


Appendix B – Safety Analysis

KY 44 Programming Study

Bullitt County, KY

February 13, 2023



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Historic Crash Analysis

A historical crash analysis was performed to examine traffic safety trends and to identify potential safety issues along KY 44. The crash data was derived using information from the Kentucky Transportation Center (KTC) Crash Data Analysis Tool (CDAT) database. Five years of data (2017 to 2021) were used in the analysis and are presented throughout the rest of this chapter.

Within the five-year analysis period, 1,694¹ crashes were reported in the study area. A breakdown of the crashes by severity is presented in **Table 1** and **Figure 1**. Most of the crashes (82.5%) were property damage only crashes. There were eight fatal crashes, 20 serious injury crashes, and 114 minor injury crashes reported over the 5-year study period.

Table 1: KY 44 Crash Severity (2017 - 2021)

Severity of Crash	Crashes	Percent
Fatal Injury (K)	8	0.5%
Serious Injury (A)	20	1.2%
Minor Injury (B)	114	6.7%
Possible Injury (C)	154	9.1%
Property Damage Only (O)	1,398	82.5%
Total	1,694	100.0%

An examination of the type of crashes along KY 44 is presented in **Table 2** and **Figure 2**.

Approximately 52% of the crashes in the study area are rear end crashes, followed by angle (21.7%) and single vehicle (10.5%) crashes. The head on crashes category had the highest average severity of all the crash types with 11 of the 27 involving a fatality or injury (1 fatal, 3 serious injury and 7 minor injury). It was also noted that commercial vehicles were involved in 2.2% of all reported crashes, which is a lower percent than their proportion of traffic volume on KY 44 (6.8% trucks).

Table 2: KY 44 Crashes by Manner of Collision (2017 - 2021)

Crash Type	Crashes	Percent
Rear End	875	51.7%
Angle	367	21.7%
Single Vehicle	178	10.5%
Sideswipe - Same Direction	116	6.8%
Sideswipe – Opposite Direction	53	3.1%
Opposing Left Turn	48	2.8%
Head On	27	1.6%
Backing	23	1.4%
Rear to Rear	7	0.4%
Total	1,694	100.0%

¹ Three crashes of unknown severity were reported in the study area and are not included in this analysis.

Figure 1: KY 44 Crash Severity Map (2017 – 2021)

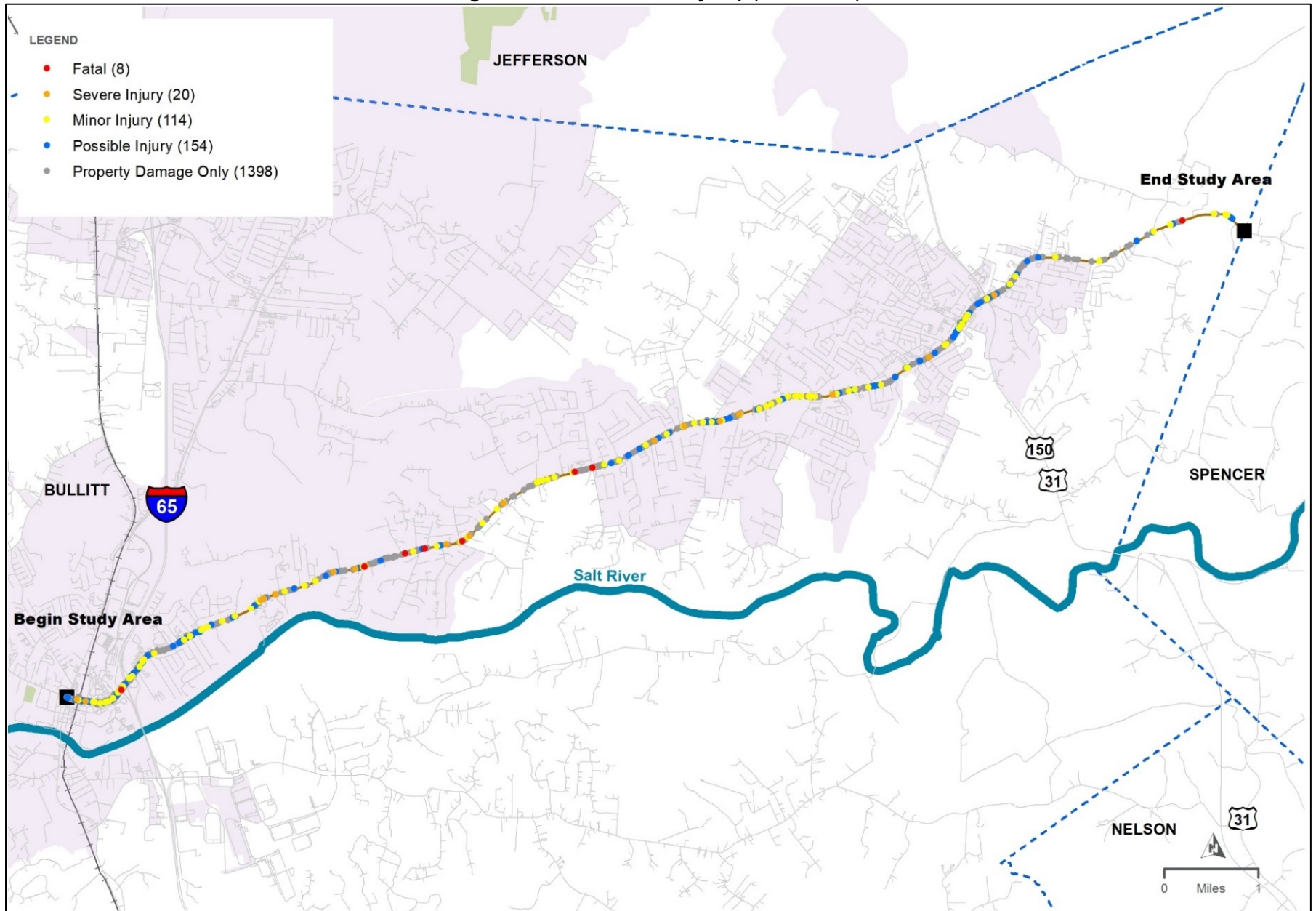
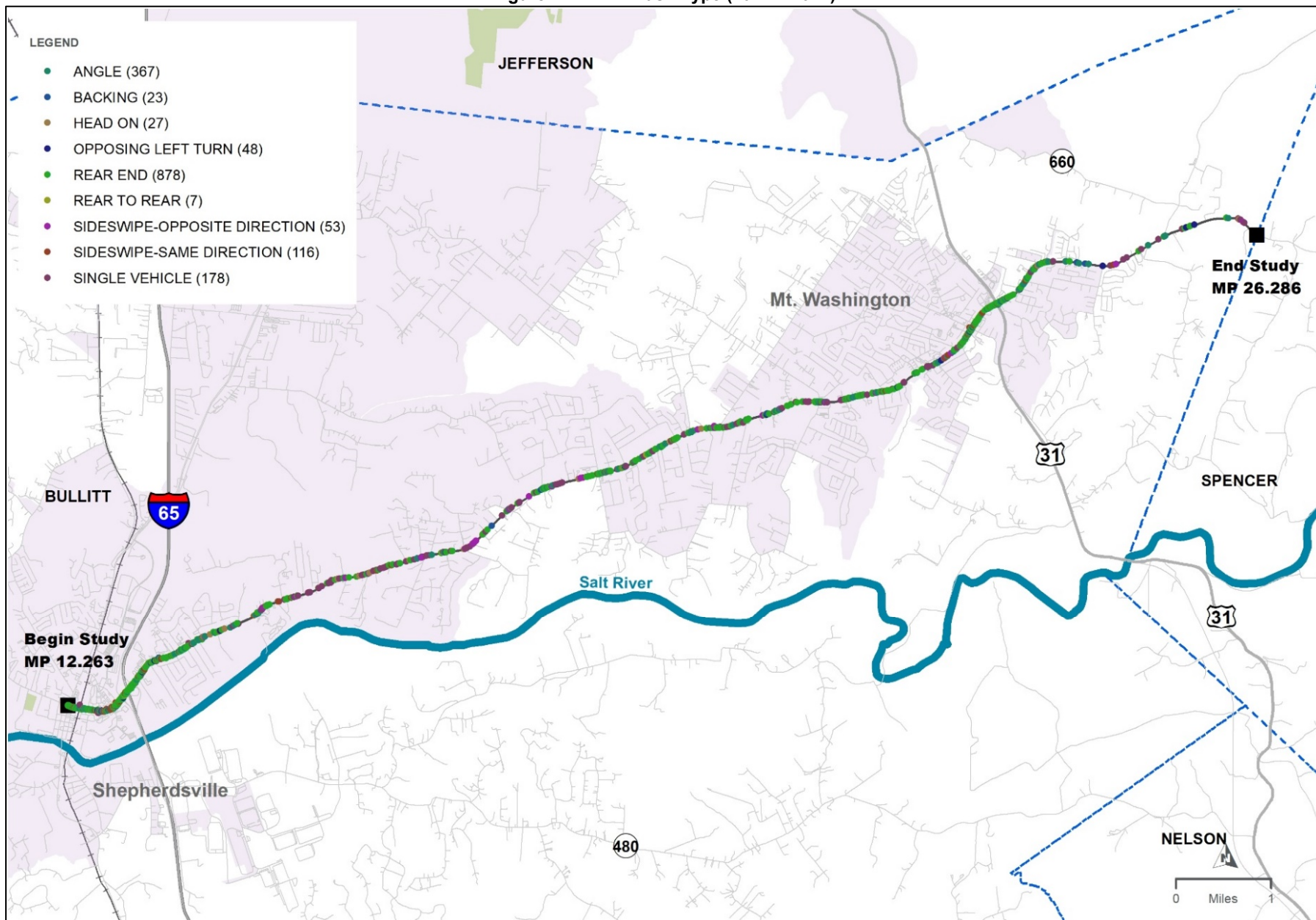


Figure 2: KY 44 Crash Type (2017 – 2021)



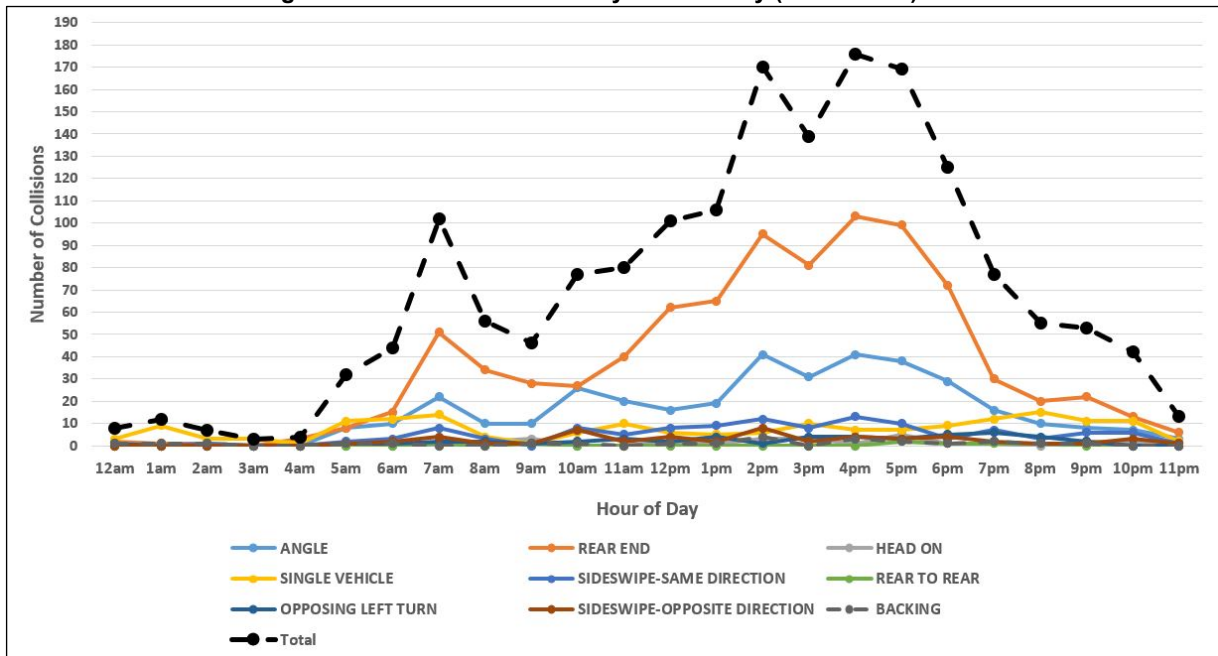
With there being over 546 intersections and access points along KY 44, intersection and driveway related crashes were reviewed. Angle, rear end, opposing left turn, and sideswipe-opposite direction crashes that occurred within 400 ft of an intersection and within 50 ft of an entrance/driveway were screened. This resulted in approximately 60% of all crashes occurring at an intersection or entrance/driveway. **Table 3** provides a breakdown of crash type occurring at intersections and driveways.

Table 3: KY 44 Crashes at Intersections and Entrances/Driveways (2017 - 2021)

Crash Type	Crashes	Percent
Rear End	657	64.3%
Angle	300	29.4%
Opposing Left turn	42	4.1%
Sideswipe-Opposite Direction	22	2.2%
Total	1,021	100%

A review of crashes by time of day, **Figure 3**, shows that crashes tend to peak in the afternoon, with the largest number of crashes occurring between 2:00 and 6:00 pm. This peaking pattern can be attributed to higher volumes of traffic in the pm peak period and to increased school related traffic in the afternoon.

Figure 3: Manner of Collision by Time of Day (2017 - 2021)



The affect that weather events and pavement condition had on crashes were investigated. 1481 crashes occurred in clear or cloudy conditions (67% and 20.3% respectively). **Figure 4** provides crashes by weather condition. **Figure 5** provides crashes by pavement condition. There were 1373 crashes that occurred under dry pavement conditions (81.1%).

Figure 4: Crashes by Weather Condition (2017 – 2021)

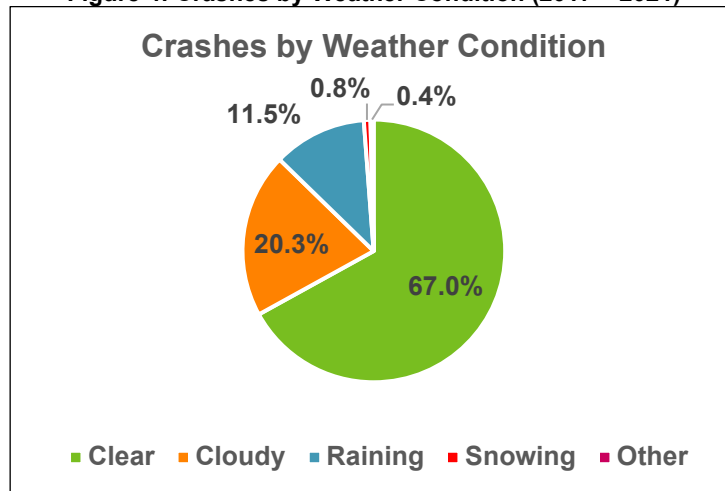
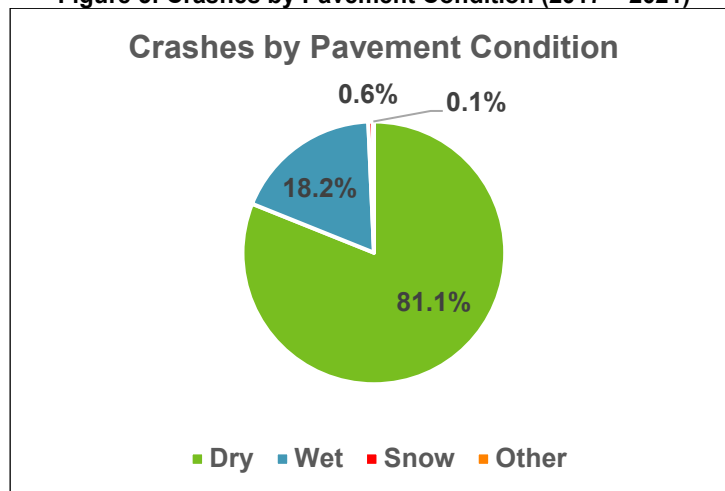


Figure 5: Crashes by Pavement Condition (2017 – 2021)



The direction of travel that crashes occurred in was analyzed. Eastbound and westbound traffic accounted for 42% of crashes each. 16% of crashes did not contain enough information to assign a direction.

The density of crashes along the study area was plotted (**Figure 6**) to show locations with higher concentration of crashes. The locations of fatal and serious injury crashes were overlaid on this map. Three trends emerged from this analysis. High concentrations of crashes occurred in Shepherdsville from KY 61 (MP 12.215) to Bullitt Central High School (MP 13.592). Crashes were also concentrated in the Mt. Washington area between Woodlake Drive (MP 22.103) and Cornell Avenue (MP 23.952). These two areas are located where traffic volumes are also the highest in the study area. The third location of interest occurred in the middle portion of the study area between Douglas Lane (MP 15.552)

and KY 2706 (Greenbriar Road) (MP 19.895). Although the concentration of crashes was not as high, the numbers of fatal and serious injury crashes were higher than other locations of the study. This can be attributed to the higher speeds that are observed in this area.

Bicycle and pedestrian related crashes were also reviewed. No crashes involving a bicycle were recorded within the analysis period. Fourteen pedestrian related crashes were recorded. Of these crashes, one fatal, one serious injury, seven minor injury and three possible injury crashes were observed. Nine of the fourteen crashes involving a pedestrian occurred at night. **Figure 7** shows the location of where these pedestrian crashes occurred.

Figure 6: KY 44 Crash Density (2017 – 2021)

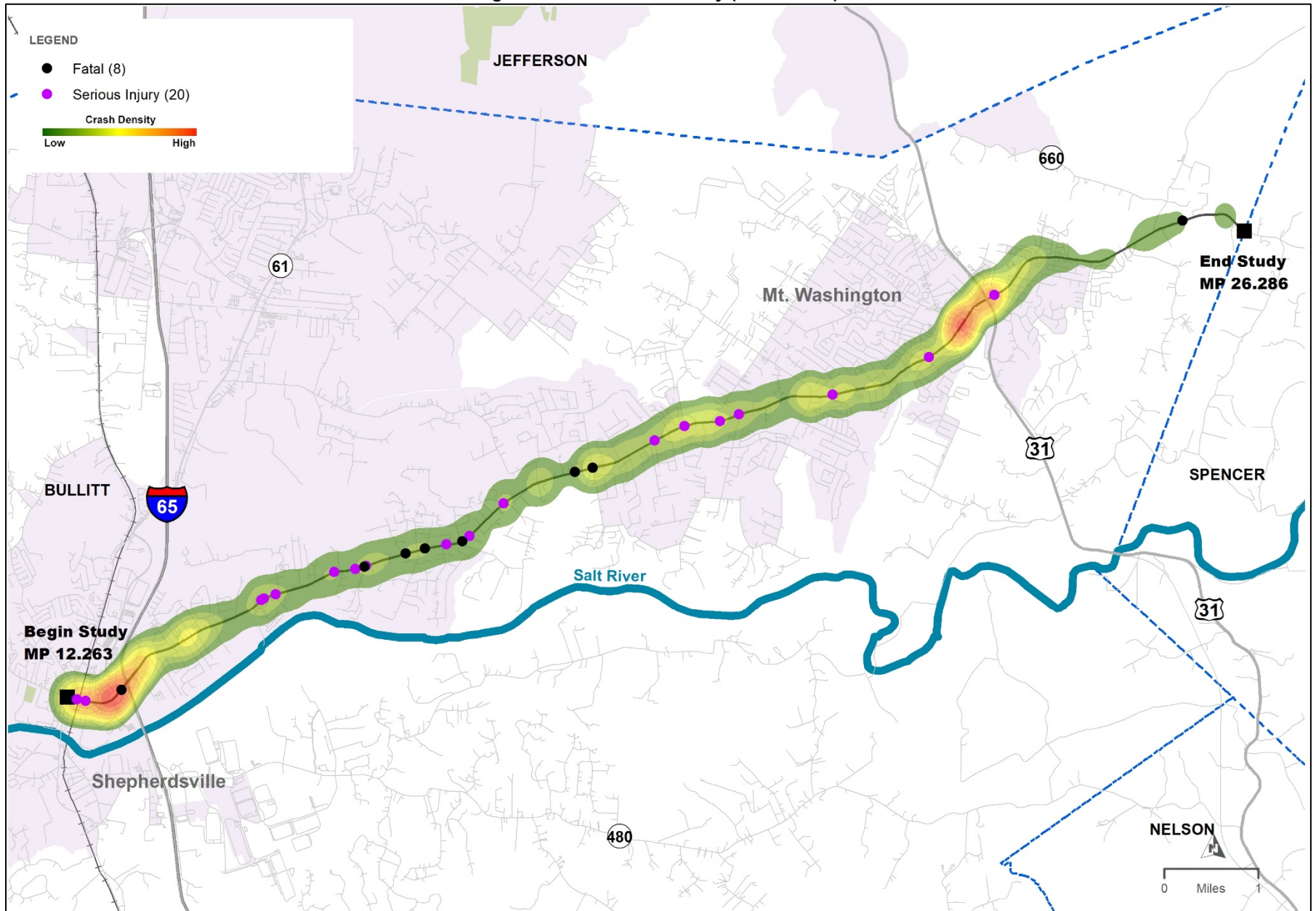
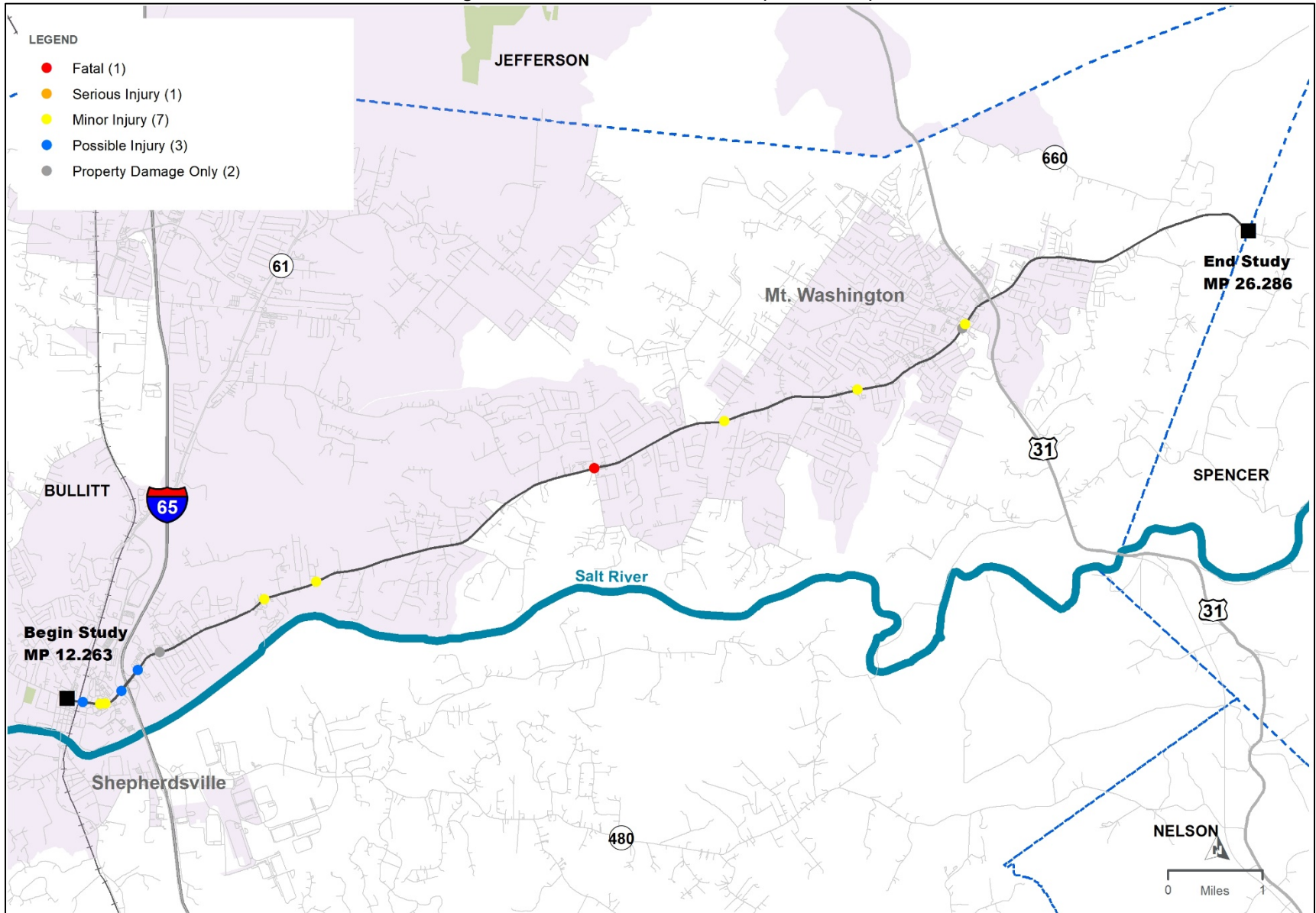


Figure 7: KY 44 Pedestrian Crashes (2017 – 2021)



Intersection Crash Rates

Crash rates were calculated at the KY 44 study intersections using the 2017 – 2021 crash data and traffic volumes. The average intersection crash rate in the study area is 1.41. Seven intersections equaled or exceeded this average crash rate. These intersections include the I-65 southbound ramp (crash rate of 5.39), Adam Shepherd Parkway (4.44), US 31EX (2.97), KY 61 (2.64), I-65 northbound ramp (1.78), Carpenter Street (1.74), and US 31E (1.41). **Table 4** provides study intersection crash rates.

Table 4: KY 44 Intersection Crash Rates (2017 - 2021)

Intersection Name	Intersection Crash Rate ¹
KY 44 at KY 61	2.64
KY 44 at Carpenter Street	1.74
KY 44 at Adam Shepherd Parkway	4.44
KY 44 at I-65 Southbound Ramps	5.39
KY 44 at I-65 Northbound Ramps	1.78
KY 44 at South Lakeview Drive	1.13
KY 44 at Bullitt Central High School	0.14
KY 44 at Highland Court	1.28
KY 44 at Lees Valley Road	0.88
KY 44 at Boardwalk Avenue	0.79
KY 44 at Dennis Drive / Sunview Drive	0.35
KY 44 at KY 1526 (Bells Mill Road)	0.57
KY 44 at Lloyd Lane / Bogard Lane	1.11
KY 44 at Bethel Church Road	1.01
KY 44 at KY 2706 (Greenbriar Road)	0.66
KY 44 at Fisher Lane	1.27
KY 44 at US 31EX	2.97
KY 44 at US 31E	1.41
KY 44 at KY 1319 (Kings Church Road)	0.87
KY 44 at Tollview Drive	0.97
KY 44 at Highland Springs Drive	0.68
KY 44 at Woodlake Drive	0.40
KY 44 at Stringer Lane	0.42
KY 44 at Oakbrooke Drive	1.02

¹ Per million entering volume

Excess Expected Crashes

KYTC and KTC have developed a more refined statistical methodology based on the Highway Safety Manual (HSM) to rank the safety needs of projects. Excess Expected Crashes (EEC) is based on a crash prediction model estimating the number of crashes expected on an average roadway segment of a given type and length. It represents the number of excess crashes a segment is experiencing compared to other roadways of its type, adjusting for traffic volumes and a statistical correction. EEC is positive when more crashes are occurring than expected and negative when fewer crashes are occurring than expected.

Intersection and segment EEC values for KY 44 were analyzed and summarized in **Table 5**. Segments were separated into four types based on their typical section and median type, with these being urban two-lane highway, urban multi-lane undivided highway, urban multi-lane divided highway and rural two-lane highway. The only segment type with an overall negative EEC value is the urban two-lane type roadway, but this same segment type also has the highest fatal and serious injury EEC value. The other segment types have positive EEC values indicating that more crashes are occurring than expected. Intersection EEC was also positive with the possible injury and property damage only category being exceptionally high. Intersection EEC values being higher than segment EEC values matches up with the observation of more crashes being at or in the vicinity of intersections and driveways. This high value possibly shows that the density of intersections is leading to a higher number of crashes.

Figure 8 shows positive and negative KY 44 total EEC (including fatal, injury, and property damage only) segments. Positive EEC segments are present in Shepherdsville west of I-65, in Mt. Washington approaching the US 31E intersection and in the far eastern study area east of the KY 1319 (Kings Church Road) intersection. Positive and negative EEC intersections are spread throughout the KY 44 study area, but are more concentrated in Shepherdsville and Mt. Washington (see **Figure 9**).

Table 5: KY 44 EEC Rates

Location	KAB EEC*	CO EEC*	Location Total EEC
Urban Two-lane	26.36	-213.27	-186.91
Urban Multi-lane Undivided	3.84	51.67	55.51
Urban Multi-lane Divided	2.56	64.64	67.20
Rural Two-lane	1.67	0.33	2.00
Segment Totals	34.43	-96.63	-62.20
Intersections	26.70	651.07	677.77

*K = Fatal Injury, A = Serious Injury, B = Minor Injury, C = Possible Injury, O = Property Damage Only

Figure 8: KY 44 Segment Excess Expected Crashes (2017-2021)

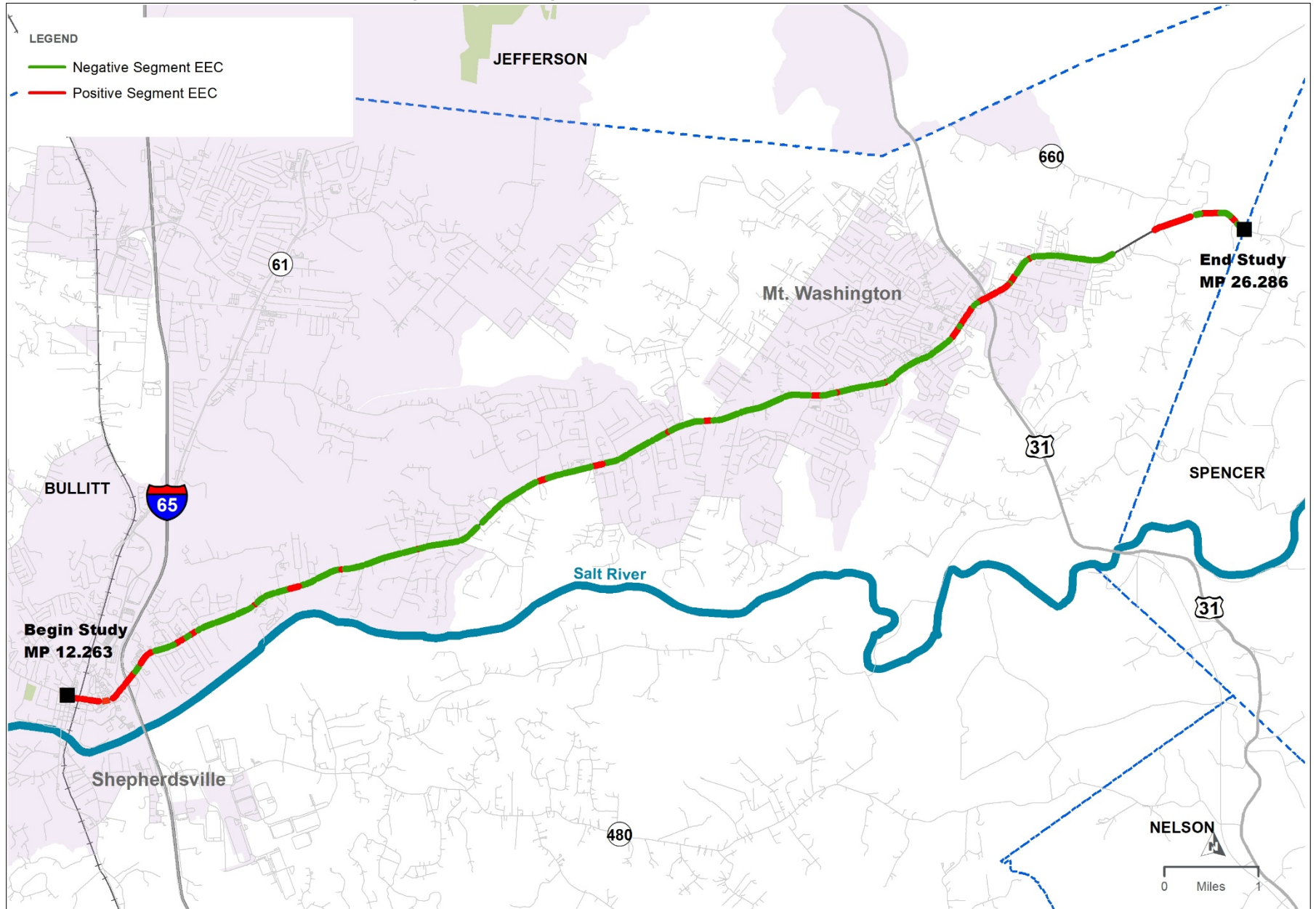
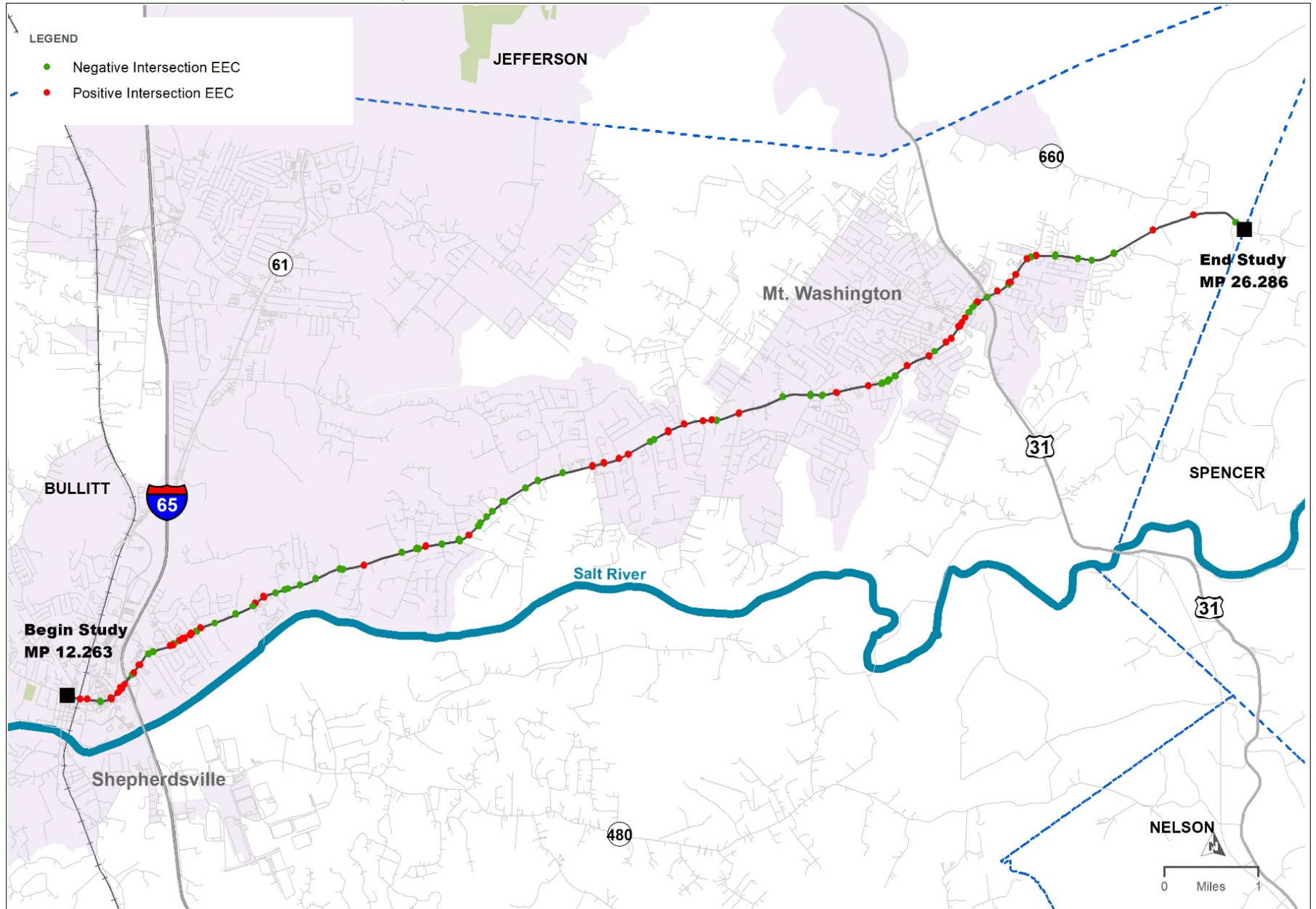


Figure 9: KY 44 Intersection Excess Expected Crashes (2017-2021)



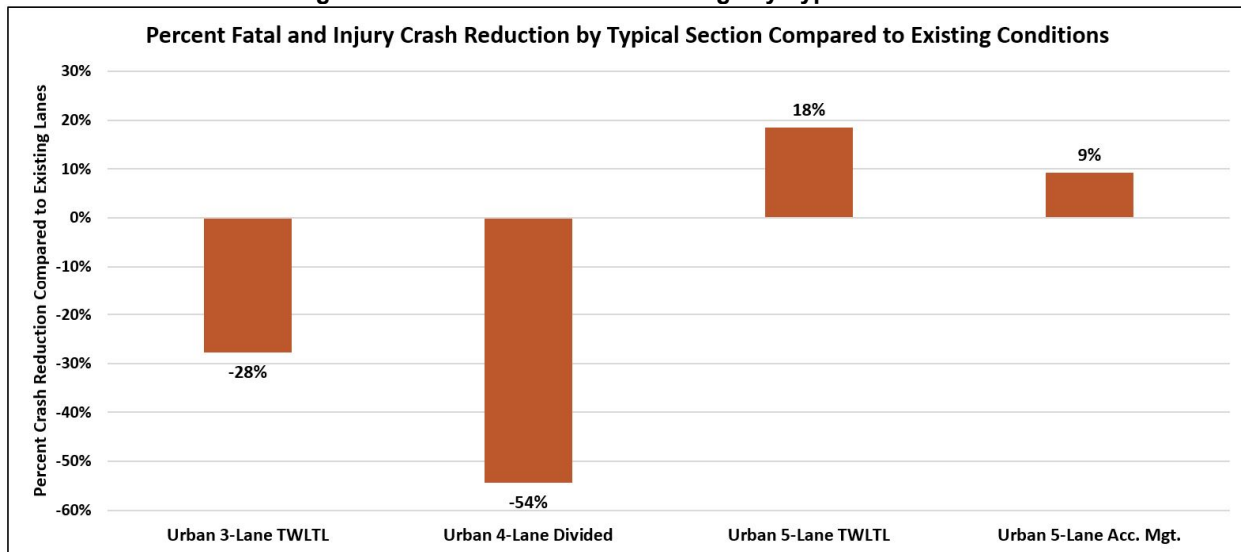
Predictive Safety Analysis

A simplified predictive safety analysis that compares the safety performance of the proposed typical sections to the existing conditions was performed. Highway Safety Software (HSS), which is part of the HCS 2022 program, was used to evaluate the safety performance of each typical section. **Attachment A** provides the HSS output files. A representative location under existing conditions (two-lane) was analyzed to serve as a baseline for comparison to the other proposed typical sections. Representative locations of the following typical sections were selected for analysis.

- urban three-lane with two-way left turn lane (TWLTL)
- urban four-lane with a raised median
- urban five-lane with TWLTL
- urban five-lane with TWLTL including access management (this reduced the number of access points)

Predicted crashes were calculated for each of these typical section types. The percentage of fatal and injury crashes reduced by typical section as compared to existing conditions was calculated and is shown in Figure X.

Figure 10: Crash Reduction Percentage by Typical Section



Compared to the existing lane configurations on KY 44, the urban four-lane divided with a raised median provided the greatest safety benefit, resulting in a 54% reduction in crashes compared to the existing rural two-lane typical section. This is due to the reduction in conflict points by adding the raised median and less opportunities for crashes to occur. The urban three-lane with a TWLTL also provided a safety benefit, reducing crashes by 28%. This is due to the TWLTL providing a deceleration area for left turning vehicles to perform this movement outside the through lanes and is in line with *Highway Safety Manual* predictions. The urban five-lane typical section is expected to increase crashes by 18%, due to an increased number of conflict points with additional lanes and longer gaps in time needed for vehicles to safely make a turning

movement. Given this increase in crash performance with the five-lane with TWLTL typical section another five-lane with TWLTL typical section was modeled with reduced number of access points (50% less access points) that resulted in a 9% increase in crashes compared to existing conditions.

Summary of Safety Issues & Use of Safety Data

Overall, KY 44 in the study area is less safe than similar type facilities in Kentucky. This is most clearly demonstrated by the number of intersections with a total positive EEC value and that seven of the 24 study intersections have a crash rate over the study average of 1.41. Overall, segments exhibit positive EEC values in the fatal and injury category. Along KY 44, the majority of crashes occur at intersections. The review of crash history has resulted in three areas of concern being identified that have a higher concentration of crashes and a higher proportion of fatal and injury crashes. The first of these locations is in Shepherdsville between KY 61 and Bullitt Central High School. The second location being in Mt. Washington between Woodlake Drive and Cornell Avenue, and the third location being in the middle of the study area between Douglas Lane and KY 2706 (Greenbriar Road). This middle section has the highest number of fatal and injury crashes indicating that speed may be a contributing factor to the severity.



Attachment A – Predictive Safety Output

KY 44 Programming Study

Bullitt County, KY

December 8, 2022

Highway Safety Software Rural Two Lane Segment Report

Project Information

Analyst	HDR	Date	10/26/2022
Jurisdiction	KY 44	Analysis Year	2022
Project Description			

Input Data

Length of Segment (mi)	2.930	AADT (veh/day)	18000
Lane Width (ft)	10.0	Grade (%)	0.0
Shoulder Type	Paved	Shoulder Width (ft)	4.0
Driveway Density (driveway/mi)	26	Roadside Hazard Rating	3
Centerline Rumble Strips	No	Passing Lanes	No Passing or Climbing Lanes
Two-Way Left Turn Lane	No	Segment Lighting	No
Automated Speed Enforcement	No	Calibration Factor	1.00

Crash Modification Factors

Lane Width - CMF1	1.172	Centerline Rumble Strips - CMF7	1.000
Shoulder Type/Width - CMF2	1.080	Passing Lanes - CMF8	1.000
Horizontal Curve - CMF3	1.000	Two-Way Left Turn Lane - CMF9	1.000
Superelevation - CMF4	1.000	Roadside Design - CMF10	1.000
Grade - CMF5	1.000	Lighting - CMF11	1.000
Driveway Density - CMF6	1.065	Auto Speed Enforcement - CMF12	1.000
Combined CMF	1.348		

Predicted Roadway Section Crashes

Crash Severity	Overdispersion Parameter	N _{spf,rs} by Severity	Predicted Crash Frequency	Crash Rate (crashes/mi/year)
Fatal and Injury (FI)	-	4.523	6.098	2.081
Property Damage Only (PDO)	-	9.568	12.899	4.403
Total	0.081	14.091	18.998	6.484

Economic Analysis (Predicted Crashes)

Crash Severity	Per Crash Societal Crash Cost	Predicted Annual Crashes	Total Societal Crash Cost
Fatal and Injury (FI)	\$158,200.00	6.098	\$964,740.62
Property Damage Only (PDO)	\$7,400.00	12.899	\$95,455.41
Total	-	18.998	\$1,060,196.03

Highway Safety Software Urban Segment Report

Project Information

Analyst	HDR	Date	10/26/2022
Jurisdiction	KY 44	Analysis Year	2022
Project Description			

Input Data

Segment Type	Three-Lane Segment Including a center TWLTL (3T)		
Length of Segment (mi)	2.930	AADT (veh/day)	18000
Median Width (ft)	15	Lighting	Yes
Type of On-street Parking	None	On-Street Parking Curb Length (mi)	0.00
Automated Speed Enforcement	No	Posted Speed (mi/h)	45
Roadside Fixed Object Density	-	Offset to Roadside Fixed Obj. (ft)	-
# Major Commercial Driveways	4	# Minor Commercial Driveways	2
# Major Industrial/Insti. Driveways	4	# Minor Industrial/Insti. Driveways	2
# Major Residential Driveways	15	# Minor Residential Driveways	10
# Other Driveways	10	Calibration Factor	1.00

Crash Modification Factors

On-Street Parking - CMF1	1.000	Lighting - CMF4	0.934
Roadside Fixed Objects - CMF2	1.000	Automated Speed Enforcement - CMF5	1.000
Median Width - CMF3	1.000	Combined CMF	0.934

Predicted Roadway Section Crashes

Crash Severity	Predicted Crash Frequency	Crash Rate (crashes/mi/year)
Fatal and Injury (FI)	4.424	1.510
Property Damage Only (PDO)	11.135	3.800
Total	15.559	5.310

Economic Analysis (Predicted Crashes)

Crash Severity	Per Crash Societal Crash Cost	Predicted Annual Crashes	Total Societal Crash Cost
Fatal and Injury (FI)	\$158,200.00	4.424	\$699,803.74
Property Damage Only (PDO)	\$7,400.00	11.135	\$82,401.46
Total	-	15.559	\$782,205.20

Highway Safety Software Urban Segment Report

Project Information

Analyst	HDR	Date	10/26/2022
Jurisdiction	KY 44	Analysis Year	2022
Project Description			

Input Data

Segment Type	Four-Lane Divided Segment (4D)		
Length of Segment (mi)	2.930	AADT (veh/day)	18000
Median Width (ft)	15	Lighting	Yes
Type of On-street Parking	None	On-Street Parking Curb Length (mi)	0.00
Automated Speed Enforcement	No	Posted Speed (mi/h)	45
Roadside Fixed Object Density	-	Offset to Roadside Fixed Obj. (ft)	-
# Major Commercial Driveways	4	# Minor Commercial Driveways	2
# Major Industrial/Insti. Driveways	4	# Minor Industrial/Insti. Driveways	2
# Major Residential Driveways	15	# Minor Residential Driveways	10
# Other Driveways	10	Calibration Factor	1.00

Crash Modification Factors

On-Street Parking - CMF1	1.000	Lighting - CMF4	0.914
Roadside Fixed Objects - CMF2	1.000	Automated Speed Enforcement - CMF5	1.000
Median Width - CMF3	1.000	Combined CMF	0.914

Predicted Roadway Section Crashes

Crash Severity	Predicted Crash Frequency	Crash Rate (crashes/mi/year)
Fatal and Injury (FI)	2.755	0.940
Property Damage Only (PDO)	7.101	2.424
Total	9.856	3.364

Economic Analysis (Predicted Crashes)

Crash Severity	Per Crash Societal Crash Cost	Predicted Annual Crashes	Total Societal Crash Cost
Fatal and Injury (FI)	\$158,200.00	2.755	\$435,858.87
Property Damage Only (PDO)	\$7,400.00	7.101	\$52,549.43
Total	-	9.856	\$488,408.30

Highway Safety Software Urban Segment Report

Project Information

Analyst	HDR	Date	10/26/2022
Jurisdiction	KY 44	Analysis Year	2022
Project Description			

Input Data

Segment Type	Five-Lane Segment Including a center TWLTL (5T)		
Length of Segment (mi)	2.930	AADT (veh/day)	18000
Median Width (ft)	15	Lighting	Yes
Type of On-street Parking	None	On-Street Parking Curb Length (mi)	0.00
Automated Speed Enforcement	No	Posted Speed (mi/h)	45
Roadside Fixed Object Density	-	Offset to Roadside Fixed Obj. (ft)	-
# Major Commercial Driveways	4	# Minor Commercial Driveways	2
# Major Industrial/Insti. Driveways	4	# Minor Industrial/Insti. Driveways	2
# Major Residential Driveways	15	# Minor Residential Driveways	10
# Other Driveways	10	Calibration Factor	1.00

Crash Modification Factors

On-Street Parking - CMF1	1.000	Lighting - CMF4	0.940
Roadside Fixed Objects - CMF2	1.000	Automated Speed Enforcement - CMF5	1.000
Median Width - CMF3	1.000	Combined CMF	0.940

Predicted Roadway Section Crashes

Crash Severity	Predicted Crash Frequency	Crash Rate (crashes/mi/year)
Fatal and Injury (FI)	7.295	2.490
Property Damage Only (PDO)	17.857	6.094
Total	25.151	8.584

Economic Analysis (Predicted Crashes)

Crash Severity	Per Crash Societal Crash Cost	Predicted Annual Crashes	Total Societal Crash Cost
Fatal and Injury (FI)	\$158,200.00	7.295	\$1,154,009.16
Property Damage Only (PDO)	\$7,400.00	17.857	\$132,138.43
Total	-	25.151	\$1,286,147.59

Highway Safety Software Urban Segment Report

Project Information

Analyst	HDR	Date	10/26/2022
Jurisdiction	KY 44	Analysis Year	2022
Project Description			

Input Data

Segment Type	Five-Lane Segment Including a center TWLTL (5T)		
Length of Segment (mi)	2.930	AADT (veh/day)	18000
Median Width (ft)	15	Lighting	Yes
Type of On-street Parking	None	On-Street Parking Curb Length (mi)	0.00
Automated Speed Enforcement	No	Posted Speed (mi/h)	45
Roadside Fixed Object Density	-	Offset to Roadside Fixed Obj. (ft)	-
# Major Commercial Driveways	1	# Minor Commercial Driveways	1
# Major Industrial/Insti. Driveways	1	# Minor Industrial/Insti. Driveways	1
# Major Residential Driveways	8	# Minor Residential Driveways	5
# Other Driveways	5	Calibration Factor	1.00

Crash Modification Factors

On-Street Parking - CMF1	1.000	Lighting - CMF4	0.940
Roadside Fixed Objects - CMF2	1.000	Automated Speed Enforcement - CMF5	1.000
Median Width - CMF3	1.000	Combined CMF	0.940

Predicted Roadway Section Crashes

Crash Severity	Predicted Crash Frequency	Crash Rate (crashes/mi/year)
Fatal and Injury (FI)	6.608	2.255
Property Damage Only (PDO)	16.206	5.531
Total	22.814	7.786

Economic Analysis (Predicted Crashes)

Crash Severity	Per Crash Societal Crash Cost	Predicted Annual Crashes	Total Societal Crash Cost
Fatal and Injury (FI)	\$158,200.00	6.608	\$1,045,423.95
Property Damage Only (PDO)	\$7,400.00	16.206	\$119,924.94
Total	-	22.814	\$1,165,348.89