf/trafficsafety/engineering/systemic-improvements.pdf
[6] Available at: https://safety.fhwa.dot.gov/systemic/fhwasa13019/

5.2 Identification of Focus Crash Types

The first step of a systemic safety process was to identify problematic crash types that should be a focus of safety improvement within the study corridor. The Texas SHSP infrastructure related emphasis areas were used as a starting point for focus crash type identification. The SHSP emphasis areas include roadway and lane departure crashes, pedestrian crashes, and intersection crashes.

To identify focus crash types a crash tree diagram method was used to analyze KAB crashes of FM roads in El Paso County. This method repeatedly breaks down the emphasis area crashes to identify common crash characteristics. This method highlights the common characteristic that makes up the plurality of crashes at each level as potential focus type crashes.

For example, intersection crashes were broken down by intersection traffic control, then by manner of collision, and finally by presence of median. The method revealed that the plurality of KAB crashes were angle crashes occurring at unsignalized intersections with no medians. The creation of the levels of the crash tree diagrams is an iterative process that is repeated until the results of the process are deemed sufficiently meaningful and actionable. The identified focus crash types are summarized in **Table 11** and final crash tree diagrams for each SHSP emphasis area are presented in the **Appendix B.2**.

Table 11: Focus Crash Types

Emphasis Area	Focus Crash Type
RLD	Crashes on segments with no median during night-time
PED/BIKE	Single vehicle crashes at segments with no median during night-time
Intersection	Angle collisions at unsignalized intersections with no median

These focus crash types helped identify the possible contributing factors that were used in the next steps of the systemic safety process, to identify risk factors and select potential near- and long-term strategies recommended to reduce the risk of these crash types.

5.3 Identification and Analysis of Contributing Factors

The TxDOT Roadway Inventory data contains roadway features that can be used to identify high-risk characteristics associated with KAB crashes. The number of lanes, lane width, shoulder width, functional classification, and presence of median were selected for further analysis in El Paso County. These roadway features were selected as they are consistent with the identified focus crash types in **Section 5.2,** had complete data within the Roadway Inventory file, and were anticipated to be potential risk factors. Due to insufficient data availability within the TxDOT Roadway Inventory database specific to intersections, only the RLD and PED/BIKE emphasis areas are processed through the contributing factors identification step of the systemic analysis.

The roadway attributes were used to create a summary of the vehicle miles traveled (VMT) using average AADT between years 2015 and 2019 and the segment length for each identified roadway feature. **Table 12** presents a summary of these network characteristics.

Table 12: Percentage VMT Summary by Roadway Characteristics for FM Roads in El Paso County

Roadway Characteristic	Category/Bins			
Number of Lanes	≤3	>3 & ≤ 6		≥7
Percentage VMT	35%	65%		0%
Lane Width	≤10	11	12	>12
Percentage VMT	13%	3%	78%	6%
Shoulder Width	0	>0 & ≤3	>3 & ≤6	>6
Percentage VMT	19%	11%	34%	36%
Presence of Medians	With Median		Without Median	
Percentage VMT	33%		67%	

In order to determine which of these characteristics may be associated with higher risks of KAB crashes, a summary of crash percentage was developed for the same roadway features. This summary was created by summarizing the RLD and PED/BIKE emphasis area crashes (as defined in **Section 1.2.1**) based on linking the crashes to an analysis segment by highway name and Distance From Origin (DFO) and summarizing how many crashes occurred in segments with the analyzed roadway characteristic. **Table 13** summarizes the results of this crash summary. Note this crash summary was conducted for risk attributes potentially associated with the emphasis area crash type.

For example, lane width and shoulder width are characteristics commonly believed to be associated with roadway or lane departure crashes.

Table 13: Percentage RLD and PED/BIKE Crashes by Roadway Characteristic

Roadway Characteristic	Category/Bins			
Number of Lanes	≤3	>3 & ≤ 6		≥7
% RLD Crashes	-	-		-
% PED/BIKE Crashes	14%	86%		0%
Lane Width	≤10	11	12	>12
% RLD Crashes	19%	0%	81%	0%
% PED/BIKE Crashes	-	-	-	-
Shoulder Width	0	>0 & ≤3	>3 & ≤6	>6
% RLD Crashes	19%	23%	42%	16%
% PED/BIKE Crashes	-	-	-	-
Presence of Medians	With Median		Without Median	
% RLD Crashes	11.5%		88.5%	
% PED/BIKE Crashes	29%		71%	

Comparing the percentage of network VMT (**Table 12**) to percentage of crashes (**Table 13**) can reveal which characteristics are associated with a disproportionate number of crashes and thus may be high risk.

The extent of this risk can be estimated by comparing the difference between the two percentages, called overrepresentation. A characteristic is overrepresented when the crash percentage exceeds the VMT percentage within the roadway network. For example, in **Figure 16**, overrepresentation was present for roadways with four to six lanes. Overrepresentation is visualized in **Figure 16** through **Figure 19**.

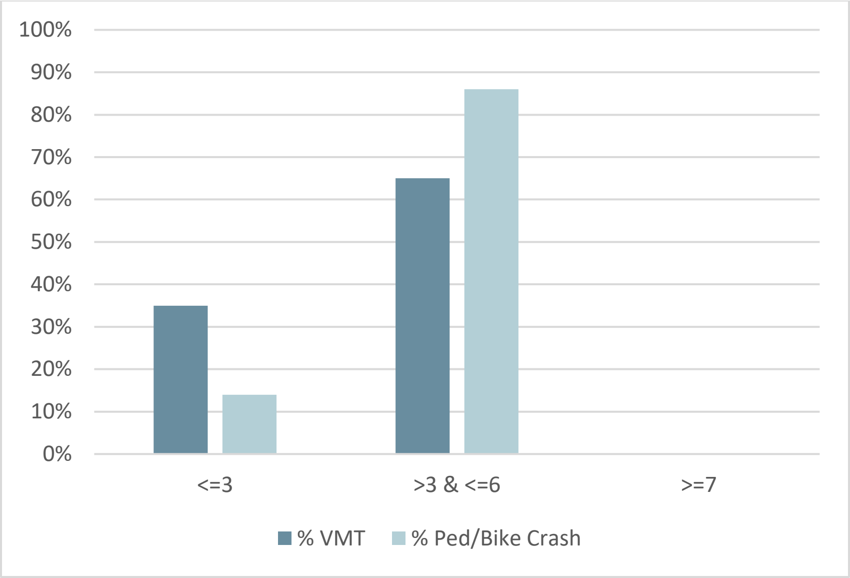

Figure 16: Number of Lanes Overrepresentation Analysis

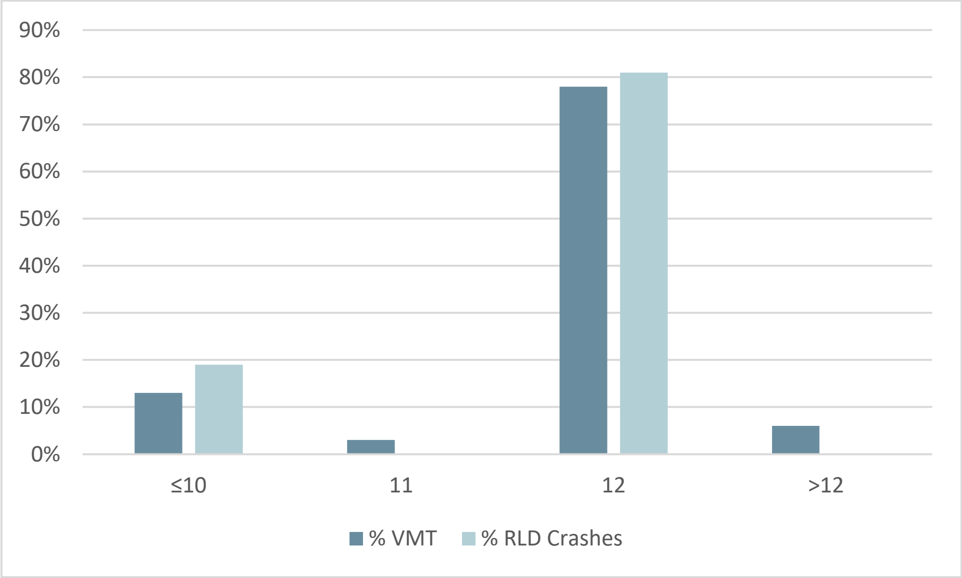

Figure 17: Lane Width Overrepresentation Analysis

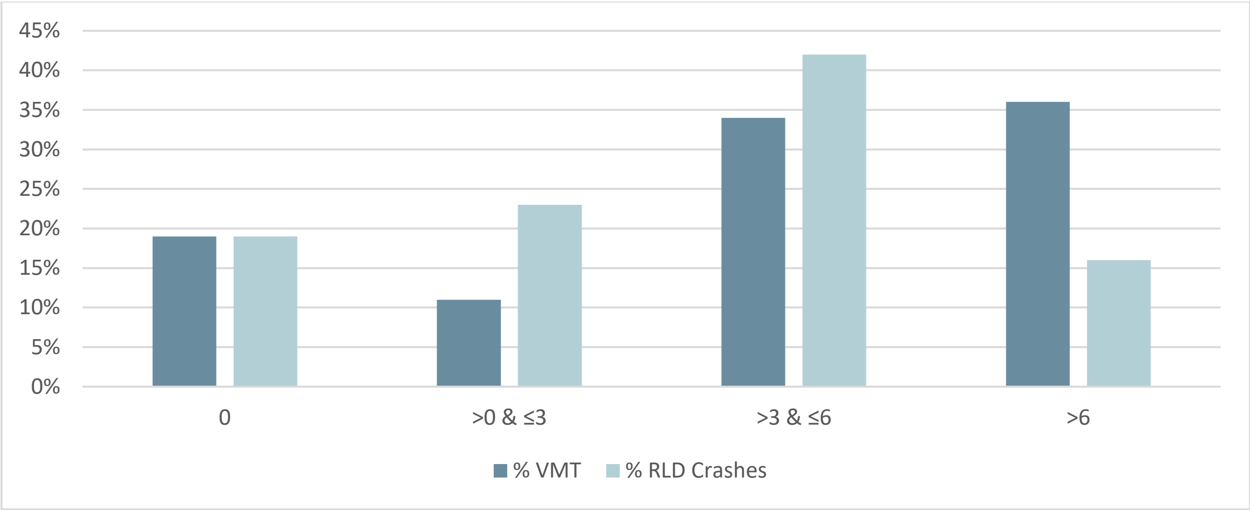

Figure 18: Shoulder Width Overrepresentation Analysis

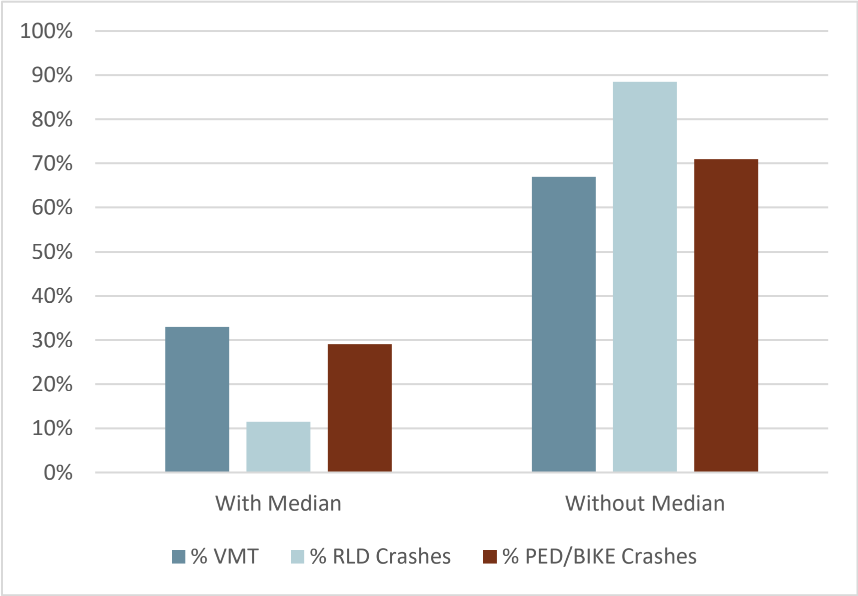

Figure 19: Median Presence Overrepresentation Analysis

Key takeaways from **Figure 16** through **Figure 19** include:

- PED/BIKE crashes are overrepresented on roadways with 4 to 6 lanes
- RLD crashes are overrepresented on roadways with 12 feet wide lanes

- RLD crashes are overrepresented on roadways with greater than 0 to equal to 6 feet shoulder width or underrepresented on roadways more than 6 feet shoulder width

- PED/BIKE crashes and RLD crashes are overrepresented at locations without medians

5.4 Systemic Countermeasures

Next, the identified contributing factors and roadway features are examined to determine if effective HSIP compliant countermeasures could be applied to address the emphasis area crash type. **Table 14** summarizes the identified problem areas and the recommended near- and long-term strategies for each emphasis area. Despite the insufficient inventory data available for intersections, some typical near- and long-term countermeasure strategies have been identified in **Table 14**.

Table 14: Systemic Near- and Long-Term Strategies

<table>
<tr><th>Emphasis</th><th>Identified Issues</th><th>Near-Term Strategies</th><th>Long-Term Strategies</th></tr>
<tr><td>RLD</td><td>RLD crashes are over-represented on roadways without a median and for shoulder width greater than 0 feet but less or equal to 6 feet

73% of RLD crashes occurred at dark condition</td><td>532 – Install Milled Edgeline Rumble Strips (Reduction Factor - 15%)

542 - Install Milled Centerline Rumble Strips (Reduction Factor - 26%)</td><td>203 - Install raised median (Reduction Factor - 25%)

304 - Safety Lighting (Reduction Factor - 49%)

536 – Widen Paved Shoulders to more than 5 feet (Reduction Factor – 31%)</td></tr>
<tr><td rowspan="5">PED/BIKE</td><td>71% of PED/BIKE crashes occurred on segments with no median</td><td rowspan="5">143 – Pedestrian Hybrid Beacon (Reduction Factor – 15%) at high pedestrian activity locations on collector roadways

403 - Install Pedestrian Crosswalk (Reduction Factor - 20%) where not present</td><td rowspan="5">203 - Install raised median (Reduction Factor - 25%)

304 - Safety Lighting (Reduction Factor - 49%)</td></tr>
<tr><td>57% of PED/BIKE crashes occurred at segments</td></tr>
<tr><td>95% of PED/BIKE crashes were hit by a single vehicle</td></tr>
<tr><td>81% of the single vehicle crashes at segments occurred during night-time</td></tr>
<tr><td>76% of crashes occur at unsignalized intersections</td></tr>
<tr><td rowspan="2">Intersection</td><td>48% of crashes at unsignalized intersections are angle collision crashes</td><td rowspan="2">401 - Install Pavement Markings (Reduction Factor - 20%) if it is currently in worn condition</td><td rowspan="2">107 - Install Traffic Signal (Reduction Factor - 35%) where warranted

203 - Install raised median (Reduction Factor - 25%)</td></tr>
<tr><td>Most unsignalized angle collisions (72%) occurred at sites with no median</td></tr>
</table>

6. Summary and Recommendations

The data-driven safety analysis presented in this report led to the identification of near- and long-term strategies to improve the safety of the FM 76 Feasibility Study corridor. The location-specific countermeasures could address identified safety problems at historically high-crash locations. The systemic countermeasures proactively treat roadways with identified high-risk characteristics based on a data-driven assessment of characteristics that have been historically associated with a high number of crashes. Additionally, the systemic analysis revealed some general trends in the county for similar types of roadway facility that should be considered when making improvements within the study corridor.

APPENDIX B.1

Collision and Condition Diagrams

APPENDIX B.2

Systemic Collision Tree Diagrams

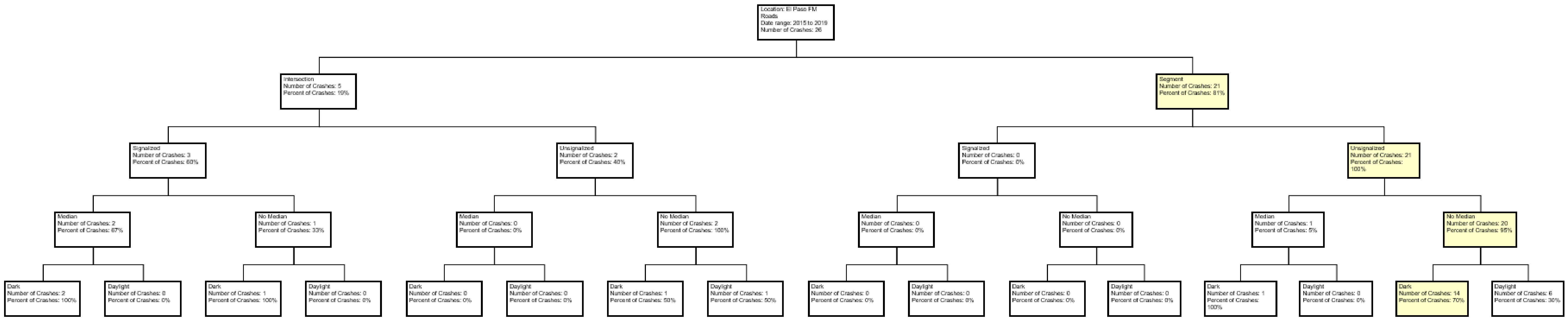

Figure S-1: Roadway and Lane Departure Crash Tree Diagram

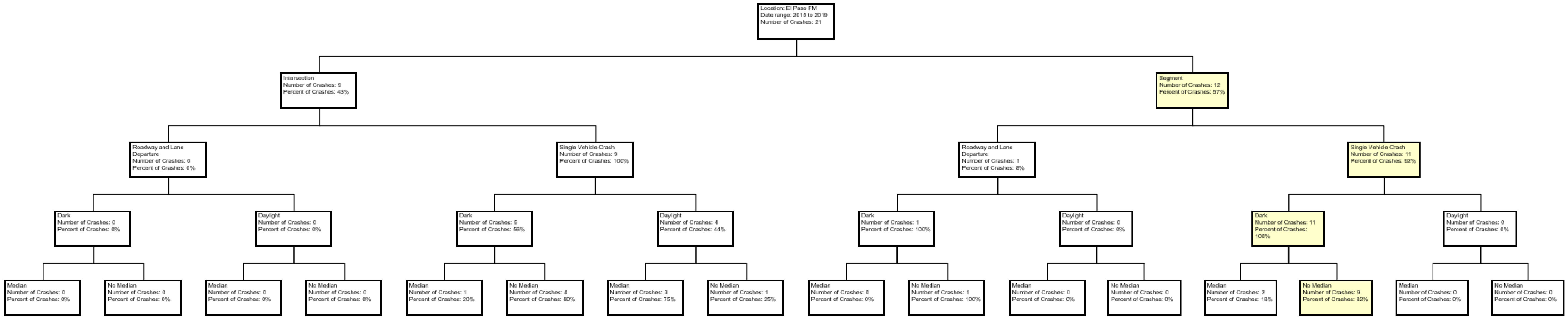

Figure S-2: Pedestrian Crash Tree Diagram

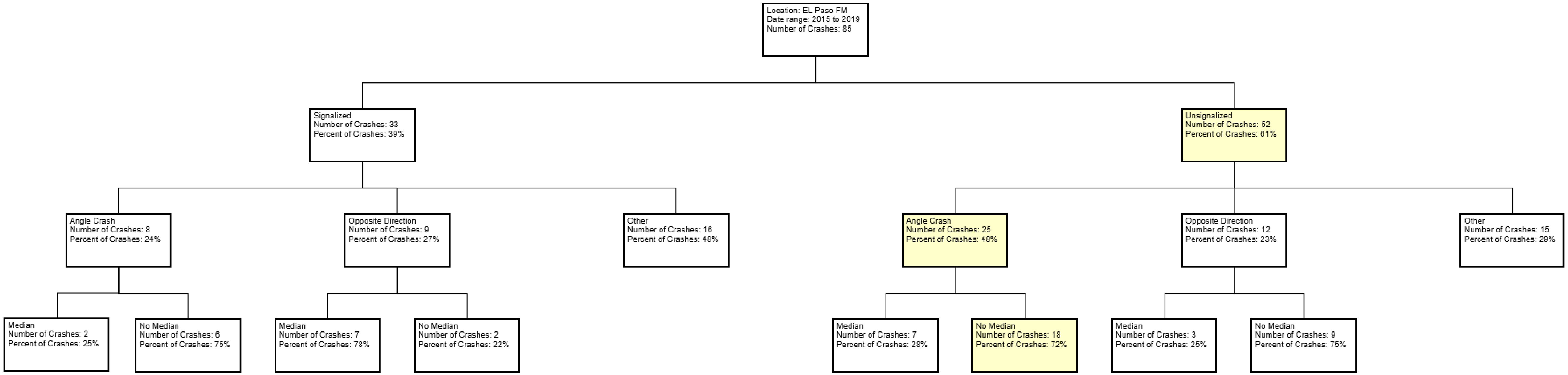

Figure S-3: Intersection Crash Tree Diagram