Appendix F
Roadway Safety Analysis

F.1 Approach

This appendix provides detailed technical information on the analysis of roadway segment and intersection safety impacts. The analysis focuses on the associated Commercial Motor Vehicle (CMV) Facility, because the proposed line has no potential to affect roadway safety. The No-Action Alternative analysis was conducted for 2031, five years after the anticipated year of the Surface Transportation Board's (Board) final decision. The No-Action Alternative reflects the projected roadway traffic volumes in the analysis year 2031 without the associated CMV Facility and assumes all international CMV traffic in Eagle Pass would continue to use Eagle Pass's existing Camino Real International Bridge (Bridge 2). The 2031 build scenario (with the associated CMV Facility) assumes all international CMV traffic would shift from Bridge 2 to the New Road Bridge and CMV Facility. Traffic volumes under both the No-Action Alternative and the 2031 build scenario assume the completion of SL 480 to the north of Eagle Pass, currently planned by the Texas Department of Transportation (TxDOT). With the completion of the connection between SL 480 and U.S. 277, traffic volumes on U.S. 277 south of the connection are anticipated to decrease by 38 percent in 2031 compared to 2024.

Table F-1 provides a list of the intersections and road segments considered in the roadway safety analysis, including identification (ID) numbers for use in the remainder of this appendix and a description of each intersection and segment. Together, they comprise the study area for the analysis of roadway safety effects. Background data used for the analysis are for the period from 2017 through 2023 (study period). The American Association of State Highway Transportation Officials' Highway Safety Manual (HSM) generally recommends at least three to five years of observed crash data for analysis; however, due to the COVID-19 global pandemic and its impacts on traffic volumes, crash frequency, and user behavior, Office of Environmental Analysis (OEA) opted to extend the study period to include three full years prior to the pandemic, for a total of seven complete calendar years of crash data (Federal Highway Administration (FHWA) 2010).

Table F-1. Roadway Safety Analysis Intersections and Road Segments

ID	Intersection/Segment	Type
1	U.S. 277 at FM 1589	3-Leg Minor Road Stop-Controlled Intersections
2	U.S. 277 at Juanita Drive	
3	U.S. 277 at Rivera Drive	
4	U.S. 277 at FM 1588	3-Leg Signalized Intersection
5	U.S. 277 between Juanita Drive and Rivera Drive	5-Lane Urban Arterial (Road Segment)
6	U.S. 277 between Rivera Drive and FM 1588	

The influence area of an intersection varies depending on many factors, including the intersection geometry and traffic speeds. For purposes of this roadway safety analysis and consistent with a suggested definition in the HSM, OEA defined the influence area of intersections as a 250-foot radius extending from the center of each intersection along each intersecting roadway. The segments listed in **Table F-1** exclude the intersection influence areas; for example, Segment ID 5 (U.S. 277 between

Juanita Drive and Rivera Drive) terminates 250 feet from the center of Intersection ID 2 (U.S. 277 at Juanita Drive) on the southern end and terminates 250 feet from the center of Intersection ID 3 (U.S. 277 at Rivera Drive) on the northern end. Refer to *Figure 3.5-1* in *Section 3.5, Roadway Safety*, of the Draft EIS for an illustration of the intersections and roadway segments included in the roadway safety analysis. As an exception, due to the short distance between Intersection IDs 1 and 2 (U.S. 277 at FM 1589 and at Juanita Drive, respectively), the intersection influence areas for these two intersections were split at the halfway point.

The analysis of conditions with the associated CMV Facility did not include the intersection of Marselles Drive at U.S. 277 (just south of the intersection of U.S. 277 with FM 1588) because no traffic volumes were available for Marselles Drive. The analysis of conditions with the associated CMV Facility did not include the new intersection created by the Facility's exit road at FM 1589, approximately 0.3 miles west of Intersection ID 1 (U.S. 277 at FM 1589). There is currently no intersection at this location that could provide a baseline of historic crash frequency or severity. For the 2031 condition with the associated CMV facility, the HSM does not provide a predictive method for such a facility type. Moreover, the traffic associated with the CMV Facility would consist of commercial vehicles. Commercial vehicle drivers have lower crash rates on average than non-commercial drivers (Insurance Institute for Highway Safety n.d.). Additionally, due to the geometry and location of this intersection in proximity to another intersection, speeds would be low; therefore, crash severity would be low if a crash did occur.

While the analysis focuses on effects along U.S. 277 due to the associated CMV Facility traffic, there is also the potential for safety benefits along SL 480 under the build alternatives due to the removal of CMVs from their current (and No-Action Alternative) route from Bridge 2. This analysis also does not capture potential safety impacts related to construction activities for the associated CMV Facility.

F.1.1 Observed Crash History

OEA reviewed information available publicly in the Crash Records Information System (CRIS), which is managed by TxDOT (TxDOT 2024a). Based on this information, a total of 75 crashes occurred at the four intersections and on the two roadway segments in the study area during the study period, 2017 through 2023.

Pursuant to analysis methods described below, OEA disaggregated crash data into three categories: single-vehicle (SV) crashes, multiple-vehicle (MV) non-driveway-related crashes, and multiple-vehicle driveway-related crashes (MV/Dvwy). **Table F-2** provides a summary of the crash history obtained through CRIS, including the total number of observed SV crashes, total number of observed MV crashes, and total number of observed MV/Dvwy crashes over the seven-year study period, as well as the average number of crashes per year for each of the three categories. There are no MV/Dvwy crashes at intersections.

Table F-2. Observed Roadway Crashes (2017-2023)

ID	Total Observed Crashes (2017-2023)			Crashes per Year (2017-2023)		
	SV	MV	MV/Dvwy	SV	MV	MV/Dvwy
1	4	5	--	0.57	0.71	--
2	0	11	--	0	1.57	--
3	1	11	--	0.14	1.57	--
4	4	22	--	0.57	3.14	--
5	0	3	1	0	0.43	0.14
6	1	10	2	0.14	1.43	0.29
Total	**10**	**62**	**3**	**1.43**	**8.86**	**0.43**

F.1.2 Traffic Volumes

The HSM methodology uses Annual Average Daily Traffic (AADT) volumes at each segment and intersection comprising the study area as a primary predictor of crashes. AADT data are available in the TxDOT Statewide Traffic Analysis and Reporting System (TxDOT 2024c). The AADT values used in the present analysis are based on 2023 data, which were the most recent available for each site listed in **Table F-1**. These volumes stand for 2024 existing conditions. To estimate 2031 volumes for the No-Action Alternative, OEA used a growth factor based on ratios developed as part of the Roadway Capacity Analysis (see **Appendix E**). Specifically, the growth factor was based on a ratio of turning movement volumes representing peak-hour observations from 2024 and estimates for 2031. The weighted growth factor was developed as the ratio of 2031 No-Action Alternative volumes to 2024 existing volumes, resulting in values ranging from 0.690 to 1.115. These values were applied to existing AADT volumes for each corridor to develop 2031 No-Action Alternative AADT.

The 2031 No-Action Alternative volumes were then adjusted based on projected changes in CMV traffic to estimate 2031 volumes with the associated CMV Facility. All CMV traffic currently crossing the border on existing Bridge 2 would shift to the New Road Bridge and the associated CMV Facility. The No-Action Alternative has no added CMVs and is solely based on projected roadway traffic volumes while data developed for the roadway capacity analysis were used to estimate the number of CMVs that would be added to the study area for roadway safety as follows:

- In 2023, the average monthly number of CMVs crossing Bridge 2 was 17,260; the month with the most crossings was June (peak month), with 19,657 CMVs, which equates to an average of 756 CMVs per day for June (crossings occur 6 days a week). June crossings represented 9.3 percent of the total for 2023.
- Based on a similar proportion, the peak month of 2031 would see 27,435 CMVs, which equates to an average of 1,056 CMVs per day.
- Comparing the annual monthly average to the peak monthly average results in a ratio of 0.878; applying this ratio to the daily average for that month (756) yields an average daily CMV volume of approximately 664 for 2023.
- Comparing the projected 2031 peak month daily CMV volume (1,056) to the 2023 peak month daily volumes (756) results in a growth factor of approximately 1.397.
- Combining the annual average 2023 daily CMV volume (664) with the calculated growth factor results in a daily estimate of approximately 927 CMVs (one-way directional volume) that would be added to the study area with implementation of the CMV Facility.

These results were applied with the estimated CMV trip assignment proportions derived in *Section 3.5, Roadway Capacity*, of the Draft EIS to estimate 2031 traffic volumes from the associated CMV Facility for each roadway segment and intersection included in the roadway safety analysis.

Table F-3 provides a summary of the traffic volumes used in the analysis for each segment and intersection, including 2024 existing AADTs and projected 2031 AADTs under the No-Action Alternative and with the associated CMV Facility. 2031 traffic volumes on the minor road approaches at Intersection ID 2 (U.S. 277 at Juanita Drive) and Intersection ID 3 (U.S. 277 at Rivera Drive) are the same under the No-Action Alternative and with the associated CMV Facility because none of the CMVs added to the network would use these roads. Traffic volumes used for U.S. 277 are different for Intersection ID 1 (U.S. 277 at FM 1589) from those of the other locations because the intersection analysis methodology accounts for the major and minor road approaches that have the highest traffic volumes; the higher major road approach volume for Intersection ID 1 is the northbound approach on U.S. 277.

Table F-3. Traffic Volumes for Roadway Safety Analysis

		AADT Volumes (Vehicles/Day)		
ID	**Intersection Approach**	**2024 (Existing)**	**2031 (No-Action Alternative)**	**2031 (with CMV Facility)**
1	U.S. 277 (Northbound)	23,437	16,201	16,201
	FM 1589	3,300	3,675	5,529
2	U.S. 277	17,627	12,820	14,674
	Juanita Drive	2,107	2,347	2,347
3	U.S. 277	17,627	12,820	14,674
	Rivera Drive	1,244	1,386	1,386
4	U.S. 277	17,627	12,820	14,674
	FM 1588	4,869	5,427	7,059
5	-	17,627	12,820	14,674
6	-	17,627	12,820	14,674

F.1.3 Pedestrian Volumes

The predictive methodology for roadway safety analysis described in this section requires pedestrian volume as an input for pedestrian-related analysis at signalized intersections. This is relevant only to Intersection ID 4 (U.S. 277 at FM 1588). The HSM provides estimates of pedestrian crossing volumes based on general level of pedestrian activity within the context of analysis of urban three-legged signalized intersections. Low-volume pedestrian activity is defined in the HSM as 20 pedestrians per day. After reviewing surrounding land uses and existing pedestrian infrastructure, OEA estimates that the pedestrian volumes are low at Intersection ID 4.

F.1.4 Roadway Characteristics

The predictive methodology for roadway safety analysis outlined in the HSM for urban arterial segments and intersections requires several inputs related to roadway characteristics. For segments, required inputs include number of driveways and type (high- or low-volume industrial, residential, commercial, or other); length of analysis segment; proportion of segment with parking; presence of lighting; fixed object density and offset from roadway; and traversable median width. For intersections, required inputs include number of left turn lanes; number of right turn lanes; type of left-turn signal phasing; permittance of right-turn-on-red; and, for signalized intersections only, the number of bus stops/schools/alcohol sales establishments within 1,000 feet of the intersection and the maximum number of lanes crossed by a pedestrian at the intersection. Data related to these variables were collected through review of a mixture of street-level imagery and aerial imagery available publicly online.

F.2 Roadway Safety Analysis Methods

OEA predicted crashes on urban arterial segments and intersections using observed crash history and applicable safety performance functions (SPFs) from TxDOT. This methodology is outlined in Chapter 12 of the HSM. The results include expected crashes per year in 2031 under the No-Action Alternative and with the associated CMV Facility for each segment and intersection. The expected crashes are broken out into SV, MV, and (for segments only) MV/Dvwy crashes. The basic model used in the predictive methodology in the HSM for urban arterial road segments is defined in Equation 1 and Equation 2 below:

$$N_{predicted\,rs} = C_r * \left(N_{br} + N_{pedr} + N_{biker}\right) \qquad 1$$

$$N_{br} = N_{spf\,rs} * (CMF_{1r} * CMF_{2r} * \ldots * CMF_{nr}) \qquad 2$$

Where:

$N_{predicted\,rs}$ = predicted average crash frequency of an individual roadway segment;

N_{br} = predicted average crash frequency of an individual roadway segment (excluding vehicle-pedestrian and vehicle-bicycle collisions);

$N_{spf\,rs}$ = predicted total average crash frequency of an individual roadway segment for base conditions (excluding vehicle-pedestrian and vehicle-bicycle collisions);

N_{pedr} = predicted average crash frequency of vehicle-pedestrian collisions for an individual roadway segment;

N_{biker} = predicted average crash frequency of vehicle-bicycle collisions for an individual roadway segment;

$CMF_{1r} \ldots CMF_{nr}$ = crash modification factors (CMFs) for roadway segments; and

C_r = calibration factor for roadway segments of a specific type developed for use for a particular geographical area (in this analysis, C_r is not used because the models were all developed specifically for the State of Texas).

The SPF portion ($N_{spf\,rs}$) of the predicted average crash frequency of an individual roadway segment (N_{br}) is further separated into three components by collision type shown in Equation 3.

$$N_{spf\ rs} = N_{brMV} + N_{brSV} + N_{brMV/Dvwy} \qquad 3$$

Where:

N_{brMV} = predicted average crash frequency of multiple-vehicle non-driveway collisions for base conditions;

N_{brSV} = predicted average crash frequency of single-vehicle crashes for base conditions; and

$N_{brMV/Dvwy}$ = predicted average crash frequency of multiple-vehicle driveway-related collisions.

For intersections, Equation 1 and Equation 2 are applicable, but the subscripts change to denote intersections (i or int) instead of roadway segments (r or rs). Furthermore, there are only two components of the SPF portion (Nspf int) of the predicted average crash frequency of an individual intersection (Nbi) as shown in Equation 4.

$$N_{spf\ int} = N_{biMV} + N_{biSV} \qquad 4$$

Where:

$N_{spf\ int}$ = predicted total average crash frequency of intersection-related crashes for base conditions (excluding vehicle-pedestrian and vehicle-bicycle collisions);

N_{biMV} = predicted average crash frequency of multiple-vehicle crashes for base conditions; and

N_{biSV} = predicted average crash frequency of single-vehicle crashes for base conditions.

State-calibrated SPFs were obtained from the TxDOT report titled, *Calibrating the Highway Safety Manual Predictive Methods for Texas Highways: Technical Report*, for five-lane urban arterial segments (U5T), urban three-legged signalized intersections (3SG), and urban three-legged minor-road stop-controlled (3ST) intersections (Murphy el at. 2021). These SPFs were used to predict average crash frequency for base conditions for the four intersections and two segments in the study area under 2024 existing conditions, 2031 No-Action Alternative conditions, and 2031 conditions with the associated CMV Facility.

The next step in the HSM predictive methodology is to modify the predicted crash frequency under base conditions (Nspf rs and Nspf int) using crash modification factors (CMFs) that account for various roadway cross-sectional characteristics. The HSM lists five CMFs that apply to urban arterial segments, which account for presence of on-street parking, density of roadside fixed objects, traversable median width, lighting, and presence of automated speed enforcement. For urban arterial intersection analysis, the HSM lists six CMFs that account for presence of left-turn lanes, type of left-turn signal phasing, presence of right-turn lanes, permittance of right-turn-on-red, and presence of red-light violation cameras. OEA reviewed the existing segment and intersection characteristics to determine which CMFs applied for each segment and intersection. For pedestrians at signalized intersections, three additional CMFs are provided in the HSM; these account for the presence of bus stops, presence of schools, and presence of alcohol sales establishments within 1,000 feet of the intersection. The combined total CMF for each segment and intersection was used in Equation 2 for segments and similarly for intersections.

The last step in the predictive methodology in the HSM is to use the empirical Bayes (EB) statistical method for weighting predicted crash frequencies by observed crash frequencies to estimate expected crash frequencies for each site. Weighting predicted and observed crash frequencies results in a more reliable estimate of expected crash frequency for roadway safety analyses. Specifically, the EB method is used in roadway safety analysis to overcome regression-to-the-mean bias introduced when using observed crash data. The general formula for calculating expected crash frequency for a segment or intersection is provided in Equation 5.

$$N_{expected} = w * N_{predicted} + (1 - w) * N_{observed} \qquad \text{Equation 5}$$

Where:

$N_{expected}$ = expected average crash frequency for the study period;

$N_{predicted}$ = predicted average crash frequency predicted using an SPF for the study period under the given conditions (this is N_{br} or N_{bi} from Equation 2);

w = weighted adjustment to be placed on the SPF prediction; and

$N_{observed}$ = observed crash frequency at the site over the study period.

Values for $N_{observed}$ are provided in **Table F-2**. The weight (w) is calculated as a function of the overdispersion parameter, which is provided in the TxDOT report titled, *Calibrating the Highway Safety Manual Predictive Methods for Texas Highways: Technical Report*, for each SPF (excluding pedestrian and bicycle models). The overdispersion parameter is a measure of statistical variance in the datasets used to develop the models.

OEA then calculated two growth factors, one comparing the 2024 existing conditions to the 2031 No-Action Alternative and one comparing the 2024 existing conditions to the 2031 with associated CMV Facility condition. These growth factors were based on results from the crash predictions calculated using Equation 1 for segments and similarly for intersections. The two growth factors were applied to results from Equation 5 for each analysis segment and intersection to calculate the estimated expected crash frequency for design year 2031 conditions.

To account for pedestrian and bicycle collisions in the 2031 design year expected crash frequency estimates, OEA calculated predicted crash frequency using state-calibrated SPFs provided in the TxDOT report titled, *Calibrating the Highway Safety Manual Predictive Methods for Texas Highways: Technical Report,* for each analysis segment and intersection. These results were added to the design year 2031 estimates for expected crash frequency that were calculated using the growth factors described above.

F.3 Roadway Safety Analysis Results

Table F-4 presents the roadway safety analysis results by analysis segment or intersection for the 2024 existing conditions, the 2031 No-Action Alternative, and the 2031 condition with the associated CMV Facility. The table includes predicted average crash frequency, observed crash frequency, and estimated expected crash frequency for 2024 existing conditions. For the 2031 conditions, the table includes predicted average crash frequency, the estimated average expected crash frequency for 2031, the associated growth factor based on predicted crash frequencies comparing the 2031 condition to the 2024 existing condition, and the predicted average crash frequency for bicycle and pedestrian crashes only.

Table F-4. Roadway Safety Analysis Results

	2024 Existing Condition (Crashes/Year)			2031 No-Action Alternative (Crashes/Year)				2031 with CMV Facility (Crashes/Year)			
ID	$N_{predicted}$	$N_{observed}$	$N_{expected}$	$N_{predicted}$	**Growth Factor Applied**	$N_{predicted}$ **(bicycles + pedestrians)**	$N_{expected}$	$N_{predicted}$	**Growth Factor Applied**	$N_{predicted}$ **(bicycles + pedestrians)**	$N_{expected}$
1	0.902	1.286	0.880	0.635	0.704	0.012	0.635	0.752	0.834	0.015	0.749
2	0.823	1.571	1.449	0.614	0.747	0.012	1.096	0.708	0.861	0.014	1.261
3	0.661	1.714	1.407	0.493	0.746	0.010	1.061	0.569	0.861	0.011	1.222
4	1.751	3.714	3.234	1.297	0.741	0.013	2.410	1.603	0.915	0.015	2.974
5	1.031	0.571	0.881	0.758	0.735	0.046	0.700	0.863	0.837	0.053	0.790
6	3.085	1.857	2.399	2.257	0.732	0.138	1.912	2.575	0.835	0.157	2.160
Total	**8.25**	**10.71**	**10.25**	**6.05**	**--**	**0.23**	**7.81**	**7.07**	**--**	**0.27**	**9.16**