pennsylvania
DEPARTMENT OF TRANSPORTATION

Confidential Safety Study
Route 228 Mars RR Bridge West Expansion

ECMS Project #E03625

02.13.2018

PennDOT Engineering District 10, Butler County

Cranberry Township, Adams Township, and Seven Fields Borough

WRA

OS-2 (10-08)

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DEPARTMENT OF TRANSPORTATION
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DATE: February 13, 2018

SUBJECT: Butler County
Cranberry Township, Seven Field Borough, Adams Township
Route 228 Mars RR Bridge West Expansion
Traffic Design Report
ECMS Project #E03625

TO: Mark Rozich, PE
District Project Manager
Engineering District 10-0

FROM: Adam Marshall, PE
Assistant Traffic Engineer
Engineering District 10-0

The ITS / Congestion Management Section has completed its review of Whitman, Requardt & Associates, LLP's Traffic Design Report for the Route 228 Mars RR Bridge West Expansion project in Cranberry Township, Seven Fields Borough and Adams Township, Butler County and agree with its findings.

If you have any questions, please call me at 724.357.2844.

Notice

"In accordance with PA Consolidated Statutes Title 75-Vehicles (Vehicle Code) Section 3754 and 23 U.S.C. Section 409, this safety study is confidential and the publication, reproduction, release, or discussion of these materials is prohibited without the specific written consent of the Pennsylvania Department of Transportation's Office of Chief Counsel. This safety study is only provided to official agencies with official duties/responsibilities in the project development."

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Introduction

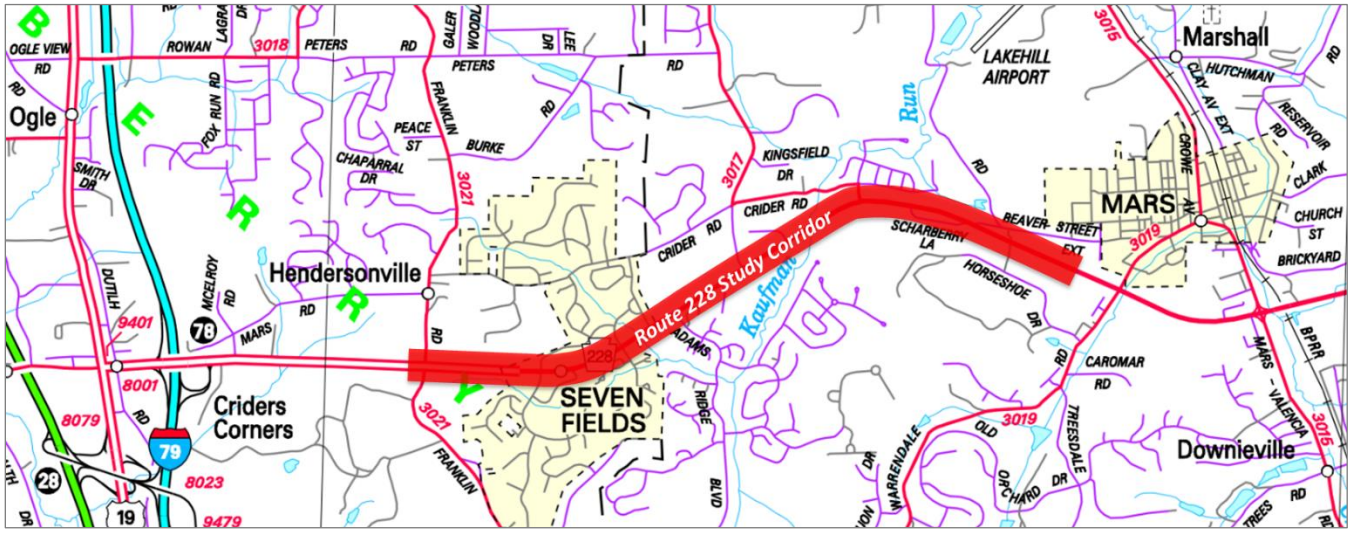
Project Summary

The Route 228 Mars Railroad (RR) Bridge West Expansion project is a design effort for Pennsylvania Department of Transportation (PennDOT) District 10-0 to implement widening, capacity, and safety improvements along the SR 228 corridor from Franklin Road in Cranberry Township, to just east of Beaver Street Extension in Adams Township, Butler County, Pennsylvania. As part of this effort and as a companion document to the project's overall Traffic Design Report, this Confidential Safety Study analyzes existing and projected safety conditions along the corridor based on a summary and evaluation of corridor-specific crash history and a safety assessment of the proposed project improvements.

Location and Study Limits

The project corridor is located in Butler County, Pennsylvania, and crosses three municipalities: Cranberry Township to the west, Seven Fields Borough in the center, and Adams Township to the east (**Exhibit 1**). Mars Borough is also less than one mile northeast of the corridor's eastern limit with direct access via Beaver Street Extension. SR 228 within the study limits is predominately oriented in the east-west direction; all roadways approaching SR 228 generally have north-south orientations.

Exhibit 1: Project Study Area



Corridor Description

SR 228 is generally a two-lane roadway with the exception of the four-lane section to the east and west of Franklin Road. On-street parking is prohibited along SR 228 and its cross streets throughout the study area. Utility poles are located along both sides of the corridor, and lighting is provided only at the following intersections:

- SR 228 at Franklin Road,
- SR 228 at Adams Ridge Boulevard, and
- SR 228 at Heritage Creek Drive.

Exhibit 2 shows key design information for the study area roadway segments. The overall study corridor is approximately three miles long and includes nine key study intersections. There are also several midblock, unsignalized commercial and/or residential driveways along the corridor.

Exhibit 2: Area Roadway Information

Roadway		Functional Classification	Traffic Pattern Group (TPG)	Area Type	Lanes Per Direction	Posted Speed Limit
SR 228	Cranberry Township	Other Principal Arterial	3	Urban	2	40 mph
	Seven Fields Borough	Other Principal Arterial	3	Urban	1	40 mph
	Adams Township	Other Principal Arterial	3	Urban	1	50 mph

Crash Analysis Segments and Intersections

Eight analysis segments along the SR 228 corridor were defined for use in the crash analysis. The segments were defined based on PennDOT segment and offset breakpoints as well as engineering judgment. Consideration was also given to roadway characteristics in order to facilitate application of Highway Safety Manual (HSM) methodologies. The PennDOT segment and offset breakpoints were consistent with the segmentation needed for the implementation of the HSM, except for Segment 0060 between the Castle Creek Drive (East) and Seven Fields Boulevard intersections. In general, the corridor is an undivided urban arterial with one lane in each direction and minimal access control. Segment A (passing across Franklin Road) has two lanes in each direction that merge to one lane when connecting to Segment B (east of Franklin Road). Numerous driveways and local routes intersect the corridor.

In addition to segments analysis, nine critical intersections were also defined for use in the crash analysis. **Exhibit 3** lists the segments including length, **Exhibit 4** lists the intersections, and **Exhibit 5** shows the location of each segment and intersection.

Exhibit 3: Crash Analysis Segments

Study Segment	Route	Termini (Intersection or Segment/Offset)		SR 228 Segments Covered	Length (miles)
A	SR 228	SEG 0030/0000	SEG 0040/0000	SEG 0030 & 0031	0.52
B	SR 228	SEG 0040/0000	SEG 0050/0000	SEG 0040	0.42
C	SR 228	SEG 0050/0000	Castle Creek Dr (East)	SEG 0050 (Partial)	0.24
D	SR 228	Castle Creek Dr (East)	Adams Ridge Blvd	SEG 0050 (Partial) SEG 0060 (Partial)	0.28
E	SR 228	Adams Ridge Blvd	SEG 0070/0000	SEG 0060 (Partial)	0.34
F	SR 228	SEG 0070/0000	SEG 0080/0000	SEG 0070	0.34
G	SR 228	SEG 0080/0000	SEG 0090/0000	SEG 0080	0.38
H	SR 228	SEG 0090/0000	SEG 0100/0000	SEG 0090	0.54

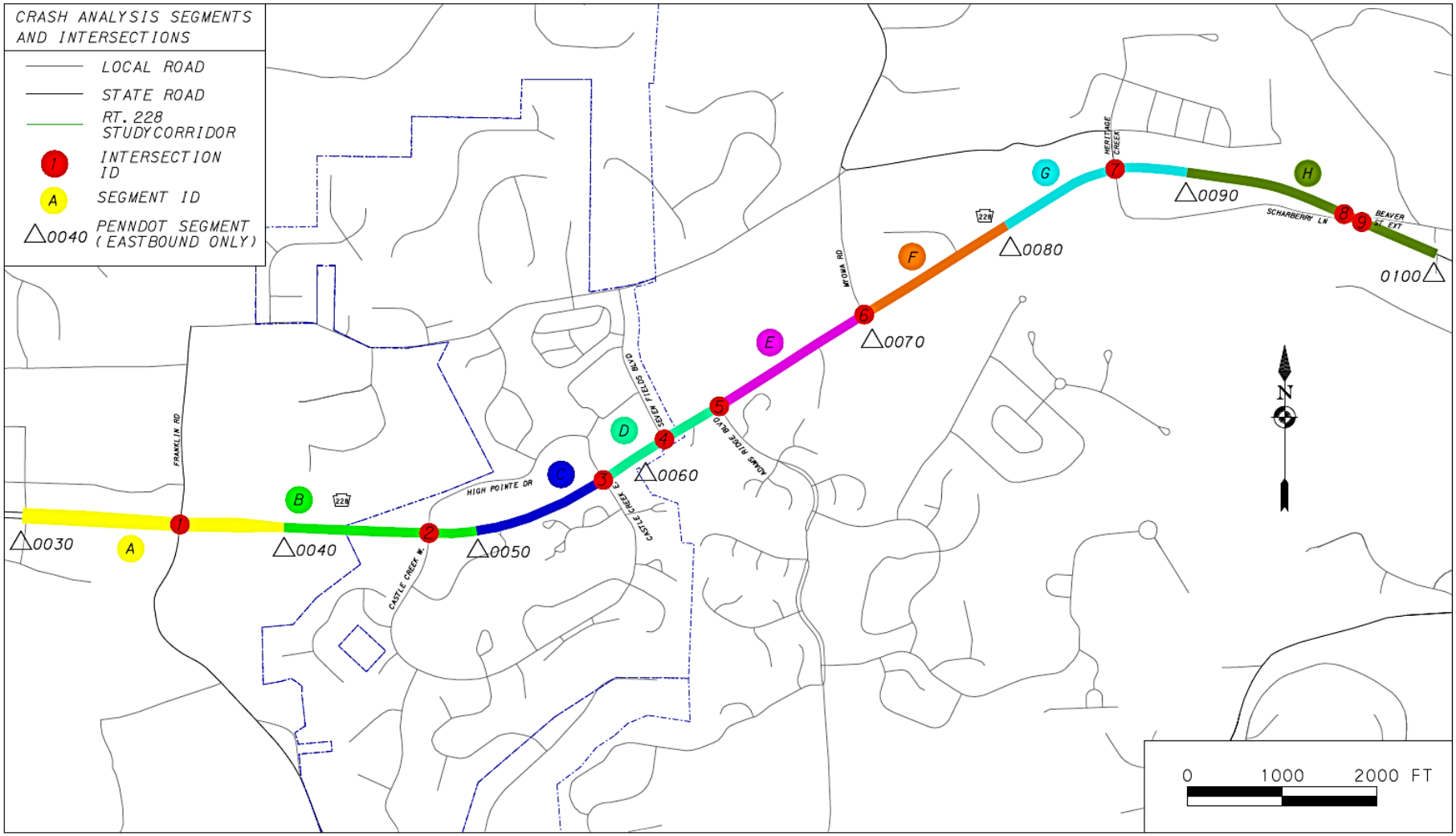
(Refer to Exhibit 5 for segment locations)

Exhibit 4: Crash Analysis Intersections

Intersection	Description		Route Segment / Offset	Municipality	Control Type
1	SR 228	Franklin Rd (SR 3021)	SR 228 SEG 0030 / 1665	Cranberry Twp	Signalized
2	SR 228	Castle Creek Dr (West)	SR 228 SEG 0040 / 1421	Seven Fields Boro	Signalized
3	SR 228	Castle Creek Dr (East)	SR 228 SEG 0050 / 1417	Seven Fields Boro	Signalized
4	SR 228	Seven Fields Blvd	SR 228 SEG 0060 / 0186	Seven Fields Boro / Adams Twp	Signalized
5	SR 228	Adams Ridge Blvd	SR 228 SEG 0060 / 0860	Adams Twp	Signalized
6	SR 228	Myoma Rd	SR 228 SEG 0070 / 0000	Adams Twp	Unsignalized
7	SR 228	Heritage Creek Dr (SR 3017)	SR 228 SEG 0080 / 1275	Adams Twp	Signalized
8	SR 228	Scharberry Ln	SR 228 SEG 0090 / 1896	Adams Twp	Unsignalized
9	SR 228	Beaver St Ext	SR 228 SEG 0090 / 2062	Adams Twp	Unsignalized

(Refer to Exhibit 5 for intersection locations)

Exhibit 5: Crash Analysis Segment/Intersection Map



Crash Data Assessments

The crash analysis was performed using multiple methods to thoroughly summarize the findings. These methods include investigating the crashes by crash characteristics, crash clusters, and applying the HSM methodology. Existing roadway and intersection characteristics were also documented and will be utilized for the safety assessment of the proposed improvements at both the segment and intersection level.

Reported crash data was obtained from PennDOT's *Crash Data Access and Retrieval Tool* (CDART) for a five-year period from January 1, 2011 through December 31, 2015 for the SR 228 corridor from Franklin Road to Beaver Street Extension (segment 0030/0000 to 0100/0000). Based on the CDART data, a total of 203 reportable crashes were documented during the study period. According to PennDOT's *Pennsylvania Crash Facts and Statistics* report, a reportable crash is a crash where an injury or fatality occurs or at least one of the vehicles involved requires towing from the scene. Non-reportable crashes are not included in the CDART database; therefore, it is possible that more crashes occurred along the corridor during the study period than are included in this assessment.

Crash characteristics were examined to explore insights into potential causes or contributing factors related to the historical crash patterns. As a method of comparison, data from the *2015 Pennsylvania Crash Facts and Statistics* report was used to compare summary crash characteristics.

Time of Crash by Year, Month, and Hour

Exhibits 6 through 8 summarize the number of crashes (crash frequency) by year, month, and time of day, respectively. The number of crashes steadily increased since 2013, climbing from 32 to 48 total crashes in 2015. However, the highest number of crashes within a single year of the five-year study period was 55 crashes occurring in 2012. Among the 203 total crashes, 103 (51%) crashes occurred between 12 PM and 6 PM; and **Exhibit 8** confirms that the highest frequencies by time of day coincide with the PM peak period.

Exhibit 6: SR 228 Crash Frequency by Year

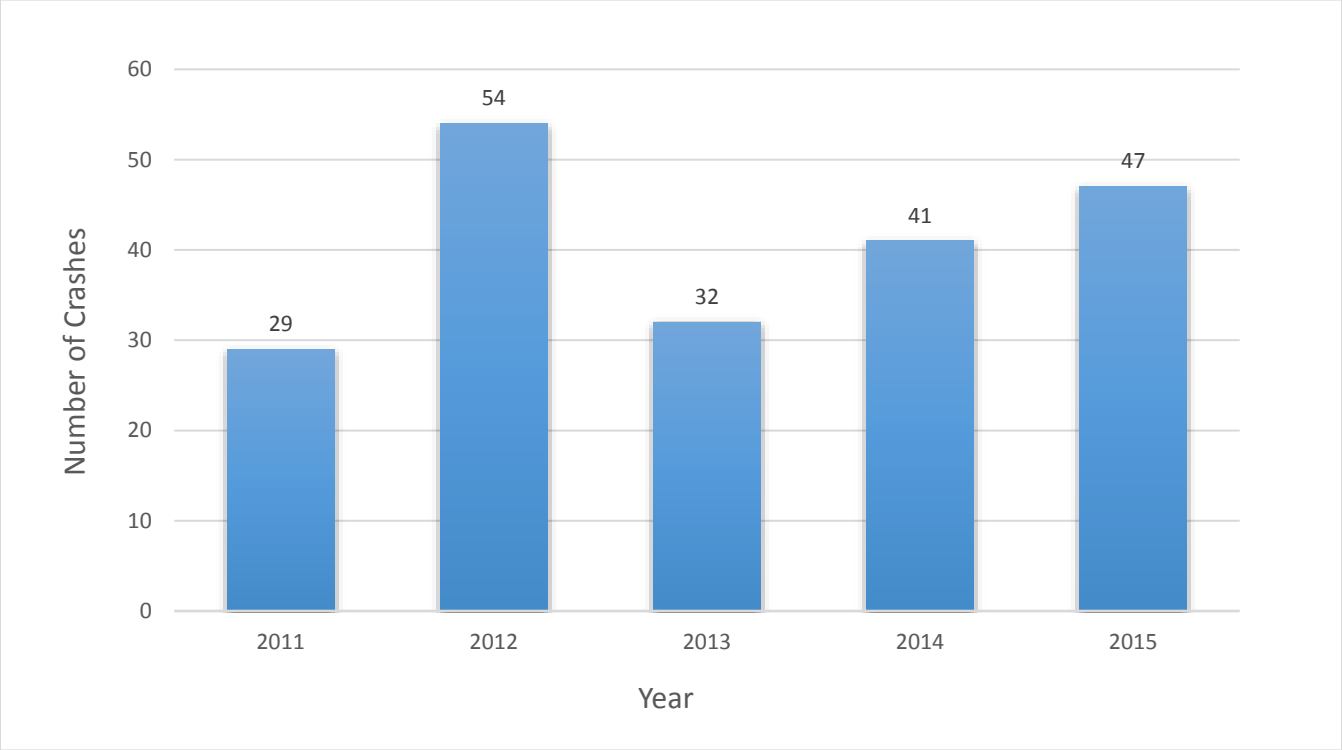


Exhibit 7: SR 228 Crash Frequency by Month

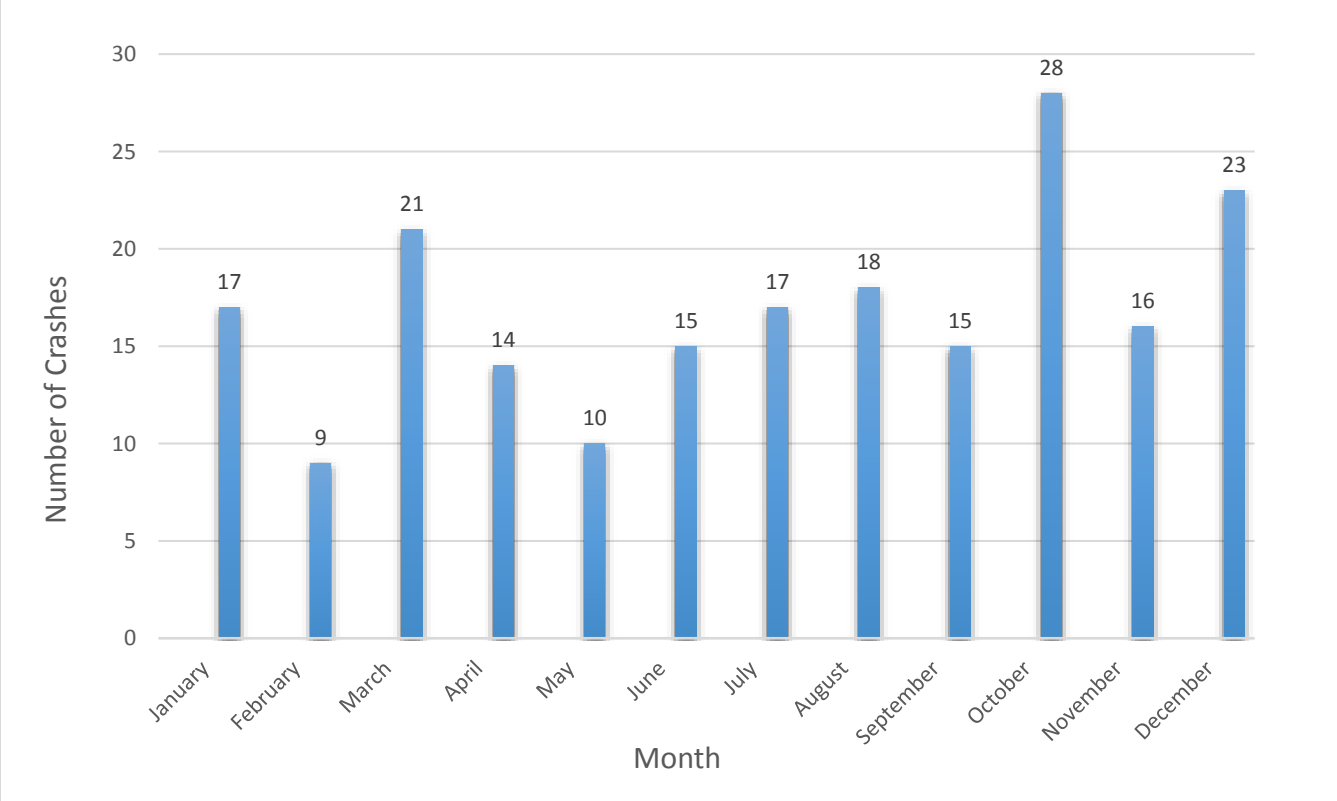
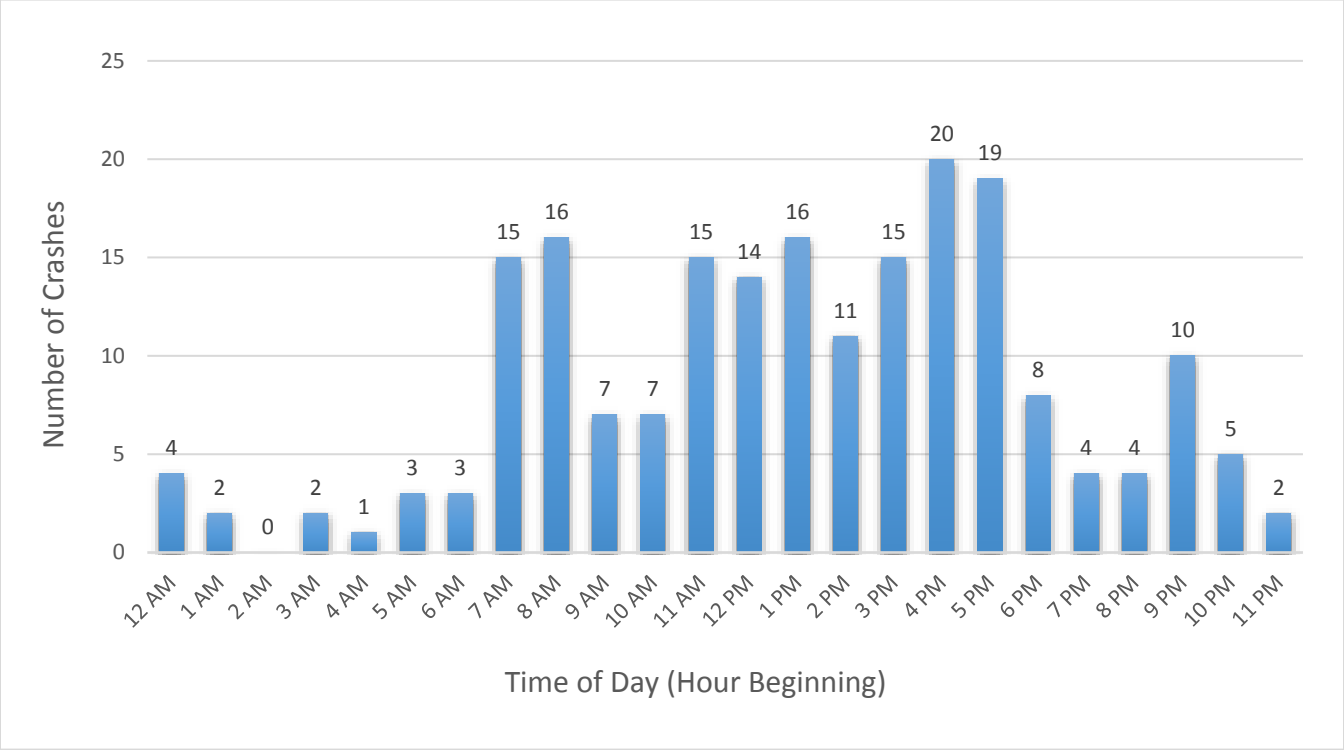


Exhibit 8: SR 228 Crash Frequency by Time of Day



Crash Types and Severities

Exhibits 9 and 10 summarize the number of crashes by crash type and severity. As shown, most crashes were classified as Rear-End (70%) type and Property Damage Only (54%) severity. Several Possible Injury and Unknown Severity were also identified during the five-year study period (23% and 17%, respectively). No fatalities were reported along SR 228 within the study area during the analysis period.

Exhibit 9: SR 228 Corridor Crashes by Type

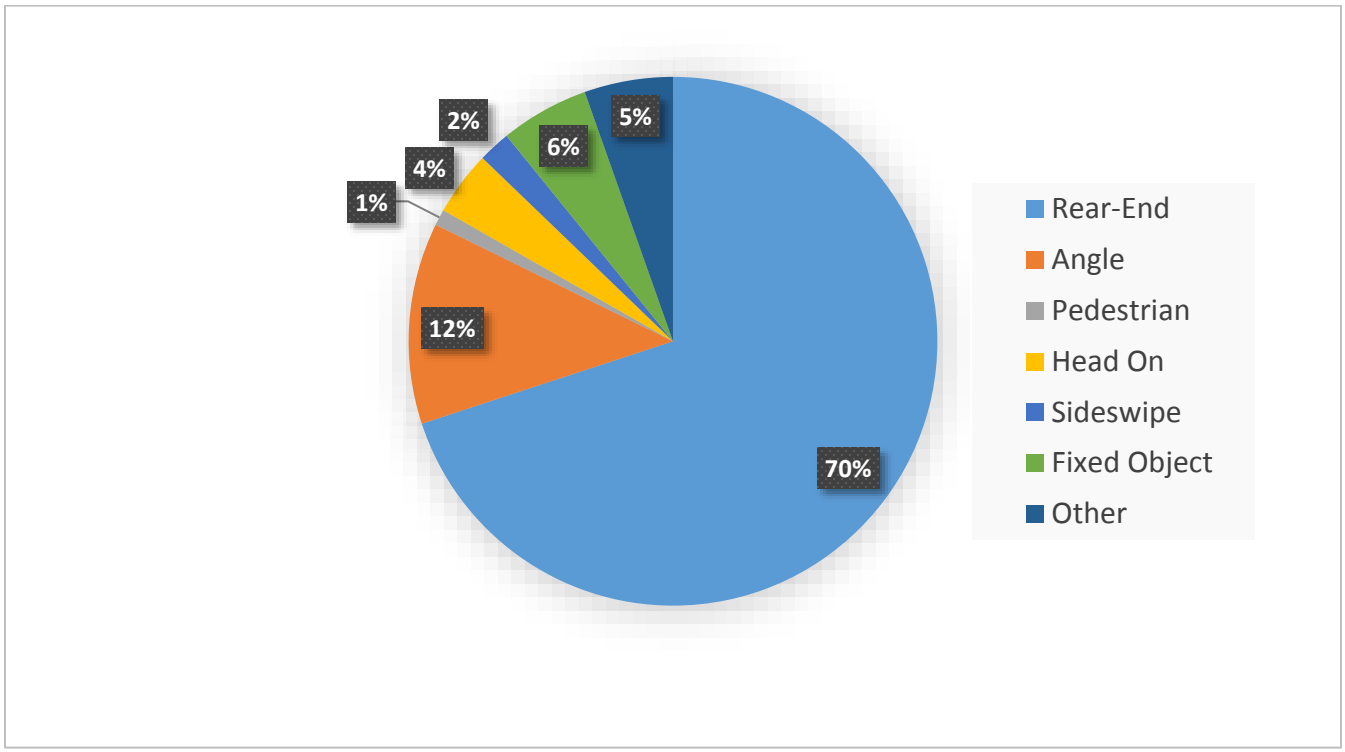


Exhibit 10: SR 228 Corridor Crashes by Severity

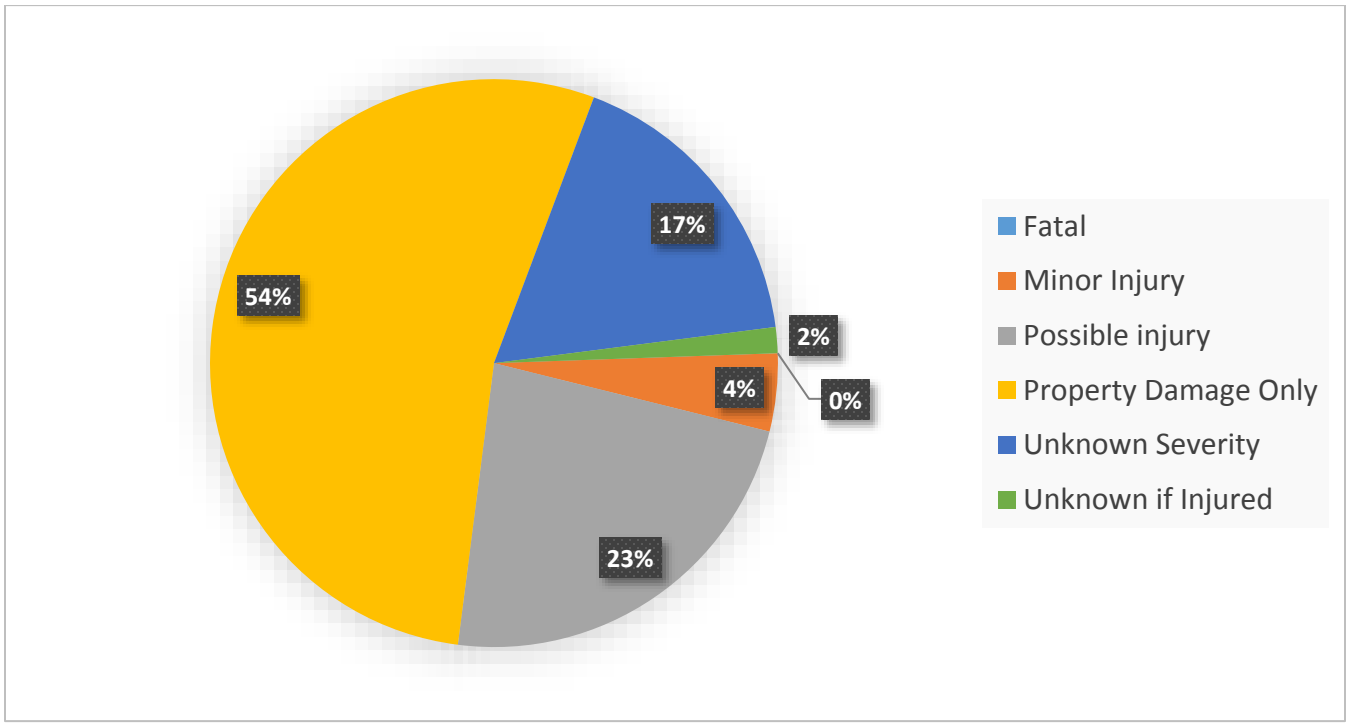
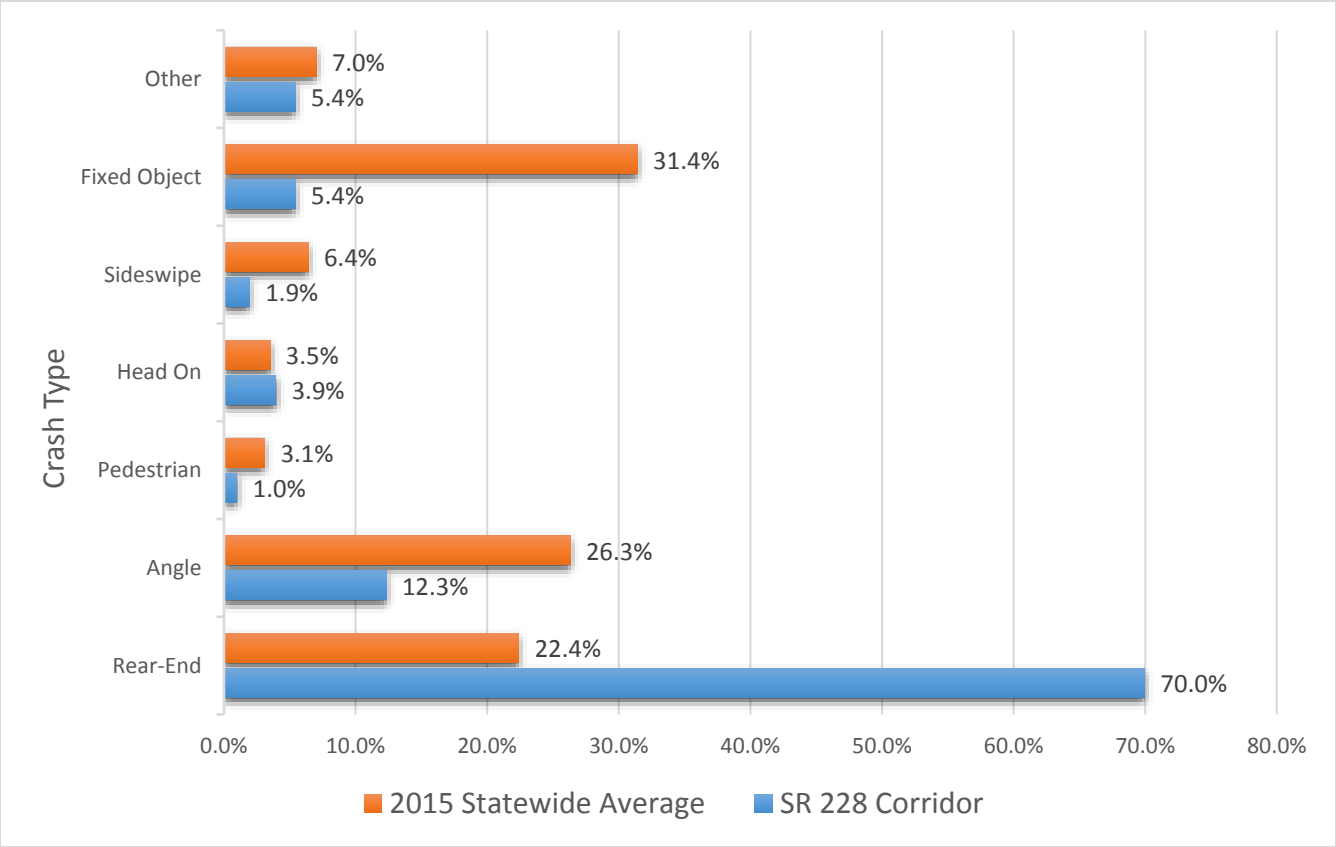


Exhibit 11 compares the reported crash types for the overall SR 228 corridor with the 2015 statewide averages. The most frequent crash type along SR 228 was Rear-End, followed by Angle. According to the statewide averages, the most common crash type was Hit Fixed Object. The SR 228 corridor had approximately one-sixth of the Hit Fixed Object crash type compared to the statewide average. However, the SR 228 corridor had approximately triple the Rear-End type crashes. The higher percentage of Rear-End crashes may be due to the high traffic volumes and congested traffic conditions, whereas the statewide average includes rural data that tends to have less traffic volume and congestion.

Exhibit 11: SR 228 Corridor Crashes by Crash Type Comparison



Road Surface and Weather Conditions

Exhibit 12 shows that most crashes (73%) within the SR 228 corridor study limits occurred under dry pavement conditions. This crash characteristic is consistent when compared to the statewide average (**Exhibit 13**). Snow, ice, and slush combined only had adverse effects on 3% of the crashes, which correlates to the comparison of crashes by weather condition (**Exhibit 14**). SR 228 is consistent with statewide averages in that most crashes occurred at times with no adverse weather conditions.

Exhibit 12: SR 228 Corridor Crashes by Road Surface Condition

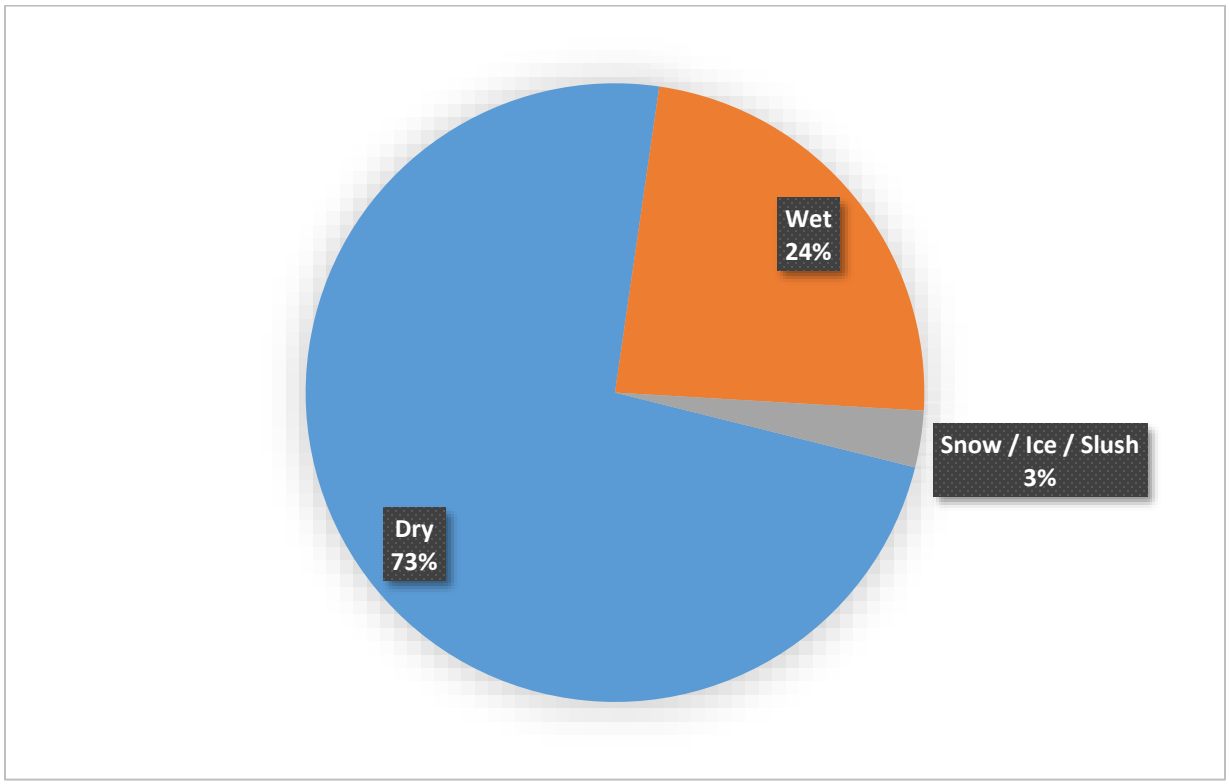


Exhibit 13: SR 228 Corridor Crashes by Road Surface Condition Comparison

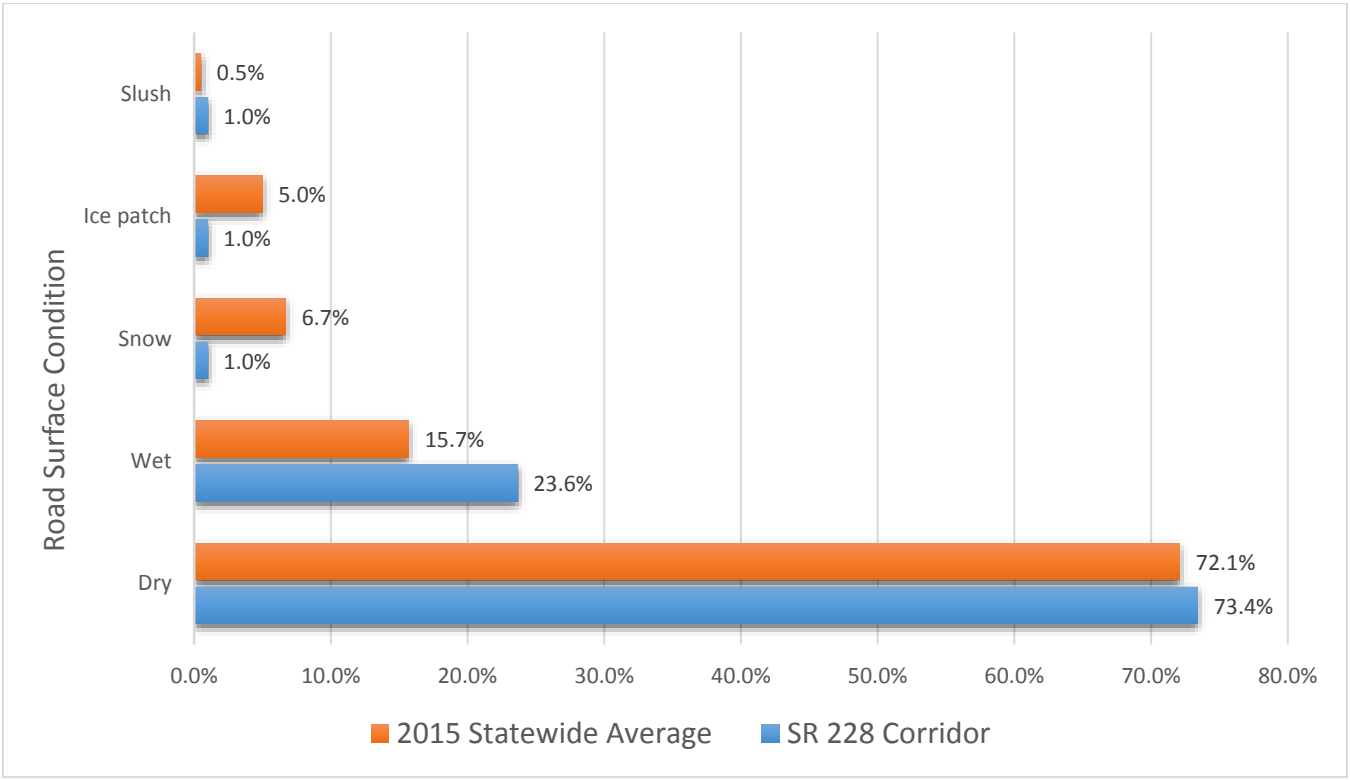
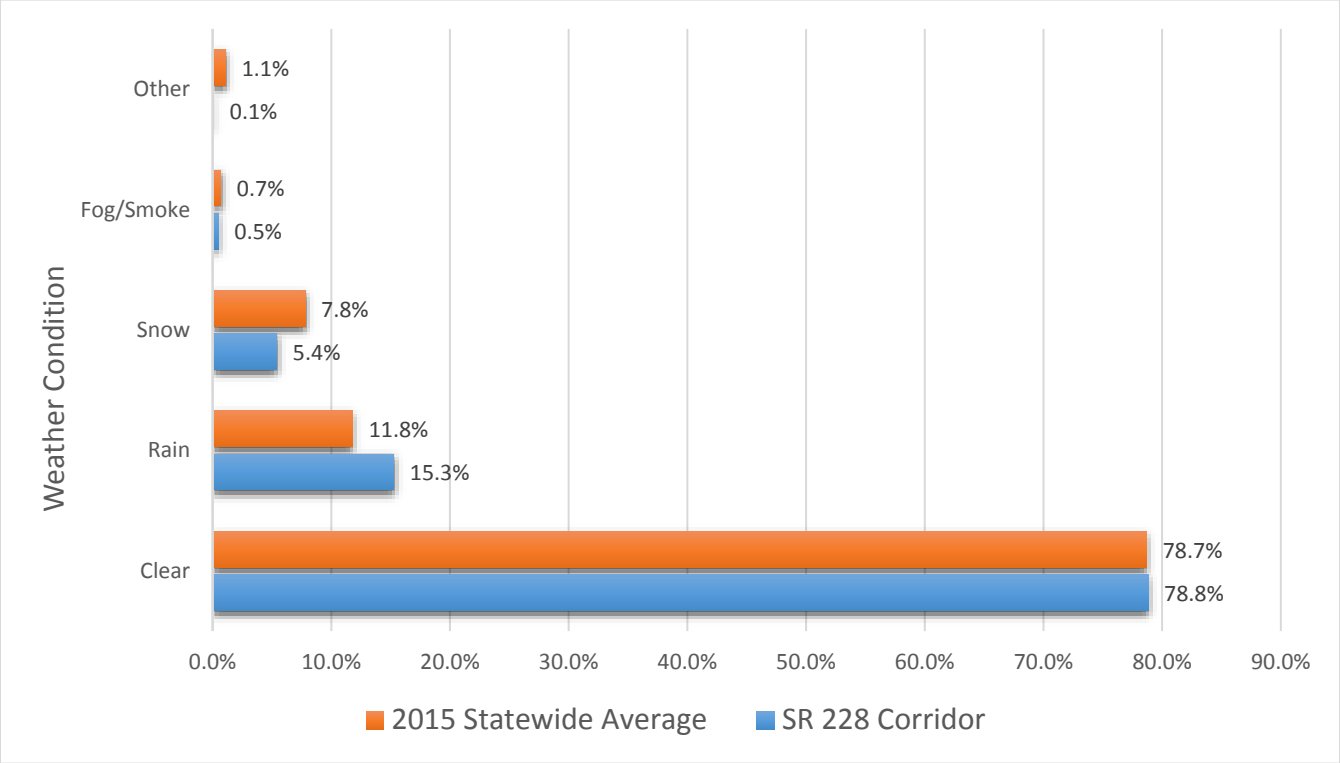


Exhibit 14: SR 228 Corridor Crashes by Weather Condition Comparison



Light Level Conditions

Another notable crash characteristic is the light level condition in which crashes occur. **Exhibit 15** shows that most crashes (76%) happened during daylight conditions, which correlates to the comparison of crashes with the statewide averages (**Exhibit 16**). SR 228 is consistent with statewide averages in that most crashes occurred during daylight conditions.

Exhibit 15: SR 228 Corridor Crashes by Light Level Condition

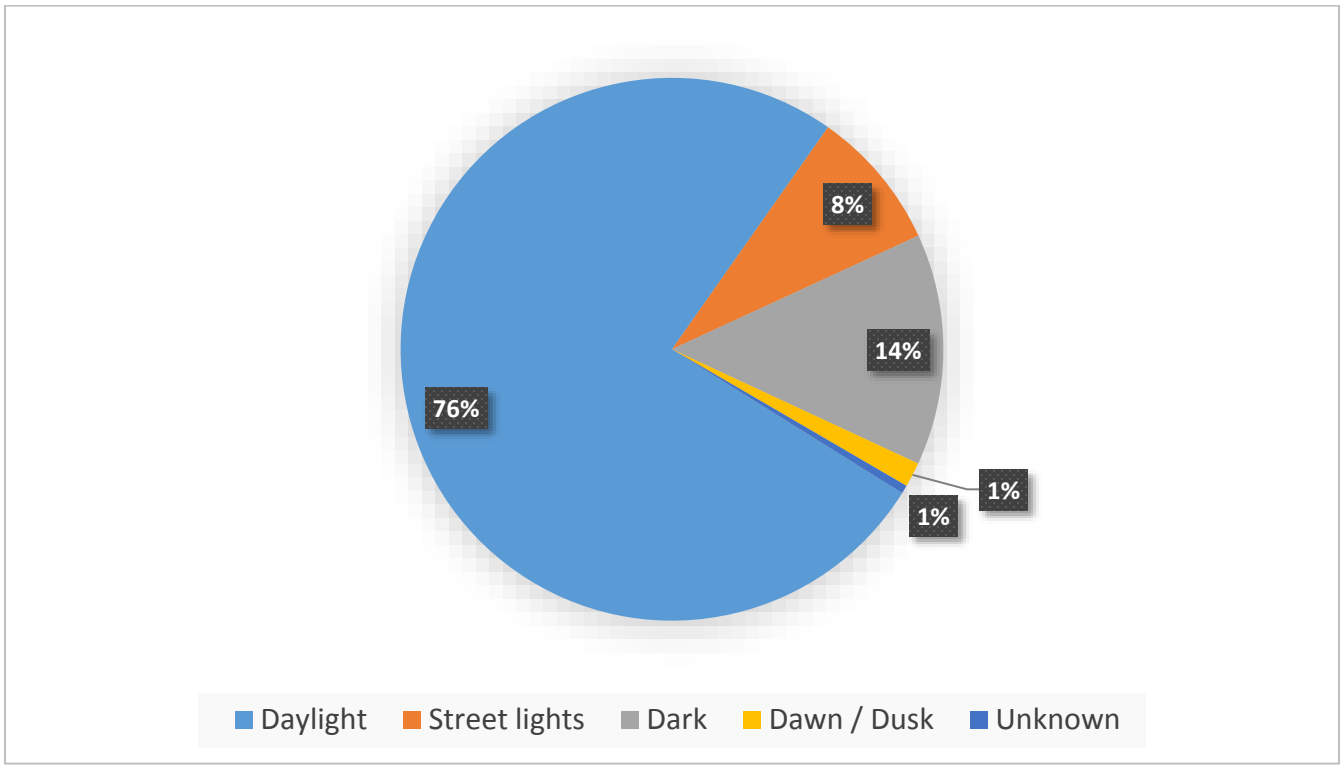
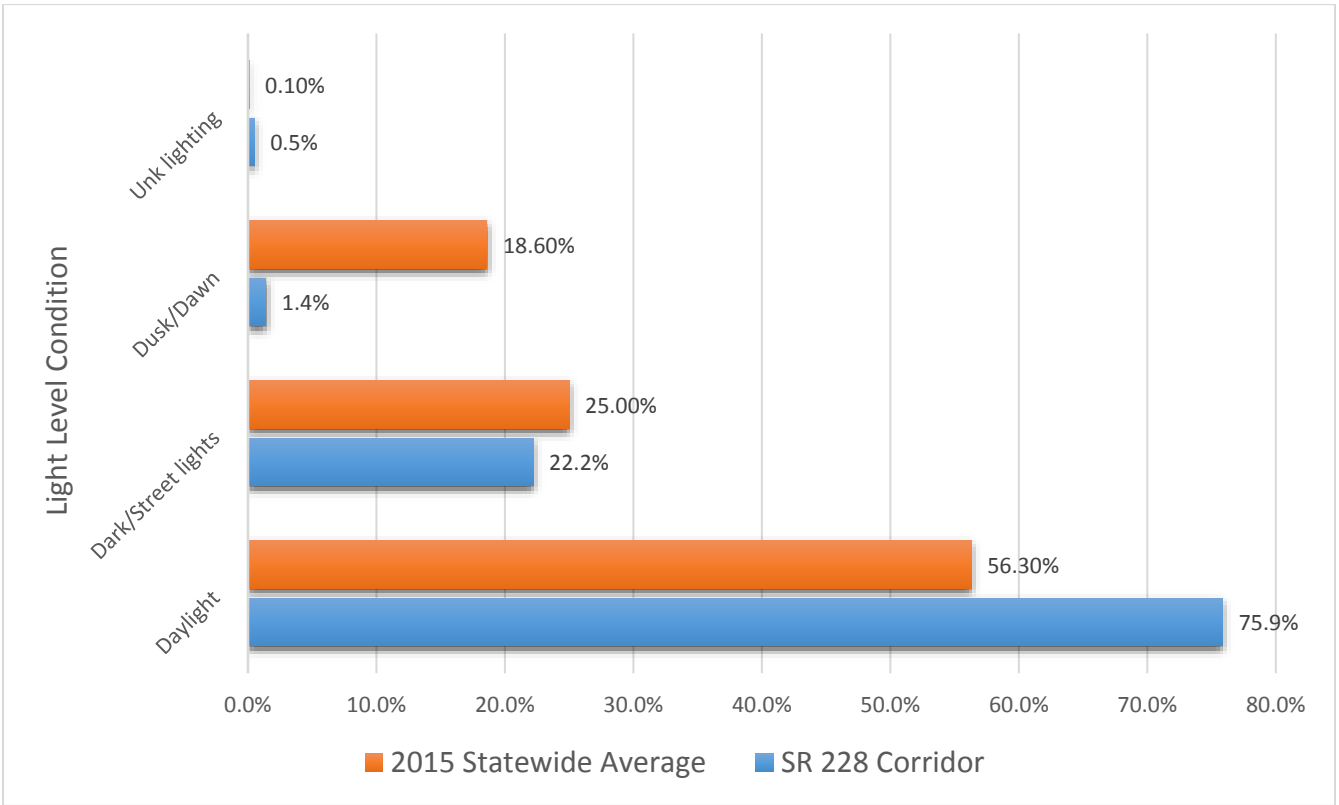


Exhibit 16: SR 228 Crashes by Light Level Condition Comparison



Crash Location Details

Collision diagrams were developed using crash detail information from CDART (**Appendix A**). The collision diagrams were used to review location-specific crash details and determine the number of crashes by crash type as required to perform HSM analyses for intersections and segments (**Exhibits 17 and 18**, respectively). The shading within each exhibit indicates the intersections and segments with ten or more crashes; each shaded location has a corresponding collision diagram. A crash cluster map was also developed to provide a graphical representation of where crashes occurred within the study area, including symbology by crash type (**Exhibit 19**).

Exhibit 17: Intersection Crash Summary (2011 - 2015)

Intersection		Crash Type							Total
		Multi-Vehicle Crashes		Single-Vehicle Crashes		Ped Crashes	Bicycle Crashes	Unknown If Injured	
		FI[1]	PDO[2]	FI[1]	PDO[2]	FI[1,3]	FI[1,3]		
1	SR 228 and Franklin Rd	9	9	0	0	1	0	0	19
2	SR 228 and Castle Creek Dr (West)	3	4	0	1	0	0	0	8
3	SR 228 and Castle Creek Dr (East)	11	6	0	2	0	0	0	19
4	SR 228 and Seven Fields Blvd	5	11	0	1	1	0	0	18
5	SR 228 and Adams Ridge Blvd	22	10	0	0	0	0	0	32
6	SR 228 and Myoma Rd	6	13	1	0	0	0	0	20
7	SR 228 and Heritage Creek Dr	4	4	0	0	0	0	0	8
8	SR 228 and Scharberry Ln	2	2	0	0	0	0	0	4
9	SR 228 and Beaver St Ext	5	2	0	3	0	0	0	10
TOTAL		**67**	**61**	**1**	**7**	**2**	**0**	**0**	**138**

[1] Fatal and Injury crashes include Unknown Severity crashes
[2] Property Damage Only crashes
[3] All pedestrian and bicycle crashes assume to result in personal injury

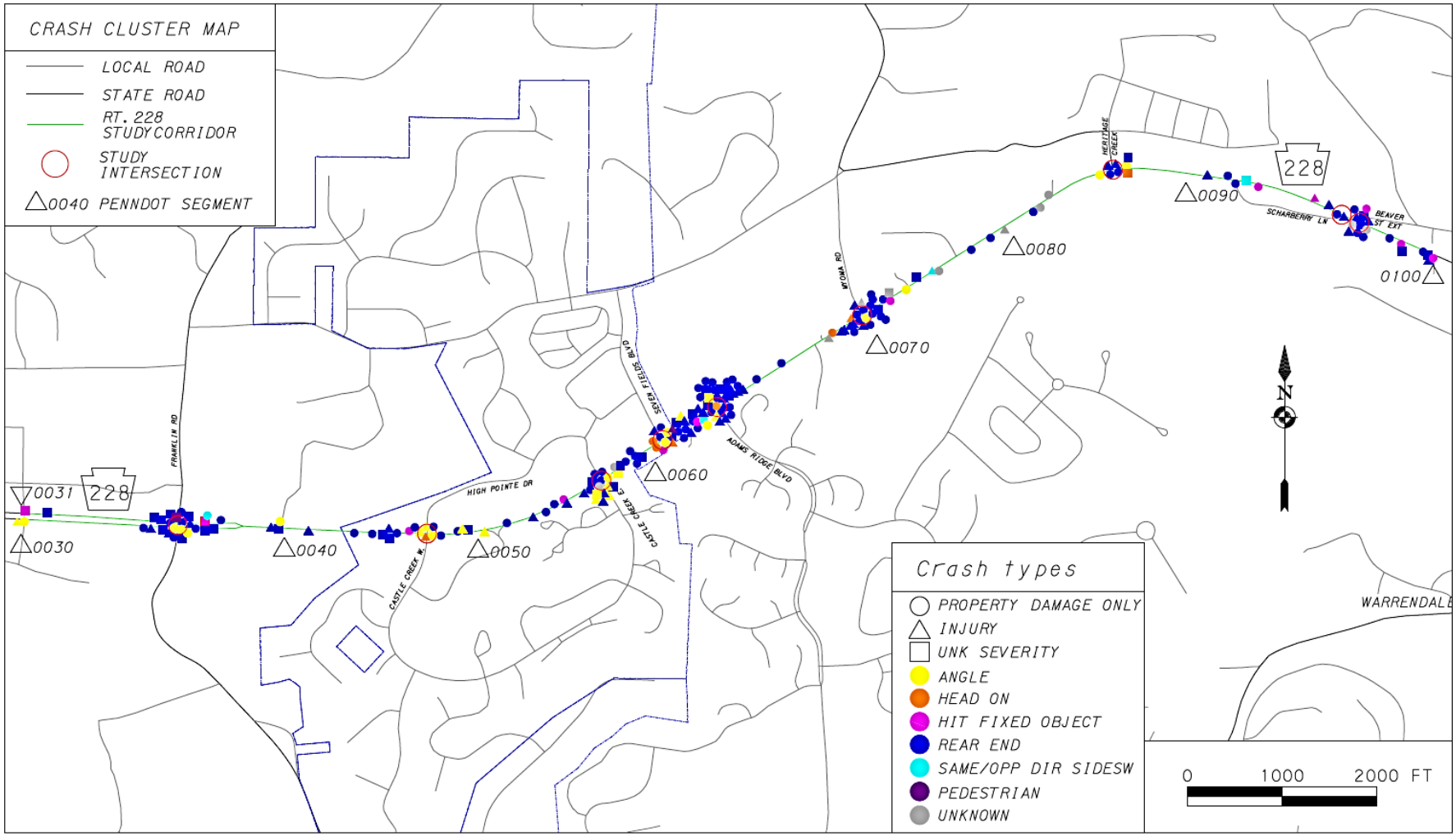
Exhibit 18: Segment Crash Summary (2011 - 2015)

SR 228		Crash Type							Total
		Multi-Vehicle Crashes				Single-Vehicle Crashes		Unknown If Injured	
From	To	Driveway Related		Non-Driveway Related					
		FI[1]	PDO[2]	FI[1]	PDO[2]	FI[1]	PDO[2]		
Segment 0030	Segment 0040	2	1	3	3	0	0	0	9
Segment 0040	Segment 0050	3	0	3	4	0	0	0	10
Segment 0050	Castle Creek Dr (East)	1	1	2	2	0	1	0	7
Castle Creek Dr (East)	Adams Ridge Blvd	1	0	3	3	0	1	0	8
Adams Ridge Blvd	Segment 0070	0	0	2	3	1	0	0	6
Segment 0070	Segment 0080	0	1	2	2	1	2	1	9
Segment 0080	Segment 0090	0	0	0	1	0	2	0	3
Segment 0090	Segment 0100	2	0	1	4	1	3	2	13
TOTAL		**9**	**3**	**16**	**22**	**3**	**9**	**3**	**65**

[1] Fatal and Injury crashes include Unknown Severity crashes

[2] Property Damage Only crashes

Exhibit 19: SR 228 Corridor Crash Cluster Map



The crash cluster map shows crashes scattered throughout the study corridor with a higher concentration of crashes at the intersections. Specific crash clusters, including possible roadway or intersection details that may contribute to their related patterns, are discussed in **Exhibit 20**. Additional crash details are also compiled on the collision diagrams for each of the primary intersections that have ten crashes or more.

Exhibit 20: Crash Cluster Details

Intersection		Crash Cluster Description	Possible Contributing Characteristics
1	SR 228 and Franklin Rd	• Rear-end crashes on both the eastbound and westbound approaches, especially eastbound inside through lane • Angle crashes involving the westbound approach	• Congestion and queuing • Eastbound lane drop approximately 300 feet past signal, causing spillback / blockage through intersection
2	SR 228 and Castle Creek Dr (West)	• Angle crashes involving the westbound and southbound approaches	• Congestion and queuing
3	SR 228 and Castle Creek Dr (East)	• Rear-end crashes on both the eastbound and westbound approaches • Angle crashes involving the eastbound approach	• Congestion and queuing
4	SR 228 and Seven Fields Blvd	• Rear-end crashes on both the eastbound and westbound approaches • Head-on and angle crashes involving the eastbound approach	• Congestion and queuing
5	SR 228 and Adams Ridge Blvd	• Rear-end crashes on both the eastbound and westbound approaches • Angle crashes involving the westbound approach	• Congestion and queuing
6	SR 228 and Myoma Rd	• Rear-end crashes on both the eastbound and westbound approaches	• Unsignalized intersection • Congestion and queuing • No eastbound left-turn lane – drivers use shoulder as bypass lane
7	SR 228 and Heritage Creek Dr	• No significant crash pattern (crashes matching overall trends)	• Congestion and queuing eastbound due to both Beaver St Ext and Pittsburgh St intersections • Sight distance north-south due to existing superelevation
8	SR 228 and Scharberry Ln	• No significant crash pattern (crashes matching overall trends)	• Unsignalized intersection • Close proximity to Beaver St Ext intersection • Congestion and queuing eastbound due to both Beaver St Ext and Pittsburgh St intersections
9	SR 228 and Beaver St Ext	• Rear-end crashes on both the eastbound and westbound approaches	• Unsignalized intersection • Skewed intersection geometry • Congestion and queuing eastbound due to Pittsburgh St intersection • No eastbound left-turn lane – drivers use shoulder as bypass lane

HSM Assessment of Baseline Conditions

SR 228 from Franklin Road to Beaver Street Extension was further analyzed to determine safety performance based on existing and future roadway characteristics per methodologies in Part C (Predictive Method) of AASHTO's *Highway Safety Manual* (HSM) using PennDOT's *HSM Analysis Tool* spreadsheet.

HSM Input Assumptions

A full summary of the inputs used for HSM analyses can be found in **Appendix B**. The analysis is based on the following assumptions:

- *Facility Type* – SR 228 is classified as an urban principal arterial; therefore, the HSM's Urban/Suburban Arterial module was used.
- *Corridor Segmentation* – The study corridor was separated into eight homogenous segments that include six signalized intersections and three unsignalized intersections (**Exhibits 3-5**).
- *Average Annual Daily Traffic (AADT)* – AADTs per **Exhibits 21-22** were used for the analysis.
- *Presence of Lighting* – Corridor lighting within the study limits is provided only for SR 228 at Franklin Rd, SR 228 at Adams Ridge Blvd. and SR 228 at Heritage Creek Dr.
- *Calibration Factor* – A Calibration Factor of 1.0 was assumed.
- *Daily Pedestrian Crossing Volumes* - Daily pedestrian crossing volumes were projected based on 2016 turning movement counts performed during the AM, PM and Saturday peak periods following the National Bicycle & Pedestrian Documentation Project's (NBPDP) Count Adjustment Factors. The highest observed peak hour pedestrian volumes at each intersection were extrapolated to daily pedestrian volumes using hourly and seasonal adjustment factors.
- *Number of Bus Stops within 1,000 feet of signalized intersections* – Bus stops do not currently exist along the corridor based on the latest available transit data and a field/aerial reviews.
- *Number of Schools within 1,000 feet of signalized intersections* – Based on field/aerial reviews, the St. Kilian Catholic School is located within 1,000 feet of the Franklin Road signalized intersection.
- *Number of Alcohol Sales Establishments within 1,000 feet of signalized intersections* – The number of alcohol sales establishments within 1,000 feet of the signalized intersections is based on a review of land uses from Google Earth. The following alcohol sales establishments were identified: Table 86 By Hines Ward, Vines, Double Wide Grill, Wine & Spirits, Yama Sushi, Springfield Grille, and Luciano's Italian Brick Oven.
- *Observed Crash Data* – CDART data provided by PennDOT for a five-year period from January 1, 2011 through December 31, 2015 was used for the purposes of the analysis (**Exhibits 17-18**).
- *Number of Driveways within a Segment* – Google Earth aerials were reviewed to identify the number of major/minor commercial driveways, major/minor industrial/institutional driveways, major/minor residential driveways, and other driveways. As noted in HSM Chapter 12, major driveways are those that serve sites with approximately 50 or more parking spaces.
- *Roadside Fixed Object Density* – The major roadside fixed objects along the study corridor are utility poles, which are located along both sides of SR 228 throughout the site limits. The roadside fixed object density was calculated by dividing the number of utility poles on both sides of the roadway by the segment length in miles.
- *Offset to Roadside Fixed Objects* – This distance was approximated based on the most common fixed object within the segment, which are utility poles; therefore, a value of 30 feet was used for the purposes of the analysis.

HSM Traffic Volume Assumptions

As detailed under separate cover in the project's overall *Traffic Design Report*, 24-hour traffic counts were collected along the SR 228 corridor in October 2016, and intersection turning movement counts were conducted at nine key intersections during typical weekday AM/PM and Saturday peak periods. To convert and extrapolate the available count data into approach-specific AADT assumptions required for HSM-based crash analyses at each intersection, a number of conversion assumptions were made. Based on the 24-hour count data, approximately 39% of the daily traffic occurred from 7:00 AM to 9:00 AM, 11:00 AM to 1:00 PM (Saturday), and 4:00 PM to 6:00 PM (i.e., the peak hour turning movement count hours). This factor was applied to the total traffic volume by intersection leg to develop average weekday ADTs for the corridor. Since the crash analysis was conducted for the years 2011 through 2015, a 0.962 AADT Adjust Factor was applied to develop AADTs, based on PennDOT's *2015 Traffic Data Manual* for TPG 3's 7-day average. Traffic volume data was also obtained from the PennDOT Roadway Management Information System (RMIS) as a reference. **Exhibits 21-22** summarize the resulting AADTs by segment and by intersection, respectively.

Exhibit 21: Year 2016 Segment AADTs

Segment	Route	Termini		Year 2016 Estimated AADTs
A	SR 228	Segment 0030	Segment 0040	31,500
B	SR 228	Segment 0040	Segment 0050	30,100
C	SR 228	Segment 0050	Castle Creek Dr (East)	28,500
D	SR 228	Castle Creek Dr (East)	Adams Ridge Blvd	28,000
E	SR 228	Adams Ridge Blvd	Segment 0070	24,400
F	SR 228	Segment 0070	Segment 0080	23,700
G	SR 228	Segment 0080	Segment 0090	25,300
H	SR 228	Segment 0090	Segment 0100	26,750

Exhibit 22: Year 2016 Intersection AADTs

Intersection		Year 2016 Estimated AADTs	
		Major Street	Minor Street
1	SR 228 and Franklin Rd	31,300	11,700
2	SR 228 and Castle Creek Dr (West)	31,700	6,500
3	SR 228 and Castle Creek Dr (East)	28,500	2,600
4	SR 228 and Seven Fields Blvd	28,200	7,500
5	SR 228 and Adams Ridge Blvd	27,500	10,900
6	SR 228 and Myoma Rd	24,400	2,400
7	SR 228 and Heritage Creek Dr	23,700	6,700
8	SR 228 and Scharberry Ln	26,900	200
9	SR 228 and Beaver St Ext	26,600	3,700

HSM Baseline Analysis

PennDOT's *HSM Analysis Tool* spreadsheet uses safety performance functions (SPFs) and crash modification factors (CMFs) to calculate the following:

- *Predicted average annual crash frequency* – Crashes per year predicted based on similar facilities
- *Expected average annual crash frequency* – Crashes per year based on similar facilities and corridor-specific crash history using Empirical Bayes methodologies
- *Potential for Safety Improvement* = Expected Crashes minus Predicted Crashes. Positive values suggest that the study element is operating worse than comparable corridors and there is a potential for safety improvement.

Appendix C includes the input data and output results from the HSM Analysis tool spreadsheet as well as a brief methodology of the data collection effort. **Exhibit 23** summarizes the segment, intersection, and corridor results using the HSM Crash Prediction methodology.

HSM Segment Results

HSM-based results suggest that no segment shows a positive potential for improvements. All of the segments are performing like or better than similar facilities based on quantitative HSM methodologies. Despite the HSM-based finding that most segments tend to correspond to "expected" or "predicted" crash traits for similar corridors, there are likely other improvements that could be considered to reduce crash potential for the corridor moving forward. These additional considerations are based on other data perspectives, qualitative comparisons, and anecdotal insights (e.g. including details in **Exhibit 20** relative to crash clusters, crash patterns, and potential contributing characteristics).

HSM Intersection Results

Results from the HSM-based intersection analysis suggest that two intersections show positive potential for improvement. These intersections include: SR 228 at Adams Ridge Boulevard, and SR 228 at Myoma Road, with details as follows:

- Adams Ridge Boulevard intersection has a closely spaced intersection to the west (SR 228 at Seven Fields Boulevard) that regularly queues back on the westbound approach, particularly during the AM peak.
- Myoma Road is an unsignalized intersection with difficult accessibility due to high mainline traffic volumes and no existing designated turn lanes.

Based on HSM methodologies, the other intersections are reported as performing like or better than similar facilities. Although these intersections are not flagged by HSM methods as having a potential for safety improvement, there are likely other improvements that could be considered to reduce crash potential for the intersections moving forward. These additional considerations are based on other data perspectives, qualitative comparisons, and anecdotal insights similar to those at the segment level.

Exhibit 23: Highway Safety Manual Project Safety Performance by Segment

Facility		HSM Site Level Analysis			
		Total Predicted Crashes / Year[1]	**Total Observed Crashes / Year[2]**	**Total Expected Crashes / Year[1]**	**Potential for Safety Improvement[3]**
SR 228 Segments	**A:** SEG 0030	10.32	1.20	2.45	-7.87
	B: SEG 0040	11.64	1.40	3.23	-8.41
	C: SEG 0050 to Castle Creek Dr (East)	4.72	1.40	2.50	-2.22
	D: Castle Creek Dr (East) to Adams Ridge Blvd	10.31	1.40	3.14	-7.17
	E: Adams Ridge Blvd to Segment 0070	5.11	1.20	2.43	-2.68
	F: SEG 0070	4.51	1.40	2.47	-2.05
	G: SEG 0080	6.72	0.60	2.19	-4.53
	H: SEG 0090	8.84	2.00	3.50	-5.34
SR 228 Intersections	**1:** Franklin Rd	3.99	2.20	3.00	-0.99
	2: Creek Dr (West)	4.82	1.60	2.86	-1.96
	3: Castle Creek Dr (East)	3.44	2.80	3.13	-0.30
	4: Seven Fields Blvd	4.79	3.00	3.75	-1.04
	5: Adams Ridge Blvd	3.82	5.40	4.78	**0.96**
	6: Myoma Rd	1.49	3.80	2.46	**0.97**
	7: Heritage Creek Dr	3.71	1.20	2.32	-1.39
	8: Scharberry Ln	0.86	0.80	0.85	-0.01
	9: Beaver St Ext	1.74	1.60	1.71	-0.04
Corridor-Wide Summary[4]					
Fatal and Injury Crashes		46.46	12.60	25.41	-21.05
Property Damage Only Crashes		44.38	20.40	21.35	-23.03
Total Crashes		90.84	33.00	46.76	-44.08

[1] Results based on calculations performed using PennDOT's *Highway Safety Manual* (HSM) *Analysis Tool* spreadsheet

[2] Five-year study period from January 1, 2011 through December 31, 2015

[3] Potential for Safety Improvement = Expected Crashes – Predicted Crashes (Shading indicates potential for safety improvement.)

[4] Based on Project Safety Performance Summary Report generated by PennDOT's *HSM Analysis Tool Spreadsheet*

HSM Assessment of Improvement Options

It is anticipated that proposed widening and turn lane additions for the SR 228 corridor will improve overall safety and operations. **Exhibit 24** (copied from the project's overall Traffic Design Report effort) shows a graphical representation of the preliminary traffic design insights and suggested segment/intersection lane improvements.

Segment-Level Improvements Analysis

As part of this project, SR 228 will be widened to a four-lane cross section (i.e., two lanes per direction, excluding median island or turn lanes, as required) between Franklin Road and Beaver Street Extension to increase capacity and reduce the amount of queuing and congestion. Based on preliminary design and safety audit considerations, two typical cross sections may occur along the SR 228 corridor:

- four-lane cross section with grass median, mountable curb end to end, and no left-turning access
- four-lane cross section with offset left-turn lane and mountable curb

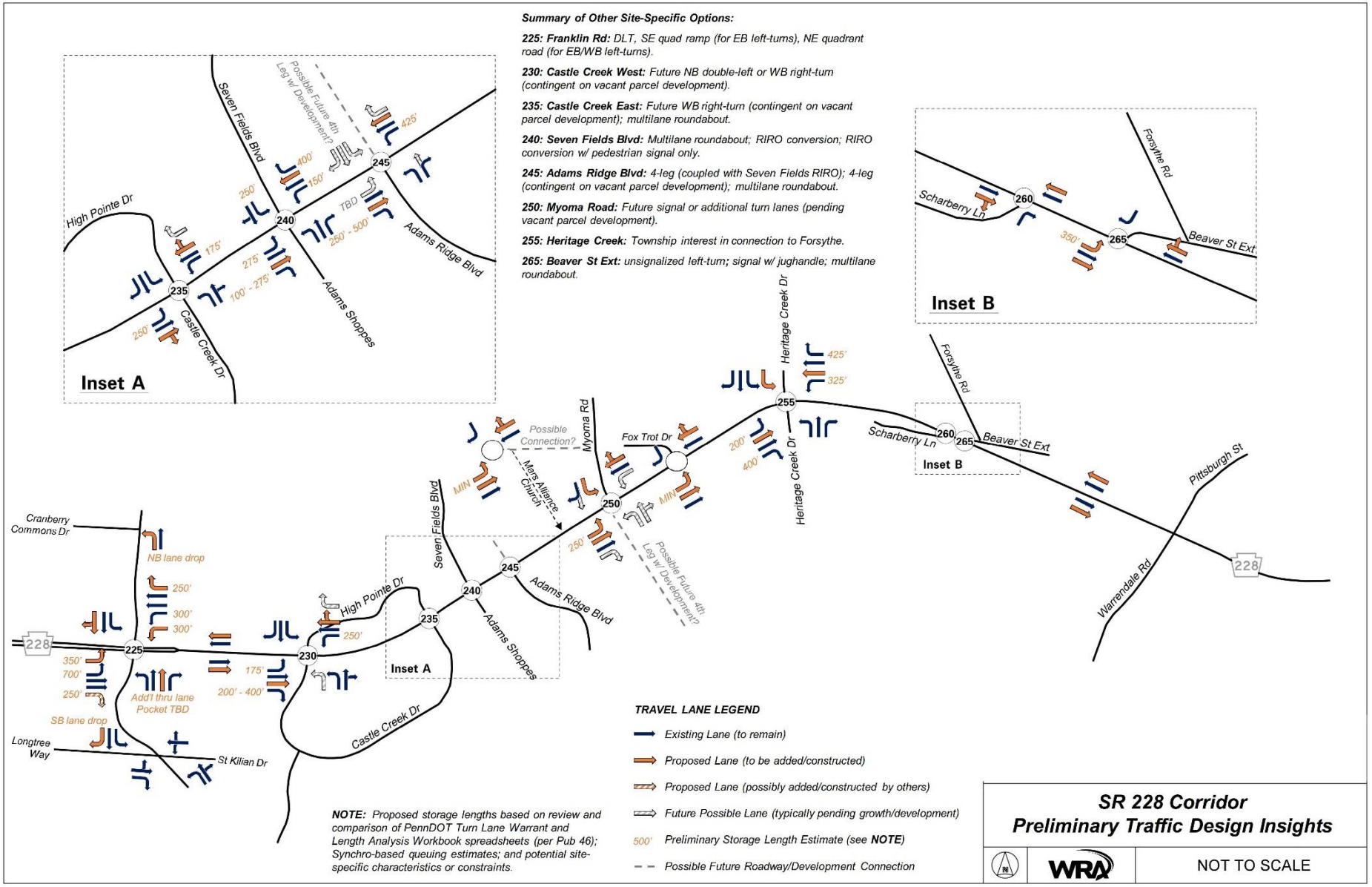
Each of these scenarios was applied to the entire corridor to determine overall safety benefits at the segment level. When available, improvements are discussed using crash modification factors (CMFs) from the HSM, the *Pennsylvania CMF Guide*, and/or the *CMF Clearinghouse*. According to the *PA CMF Guide*, only "high-quality" CMFs are deemed appropriate for application in Pennsylvania. "High-quality" CMFs are those having a star rating of three or higher based on the star quality rating system used by *FHWA's CMF Clearinghouse*. As such, CMFs with star ratings of 1 or 2 were not generally considered for this study from a quantitative perspective; however, overall trends demonstrated by these lower quality CMFs may be discussed from a qualitative perspective. As described by the *CMF Clearinghouse*, a CMF represents the long-term expected reduction in crashes, and this estimate is based on the crash experience at a limited number of study sites; therefore, the actual reduction may vary.

Considering the proposed four-lane cross section along SR 228 and according to the *PA CMF Guide*, installing a raised median is anticipated to reduce all crashes by 71 percent (i.e., CMF = 0.29). This CMF was developed based on statistical analyses used to determine correlations between access management techniques and crash histories including crash rate, severity, and type. The four-lane divided cross section is expected to improve safety for vehicles turning left into or out of driveways as well as reduce the potential for rear-end crashes caused by stopped left-turning vehicles or vehicles slowing for left-turning vehicles. Furthermore, it is expected to reduce conflict points and increase driver expectancy.

Each segment-level improvement was analyzed using a method that directly applies the available CMF(s) to the "expected crashes per year without improvements" value to determine the potential crash reduction for the proposed improvement. The "expected" value was based on existing-condition calculations performed using PennDOT's *HSM Analysis Tool* spreadsheet, which implements the methodologies outlined in Part C (Predictive Method) of AASHTO's *Highway Safety Manual.*

The summation of potential crash reductions was calculated for the entire SR 228 corridor, which resulted in an expected savings of approximately 16.03 crashes per year. This savings would be equivalent to approximately a 70% reduction in expected segment-based crash activity (as compared to segment data in **Exhibit 23**).

Exhibit 24: SR 228 Corridor Preliminary Traffic Design Insights



Note: Refer to the project's overall Traffic Design Report under separate cover for source graphic and background documentation.

Intersection-Level Improvements Analysis

Preliminary improvements are also proposed at the intersection level, in addition to the second through lane in each direction. Per **Exhibit 24**, turn lane(s) will be installed at every study intersection; some dependent upon potential future development. To simplify the safety analysis, it was assumed that the only proposed turn lanes are those to be added and constructed as part of this project.

Proposed Widening with Traffic Signal and Turn Lane Upgrades

Similar to the segment-level safety analysis, each intersection improvement was analyzed by applying CMF(s), when available, to determine the potential crash reduction for the proposed improvement. From a quantitative perspective, however, the pool of CMFs available within current research are not yet able to explicitly account for common types of improvements such as generic operational or capacity enhancements and related queueing/congestion benefits, turn bay storage length increases, signal retiming and optimization, elimination of lane drop conditions, or organization of turn access via signalized jughandles.

Such improvements are included among the proposed design for the SR 228 corridor; and corresponding safety benefits are expected, though they cannot be quantified due to current HSM methodology constraints. As previously stated, most crashes along the SR 228 corridor are Rear-End type and are most likely attributed to the oversaturated conditions and aggressive driving behaviors. Even though safety benefits cannot be quantified via HSM for such improvements, adding a through lane of capacity in each direction, adding dual left turn lanes, and increasing the turn bay storage are qualitatively expected to not only improve traffic operations but also safety at each intersection. The following study intersections provide qualitative safety benefits through operational improvements:

- SR 228 at Castle Creek Drive (West)
- SR 228 at Castle Creek Drive (East)
- SR 228 at Seven Fields Boulevard
- SR 228 at Adams Ridge Boulevard
- SR 228 at Scharberry Lane

For the quantifiable safety assessment, operational improvements with available CMFs included: providing a turn lane where one does not currently exist, changing left-turn signal phasing (e.g. permitted to protected), and installing a traffic signal. The potential crash reductions were calculated for the following intersections:

- SR 228 at Franklin Road
- SR 228 at Myoma Road
- SR 228 at Heritage Creek Drive
- SR 228 at Beaver Street Extension

The proposed improvements provide a nominal/minor crash reduction based on the quantifiable safety assessment at the intersection level, offset in part due to data for the proposed signalization at Beaver Street Extension. A positive, quantifiable safety benefit from signalization depends on the existing observed crash types at the intersection. According to the available CMFs in the HSM, installing a traffic signal reduces Angle crashes but increases Rear-End crashes. Most crashes at the Beaver Street Extension intersection are Rear-End crashes, thereby potentially resulting in a safety dis-benefit with signalization. However, most of the observed Rear-End crashes are likely due to the aggressive driving behaviors during congested conditions and no existing left-turn lane. An overall positive safety benefit is anticipated at Beaver Street Extension based on the existing roadway and driver characteristics.

Other Potential Intersection Options

Aside from the proposed preliminary design with four-lane widening and signalization, other potential traffic configurations were considered at select locations to explore the potential benefits of roundabouts, jughandles, or alternate roadway connections. Potential safety benefits for such options are summarized below.

1. A trio of multilane roundabout options were considered at:

- SR 228 at Castle Creek Drive (East)
- SR 228 at Seven Fields Boulevard
- SR 228 at Adams Ridge Boulevard

The multilane roundabouts at the above intersections were considered as a grouped installation (i.e., all three roundabouts would be installed, or none at all) and would be expected to collectively save approximately 5.3 crashes per year. This savings would be equivalent to a 45% reduction in expected crash activity through the trio of intersections (as compared to intersection data in **Exhibit 23**).

2. Individual multilane roundabout options were also considered at:

- SR 228 at Myoma Road
- SR 228 at Beaver Street Extension

The Myoma Road roundabout and Beaver Street Extension roundabout would be expected to save approximately 1.16 and 0.94 crashes per year, respectively. This savings would be equivalent to a 45-55% reduction in expected crash activity at each intersection (as compared to intersection data in **Exhibit 23**).

3. Traffic signalization with potential jughandle installations was considered at:

- SR 228 at Myoma Road
- SR 228 at Beaver Street Extension

Most crashes at the Myoma Road intersection are Rear-End crashes, thereby potentially resulting in a safety dis-benefit with signalization. However, most of the observed Rear-End crashes are likely due to the aggressive driving behaviors during congested conditions and with no existing left-turn lanes, similar to that of the Beaver Street Extension intersection. Because turn lanes are paired with the signalization, and as a result of overall congestion and queuing reductions that are expected with the widening project, an overall positive safety benefit is expected at both locations.

3. Roadway connection modifications were considered at:

- SR 228 at Seven Fields Boulevard
- SR 228 at Adams Ridge Boulevard

The three signalized intersections of Castle Creek Drive (East), Seven Fields Boulevard, and Adams Ridge Boulevard are closely-spaced (i.e., less than 1,000 feet between intersections) and congested, thereby resulting in a significant crash cluster that the HSM analysis identified as an area with a positive potential for safety improvements. One improvement option explored the conversion of the Seven Fields Boulevard southbound leg to right-in/right-out access only (potentially incorporating a pedestrian-only signal to cross SR 228), coupled with a full-access reconnection to a new southbound fourth leg at the Adams Ridge Boulevard intersection. As this option would eliminate the Seven Fields traffic signal (excluding the possibility of a pedestrian-only signal to maintain pedestrian access across SR 228), improve overall signal spacing, and reduce the number of existing conflict areas, this option would (qualitatively) have the potential to further reduce crash frequency and enhance safety throughout this portion of the corridor.

Estimated Monetary Benefits

The existing observed crashes were broken out by severity: fatalities/injuries and property damage only (PDO). The crash severity proportions by location were then applied to each improvement's annual total crashes to determine its appropriate severity breakdown. Each improvement's total annual crashes were then monetized by severity. The societal crash cost estimates used to monetize the number of crashes were based on PennDOT's *2016 Crash Facts and Statistics Book* (**Exhibit 25**).

Exhibit 25: PennDOT's 2016 Monetary Value of Crash Benefits

Crash Severity	2016 Number of Crashes in PA by Crash Severity[1]	Societal Crash Cost Estimates by Crash Severity[1]
Fatal (K)	1,188	$6,685,345
Disabling Injury (A)	4,397	$1,478,907
Evident Injury (B)	26,284	$99,235
Possible Injury (C)	23,050	$7,755
Unknown Severity	29,240	$7,755
Property Damage Only (O)	68,447	$3,102
Fatal / Injury (Including Unknown Severity) Weighted Average	84,159	$207,149
Total Weighted Average	152,606	$115,795

[1] PennDOT 2016 Crash Facts & Statistics Book, Page 8 (excluding the weighted averages)

Combining the monetary values above with the quantifiable reductions in crash activity for the proposed four-lane widening yields an estimated monetized safety benefit of approximately $1.4 million per year. As crash reductions and related benefits at the intersection level were generally unable to be quantified given current HSM methodology constraints, the majority of the estimated savings is attributable to quantifiable crash benefits at the segment-level. Based on a comparison of intersection crashes to segment crashes, the resulting quantifiable benefit really only accounts for 40-60% of all crash activity along the corridor. As such, and if all crash activity could be considered, the calculated $1.4 million per year safety benefit could more realistically be reported as roughly twice that amount – or a total order-of-magnitude benefit of approximately $3 million annually. These estimates also do not account for any additional safety benefits that could be achieved via other potential intersection options discussed on the previous page (e.g. roundabouts) should such options be incorporated into the project.

Summary

Each of the Crash Analysis components – crash characteristics, crash cluster identification, and HSM perspectives – provide valuable information for assessing locations within the SR 228 corridor. The following summary points and locations were identified through these efforts:

Corridor Crash Characteristics

- 203 reportable crashes occurred along the corridor from 2011-2015 with 68% at intersections and 32% along corridor segments.
- Annual crash totals during the study period ranged from 29 to 54 crashes per year, or the equivalent of approximately 1 to 2 crashes every other week.
- The majority of crashes involve property damage only (54%) with the remainder as injuries or possible injuries. There were zero fatalities along the corridor during the study period.
- Most crashes by type are Rear-End (70%, which is much higher than the 22% statewide average) followed by Angle (12%), and are likely attributable to substantial traffic volumes, queuing, and congestion along the corridor.
- Most crashes occur during the day with dry pavement and no adverse weather condition.

The above crash characteristics indicate that most crashes along the SR 228 corridor likely involve aggressive driving behavior and driver error during congested/oversaturated conditions. The most commonly reported driver actions include: sudden slowing/stopping, tailgating, driving too fast for conditions, red-light running, and being distracted, all of which contribute to the high proportion of rear-end crashes.

Intersection Crash Clusters

- **Intersection 1** (SR 228 and Franklin Road) as part of Segment A: rear-end crashes on both the eastbound and westbound approaches, especially eastbound inside through lane, and angle crashes involving the westbound approach
- **Intersections 3-5** (SR 228 and Castle Creek Drive East, Seven Fields Boulevard, and Adams Ridge Boulevard) as part of Segments C and D: rear-end and angle crashes involving both the eastbound and westbound approaches. HSM methodology identified the Adams Ridge Boulevard intersection as showing positive potential for improvement.
- **Intersection 6** (SR 228 and Myoma Road) as part of Segments E and F: rear-end crashes on both the eastbound and westbound approaches. HSM methodology identified this intersection as showing positive potential for improvement.
- **Intersection 9** (SR 228 and Beaver Street Extension) as part of Segment H: rear-end crashes on both the eastbound and westbound approaches

Possible contributing factors for the above crash activity may include (1) substantial congestion and queuing due to high traffic volumes and capacity deficiencies with the current two-lane corridor; (2) queue spillback, eastbound traffic blockages, and westbound left-turn interference that is caused by the existing eastbound SR 228 lane drop approximately 300 feet east of Franklin Road; (3) closely-spaced traffic signals in Seven Fields Borough; and (4) no turn lanes and limited gaps in traffic at unsignalized intersections including Myoma Road and Beaver Street Extension. It is anticipated that the proposed four-lane widening project and related intersection improvements will help to address each of the identified clusters and possible contributing factors.

Safety Benefits of Proposed Preliminary Design

It is anticipated that the proposed four-lane widening project and related intersection improvements will help to improve overall safety and operations throughout the SR 228 corridor, including the specific crash clusters and potential contributing factors identified above. Summary benefits include:

- 70% reduction in segment-based crashes, or approximately 16 fewer crashes per year based on HSM methodologies.
- A qualitative expectation for overall positive safety benefits to intersection-based crashes as a result of congestion/queuing mitigation, additional turn lanes, extended turn lane storage lengths, corridor-wide signal timing optimization, and overall infrastructure/facility upgrades.
- A monetized annual safety benefit of approximately $1.4 million based on quantifiable crash reductions; or a total order-of-magnitude safety benefit of approximately $3 million considering that 40-60% of the overall crash activity cannot be quantified under current HSM methodology limitations.

Safety Benefits of Other Potential Intersection Options

Aside from the proposed preliminary design with four-lane widening and signalization, other potential traffic configurations were explored and could further reduce crash frequency and enhance safety if incorporated into the project. These options include:

- 45% reduction in expected intersection crash activity (just over 5 crashes per year) at Castle Creek Drive (East), Seven Fields Boulevard, and Adams Ridge Boulevard if a trio of roundabout installations are considered.
- 45-55% reduction in expected intersection crash activity (approximately 1 to 2 crashes per year) at Myoma Road and Beaver Street Extension if a roundabout at one or both locations is considered.
- A qualitative expectation for overall positive safety benefits to intersection-based crashes along SR 228 through Seven Fields Borough if a right-in/right-out conversion of Seven Fields Boulevard eliminates one traffic signal and connects to a new southbound fourth leg at Adams Ridge Boulevard.

References

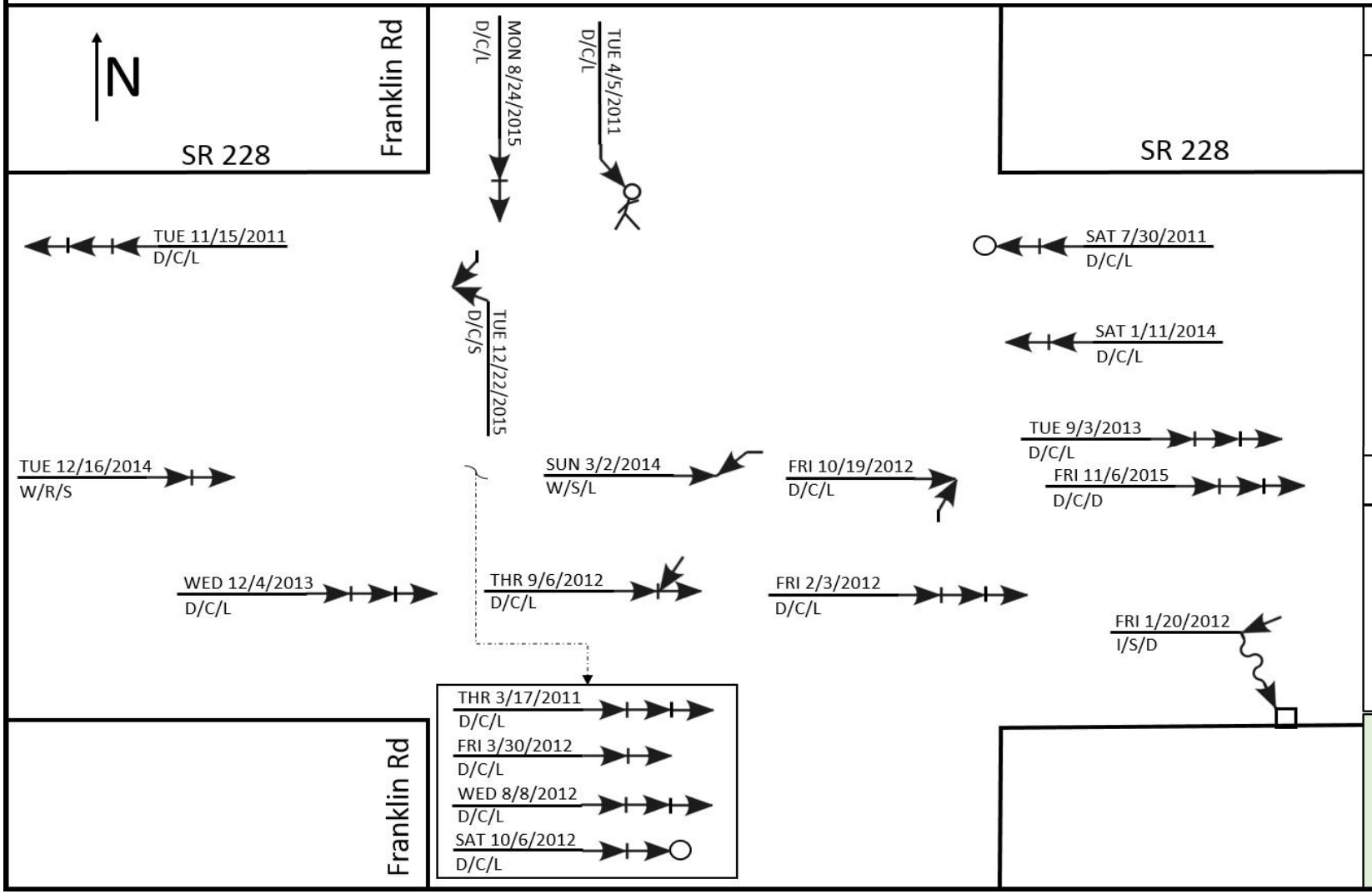
- *Crash Modification Factors (CMF) Clearinghouse,* http://www.cmfclearinghouse.org, University of North Carolina Highway Safety Research Center, U.S. Department of Transportation Federal Highway Administration, accessed November 2017.
- Gayah, Vikash V., et al. *Pennsylvania CMF Guide,* Department of Civil and Environmental Engineering Pennsylvania State University for Pennsylvania Department of Transportation, July 2014.
- *Highway Safety Manual,* 1st Edition (Vols. 1-3), AASHTO, 2010.
- *Highway Safety Manual* Analysis Tool spreadsheet, Pennsylvania Department of Transportation, 2015.
- *National Bicycle & Pedestrian Documentation Project: Count Adjustment Factors,* Alta Planning and Design and the Institute of Transportation Engineers Pedestrian and Bicycle Council, 2016.
- *Pennsylvania Crash Facts & Statistics Book*, Pennsylvania Department of Transportation, 2015, pp. 9, 12, 16, and 21.
- *Pennsylvania Crash Facts & Statistics Book*, Pennsylvania Department of Transportation, 2016, pp. 8.
- *Pennsylvania Traffic Data Manual*, Bureau of Planning and Research Transportation Planning Division, Pennsylvania Department of Transportation, 2015.

Appendix A

Intersection Collision Diagrams

Intersection Collision Diagram

Project:	Route 228 Mars RR Bridge West Expansion	**Location:**	SR 228 and Franklin Rd
Crash Period:	01/01/2011 to 12/31/2015	**Prepared by:**	XW



COLLISION SYMBOLS

- VEHICLE PATH
- BACKING VEHICLE
- NON-INVOLVED VEHICLE
- PEDESTRIAN
- FIXED OBJECT
- PARKED VEHICLE
- PERSONAL INJURY
- FATALITY
- REAR-END COLLISION
- HEAD-ON COLLISION
- SIDE SWIPE
- OUT OF CONTROL
- OVERTURNED VEHICLE
- LEFT TURN COLLISION
- RIGHT ANGLE COLLISION

CONDITION CODES

PAVEMENT CONDITION
D=DRY W=WET I=ICY S=SNOW

WEATHER CONDITION
C=CLEAR R=RAIN F=FOG S=SNOW

LIGHT CONDITION
L=DAYLIGHT D=DARK S=STREETL

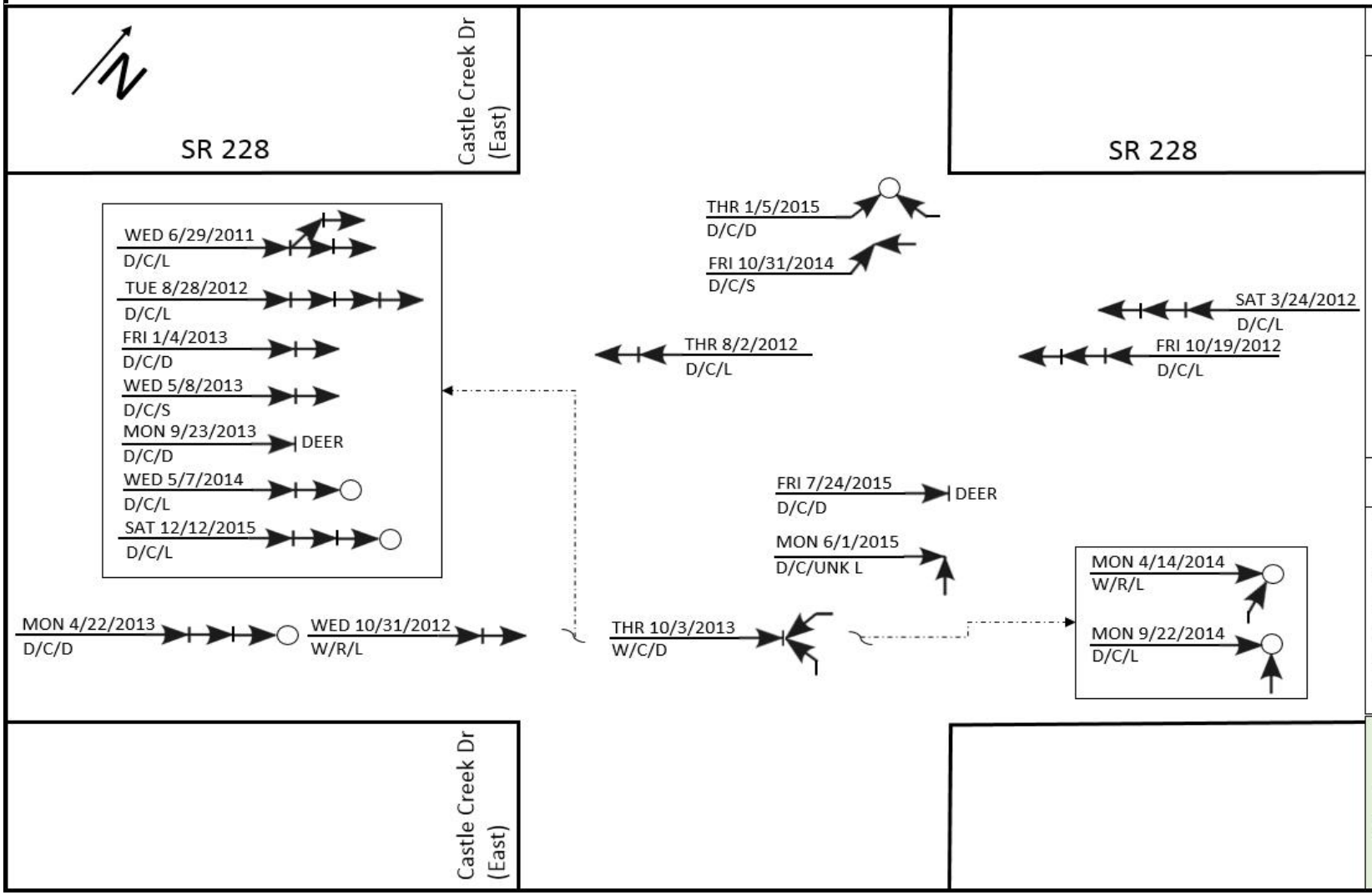
TIME OF DAY (MILITARY)

Crash Summary

	PDO	Injury	Fatal	Total
Daytime	8	3	0	11
Nighttime	1	0	0	1
Total	9	3	0	12

Intersection Collision Diagram

Project: Route 228 Mars RR Bridge West Expansion
Location: SR 228 and Castle Creek Dr (East)
Crash Period: 01/01/2011 to 12/31/2015
Prepared by: XW



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LIGHT CONDITION
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TIME OF DAY (MILITARY)

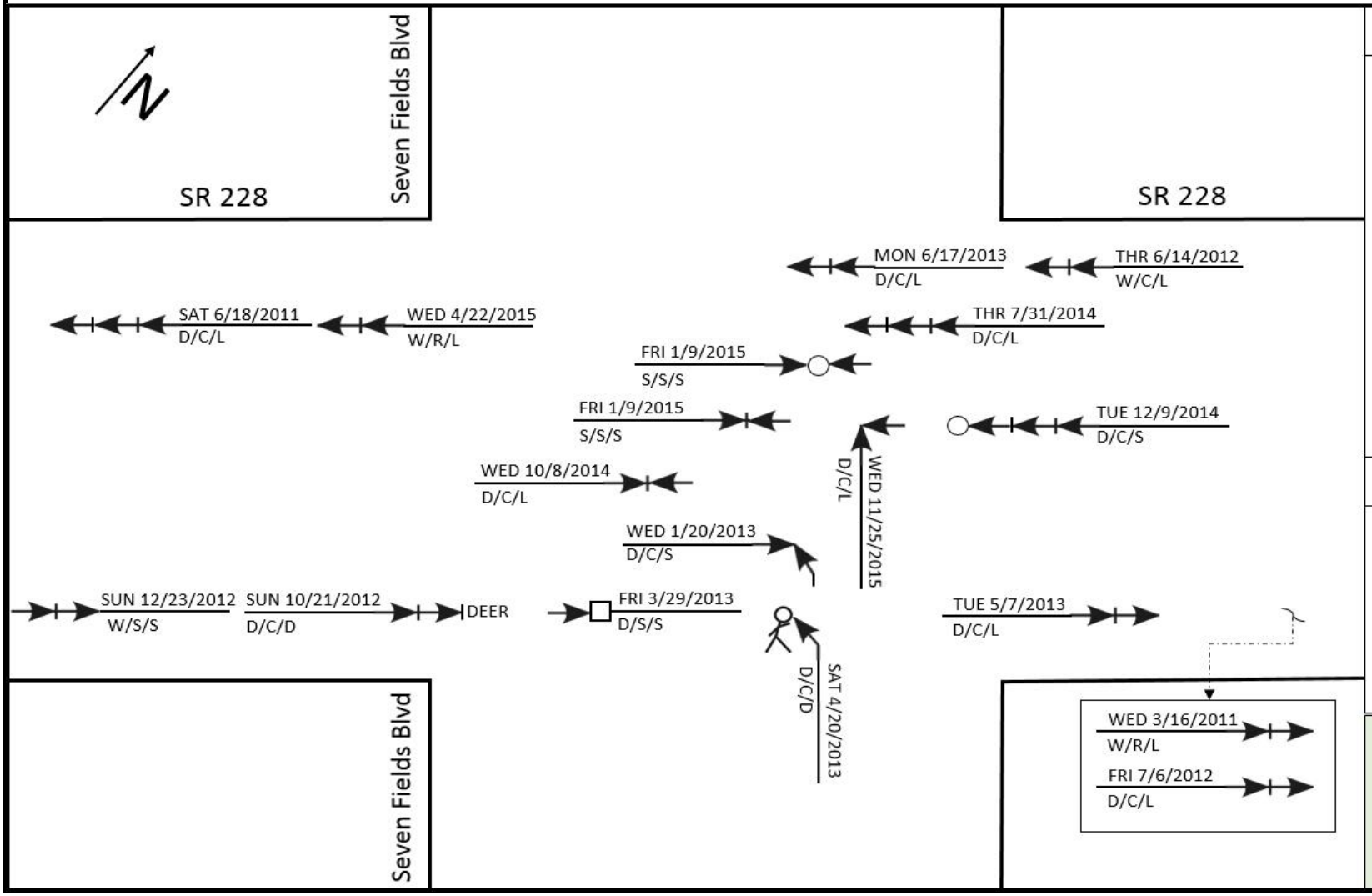
Crash Summary

	PDO	Injury	Fatal	Total
Daytime	4	4	0	8
Nighttime	4	2	0	6
Total	8	6	0	14

Intersection Collision Diagram

Project: Route 228 Mars RR Bridge West Expansion **Location:** Seven Fields Blvd

Crash Period: 01/01/2011 to 12/31/2015 **Prepared by:** XW



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LIGHT CONDITION

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TIME OF DAY (MILITARY)

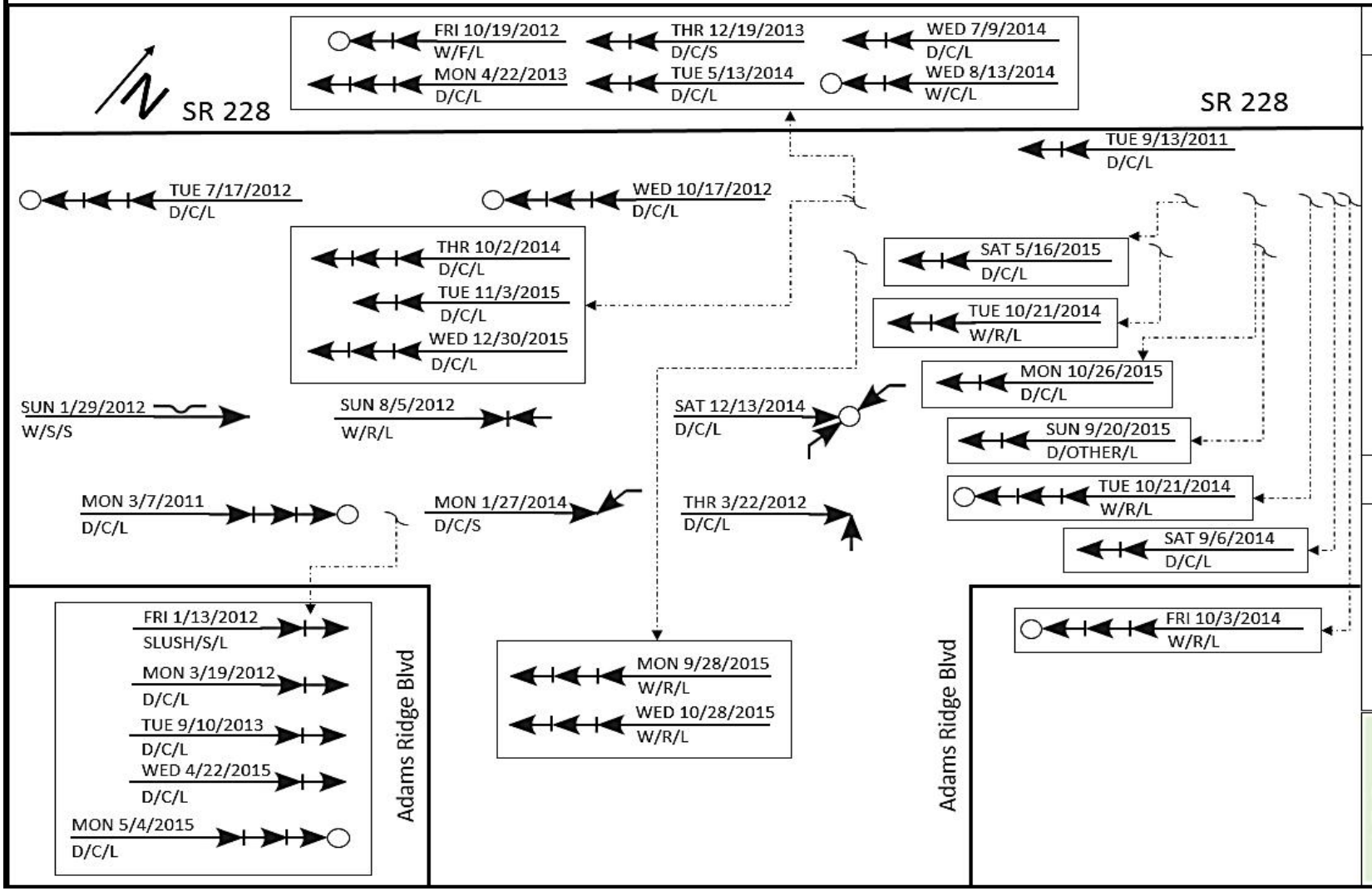
Crash Summary

	PDO	Injury	Fatal	Total
Daytime	8	1	0	9
Nighttime	4	2	0	6
Total	12	3	0	15

Intersection Collision Diagram

Project: Route 228 Mars RR Bridge West Expansion **Location:** Adams Ridge Blvd

Crash Period: 01/01/2011 to 12/31/2015 **Prepared by:** XW



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LIGHT CONDITION

L=DAYLIGHT D=DARK S=STREETL

TIME OF DAY (MILITARY)

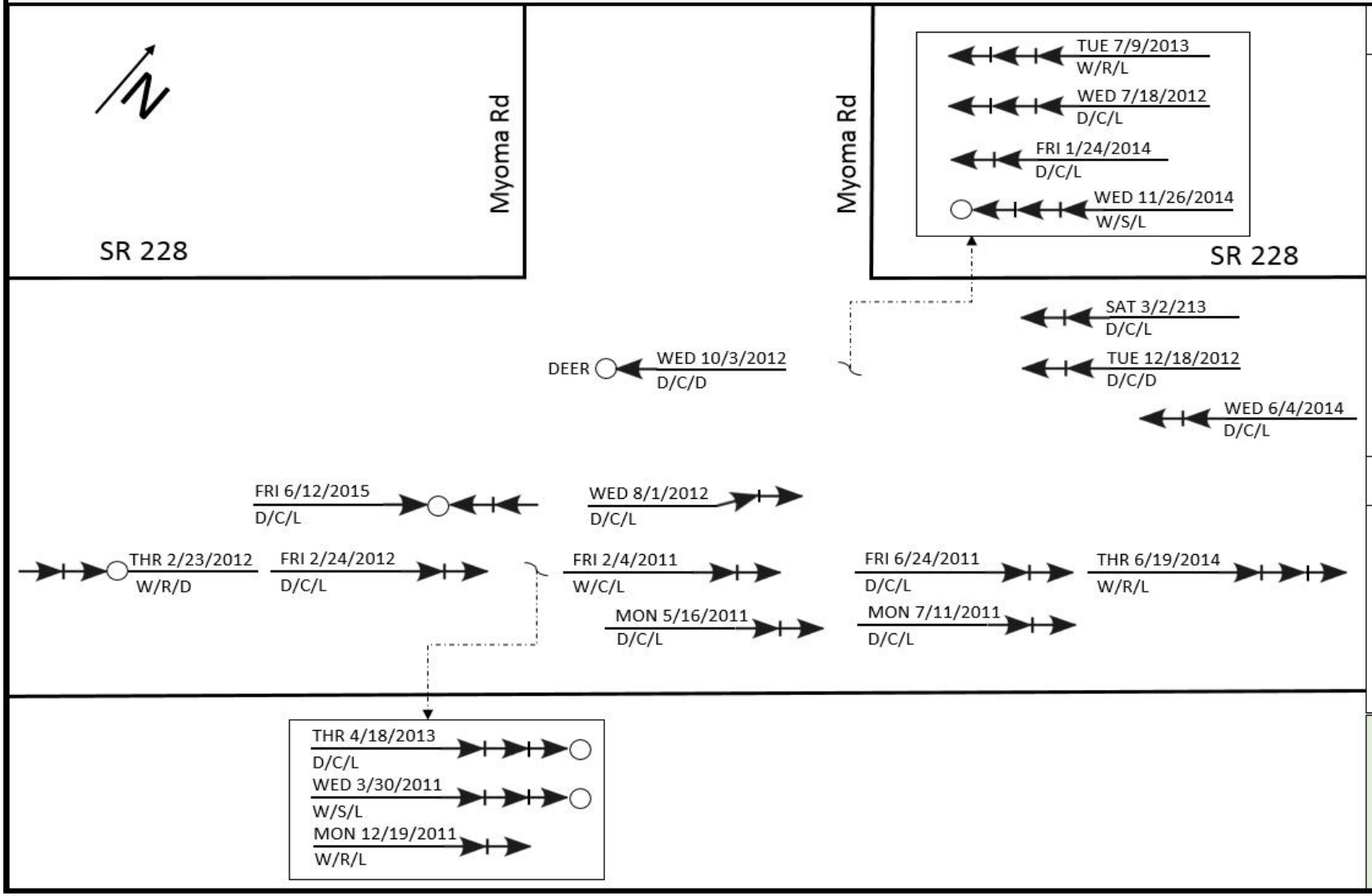
Crash Summary

	PDO	Injury	Fatal	Total
Daytime	16	10	0	26
Nighttime	1	0	0	1
Total	17	10	0	27

Intersection Collision Diagram

Project: Route 228 Mars RR Bridge West Expansion **Location:** Myoma Rd

Crash Period: 01/01/2011 to 12/31/2015 **Prepared by:** XW



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LIGHT CONDITION
L=DAYLIGHT D=DARK S=STREETL

TIME OF DAY (MILITARY)

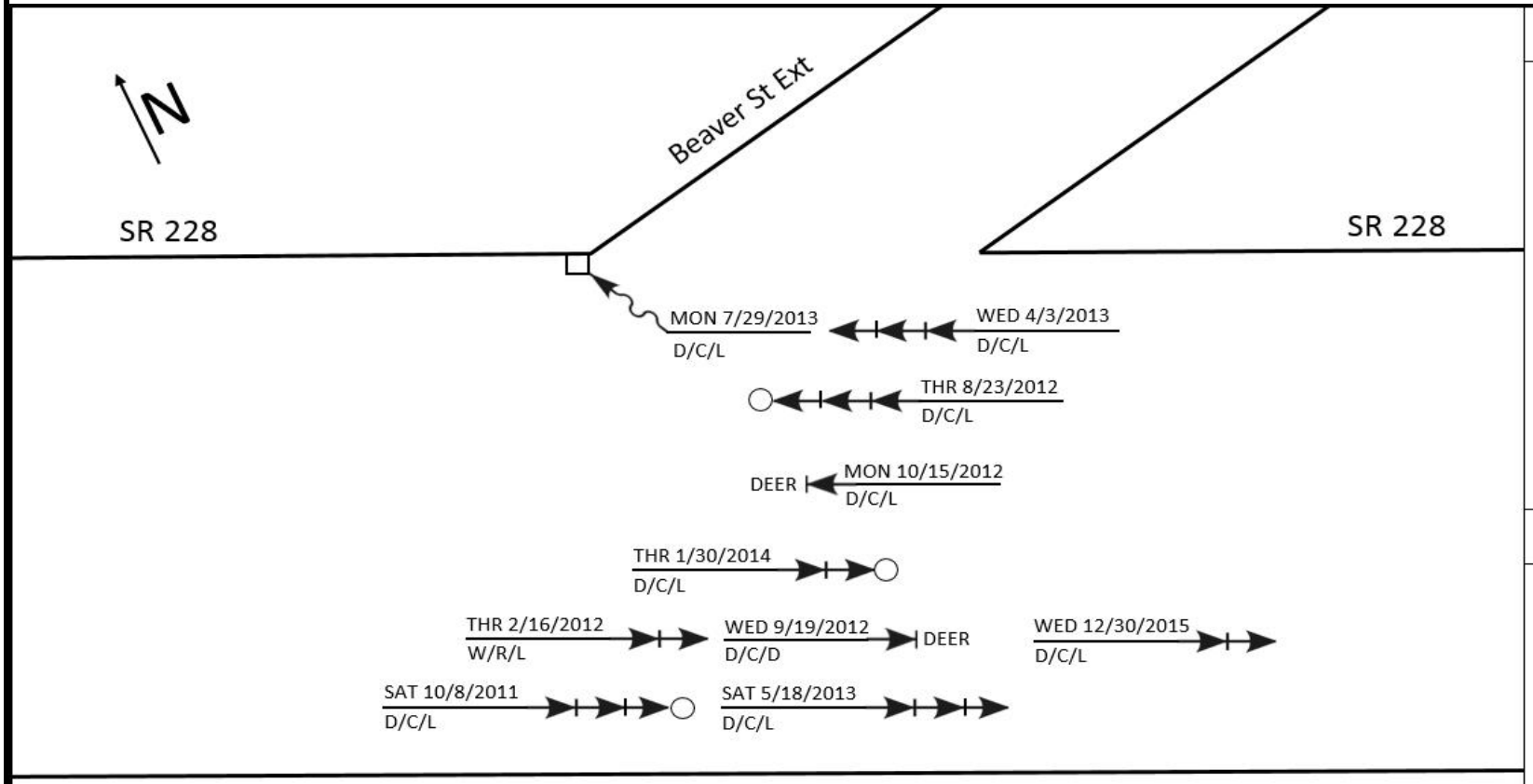
Crash Summary

	PDO	Injury	Fatal	Total
Daytime	12	4	0	16
Nighttime	1	2	0	3
Total	13	6	0	19

Intersection Collision Diagram

Project: Route 228 Mars RR Bridge West Expansion **Location:** Beaver St Ext

Crash Period: 01/01/2011 to 12/31/2015 **Prepared by:** XW



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LIGHT CONDITION
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TIME OF DAY (MILITARY)

Crash Summary

	PDO	Injury	Fatal	Total
Daytime	4	3	0	7
Nighttime	1	0	0	1
Total	5	3	0	8

Appendix B

PennDOT Highway Safety Manual Analysis Tool Spreadsheet Existing Inputs Summary

Contents:

Appendix B1:

Intersection-Level Existing Inputs Summary

Urban and Surburban Arterials Intersection Data																																
											Signalized Intersections														Unsignalized Intersections		Existing Crash Data (2011-2015)						
																											Multi-Vehicle		Single-Vehicle				
Int #	Major Road	Minor Road	PennDOT Route / Segment / Offset	Traffic Control Type (Signal vs. Unsignalized)	Intersection Type (3ST, 4ST, 3SG, 4SG)	AADT Major	AADT Major Source	AADT Minor	AADT Minor K-Factor Source	Intersection Lighting?	# of Approaches with Left-Turn Lane	L/T Phasing: Leg 1 (EB SR 228)	L/T Phasing: Leg 2 (WB SR 228)	L/T Phasing: Leg 3 (NB)	L/T Phasing: Leg 4 (SB)	Approaches w/ R/T Lane	# of Approaches with RTOR Prohibited	Int. Red Light Camera?	Ped Crossing Volume (Daily Vol Crossing All Legs)	Max # of Lanes Crossed by a Ped	# of Bus Stops (within 1,000 ft)	Any school w/in 1,000 ft?	# of Alcohol Establishments (within 1,000 ft)	# of Major Road Approaches with a Left-Turn Lane	# of Major Road Approaches with a Right-Turn Lane	KABC	PDO	KABC	PDO	Ped	Bike	Total Crashes
1	SR 228	Franklin Rd	SR 228 / 0030 / 1665	sig	4SG	31,300	Oct 16 ADT along SR 228	11,700	Oct 16 ADT along SR 228	Y	4	Pro	Pro	E/P	E/P	2	0	N	40	5	0	1	0			1	9	0	0	1	0	**11**
2	SR 228	Castle Creek Dr (West)	SR 228 / 0040 / 1421	sig	4SG	31,700	Oct 16 ADT along SR 228	6,500	Oct 16 ADT along SR 228	N	4	Pm	E/P	Pm	Pm	3	0	N	40	4	0	0	2			3	4	0	1	0	0	**8**
3	SR 228	Castle Creek Dr (East)	SR 228 / 0050 / 1417	sig	4SG	28,500	Oct 16 ADT along SR 228	2,600	Oct 16 ADT along SR 228	N	4	E/P	E/P	Pm	Pm	3	0	N	140	4	0	0	2			6	6	0	2	0	0	**14**
4	SR 228	Seven Fields Blvd	SR 228 / 0060 / 0186	sig	4SG	28,200	Oct 16 ADT along SR 228	7,500	Oct 16 ADT along SR 228	N	4	E/P	E/P	Pm	Pm	3	0	N	210	5	0	0	3			2	11	0	1	1	0	**15**
5	SR 228	Adams Ridge Blvd	SR 228 / 0060 / 0860	sig	3SG	27,500	Oct 16 ADT along SR 228	10,900	Oct 16 ADT along SR 228	Y	2	-	E/P	Pro	-	2	0	N	0	-	0	0	2			17	10	0	0	0	0	**27**
6	SR 228	Myoma Rd	SR 228 / 0070 / 0000	unsig	3ST	24,400	Oct 16 ADT along SR 228	2,400	Oct 16 ADT along SR 228	N														0	0	5	13	1	0	0	0	**19**
7	SR 228	Heritage Creek Dr	SR 228 / 0080 / 1275	sig	4SG	23,700	Oct 16 ADT along SR 228	6,700	Oct 16 ADT along SR 228	Y	4	E/P	E/P	Pm	Pm	4	0	N	0	4	0	0	2			2	4	0	0	0	0	**6**
8	SR 228	Scharberry Ln	SR 228 / 0090 / 1896	unsig	3ST	26,900	Oct 16 ADT along SR 228	200	Oct 16 ADT along SR 228	N														0	1	2	2	0	0	0	0	**4**
9	SR 228	Beaver St Ext	SR 228 / 0090 / 2062	unsig	3ST	26,600	Oct 16 ADT along SR 228	3,700	Oct 16 ADT along SR 228	N														0	0	3	2	0	3	0	0	**8**

Appendix B2:

Segment-Level Existing Inputs Summary

SR 228 Mars RR Bridge West Expansion - PennDOT HSM Spreadsheet Tool Input Summary

Urban and Surburban Arterials Segment Data																								
Segment #	SR 837		Segment Type (2U, 3T, 4U, 4D, 5T)	Length of Segment (ft.) *measured from google earth*	Length of Segment (miles)	AADT (Both Directions)	Posted Speed Limit (≤ 30 mph OR > 30 mph)	On-Street Parking?	Roadside and Other Data												Existing Crash Data (2011-2015)					
																					Multi-Vehicle (Driveway-Related)		Multi-Vehicle (Non-Driveway)		Single-Vehicle	
	From	To							Major Commercial Driveways	Minor Commercial Driveways	Major Industrial/ Institutional Driveways	Minor Industrial/ Institutional Driveways	Major Residential Driveways	Minor Residential Driveways	Other Driveways	Segment Lighting?	Roadside Fixed Object Density (# of fixed objects on both sides/segment length in miles)	Offset to Roadside Fixed Objects (2.5,10,15,20,25,or 30)	Auto Speed Enforcement?	KABC	PDO	KABC	PDO	KABC	PDO
A	Segment 0030	Segment 0040	4D	2745	0.52	31,500	40	N	1	2	0	0	0	0	0	N	85	30	N	1	1	1	3	0	0
B	Segment 0040	Segment 0050	3T	2210	0.42	30,100	40	N	0	1	0	0	0	0	0	N	55	30	N	0	0	3	4	0	0
C	Segment 0050	Castle Creek Dr (East)	3T	1260	0.24	28,500	40	N	0	0	0	0	0	0	0	N	25	30	N	1	1	2	2	0	1
D	Castle Creek Dr (East)	Adams Ridge Blvd	3T	1455	0.28	28,000	40	N	0	1	0	0	0	0	0	N	105	30	N	0	0	3	3	0	1
E	Adams Ridge Blvd	Segment 0070	2U	1800	0.34	24,400	50	N	0	1	0	1	0	1	0	N	45	30	N	0	0	2	3	1	0
F	Segment 0070	Segment 0080	2U	1795	0.34	23,700	50	N	0	0	0	0	1	2	0	N	35	30	N	0	1	1	2	1	2
G	Segment 0080	Segment 0090	2U	2007	0.38	25,300	50	N	0	0	0	0	0	4	0	N	60	30	N	0	0	0	1	0	2
H	Segment 0090	Segment 0100	2U	2860	0.54	26,750	50	N	0	0	0	0	0	1	0	N	45	30	N	1	0	1	4	1	3

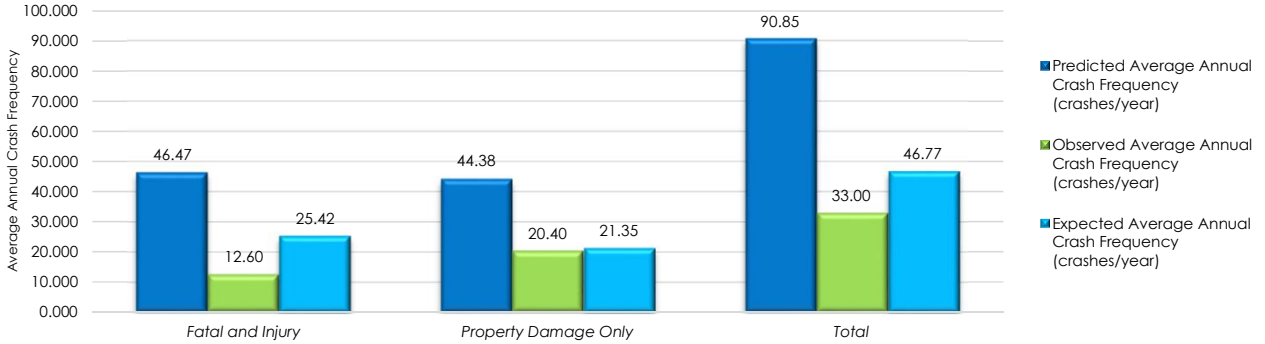
Appendix C

PennDOT Highway Safety Manual Analysis Tool Spreadsheet Summary Reports

Project Safety Performance Summary Report

Project Description	Route 228 Mars RR Bridge West Expansion
Date	4/25/2017
Analysis Year	2017
Analysis Type	Site Level Analysis
Facility Type(s)	Urban/Suburban Arterials

Summary of Average Safety Performance for the Project (crashes/year)



Project Totals	*Fatal and Injury Crashes*	*Property Damage Only Crashes*	*Total Crashes*
Predicted Average Annual Crash Frequency	46.47	44.38	90.85
Observed Average Annual Crash Frequency	12.60	20.40	33.00
Expected Average Annual Crash Frequency	25.42	21.35	46.77
Potential for Safety Improvement (PSI)	-21.05	-23.03	-44.08

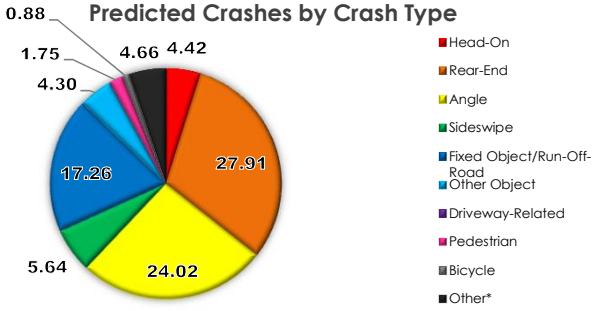
Total Project Summary

Segments	*Fatal and Injury*	*Property Damage Only*	*Total*
Predicted Average Annual Crash Frequency (crashes/yr)	31.59	30.58	62.17
Observed Average Annual Crash Frequency (crashes/yr)	3.80	6.80	10.60
Expected Average Annual Crash Frequency (crashes/yr)	13.17	8.73	21.90

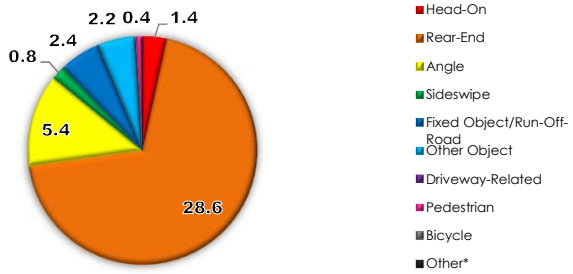
Intersections	*Fatal and Injury*	*Property Damage Only*	*Total*
Predicted Average Annual Crash Frequency (crashes/yr)	14.88	14.25	28.68
Observed Average Annual Crash Frequency (crashes/yr)	8.80	13.60	22.40
Expected Average Annual Crash Frequency (crashes/yr)	12.24	12.63	24.87

Total	*Fatal and Injury*	*Property Damage Only*	*Total*
Predicted Average Annual Crash Frequency (crashes/yr)	46.47	44.38	90.85
Observed Average Annual Crash Frequency (crashes/yr)	12.60	20.40	33.00
Expected Average Annual Crash Frequency (crashes/yr)	25.42	21.35	46.77

Project Total: Predicted Crashes by Crash Type



Project Total: Observed Crashes by Crash Type



*Note: "Other Crashes" include animal, overturn, parked vehicle, noncollisions, and other single-/multiple-vehicle crashes

Project Safety Performance Detailed Report

Urban and Suburban Arterials

Project Description Route 228 Mars RR Bridge West Expansion
Date 4/25/2017
Analysis Year 2017
Analysis Type Site Level Analysis
Facility Type(s) Urban/Suburban Arterials

Urban and Suburban Arterials: Segments

Segment Name	*PennDOT Segment*	*PennDOT Offset*	*Total Predicted Crashes*	*Total Observed Crashes*	*Total Expected Crashes*	*Potential for Safety Improvement*
Segment 1	40	0	10.32	1.20	2.45	-7.87
Segment 2	50	0	11.64	1.40	3.23	-8.41
Segment 3	50	1417	4.72	1.40	2.50	-2.22
Segment 4	60	860	10.31	1.40	3.14	-7.17
Segment 5	70	0	5.11	1.20	2.43	-2.68
Segment 6	80	0	4.51	1.40	2.47	-2.05
Segment 7	90	0	6.72	0.60	2.19	-4.53
Segment 8	100	0	8.84	2.00	3.50	-5.34

Project Safety Performance Detailed Report

Urban and Suburban Arterials

Project Description Route 228 Mars RR Bridge West Expansion
Date 4/25/2017
Analysis Year 2017
Analysis Type Site Level Analysis
Facility Type(s) Urban/Suburban Arterials

Urban and Suburban Arterials: Intersections

Intersection Name	*Major Road*	*Minor Road*	*Total Predicted Crashes*	*Total Observed Crashes*	*Total Expected Crashes*	*Potential for Safety Improvement*
Intersection 1	SR 228	Franklin Rd	4.00	2.20	3.01	-0.99
Intersection 2	SR 228	Castle Creek Dr (West)	4.82	1.60	2.86	-1.96
Intersection 3	SR 228	Castle Creek Dr (East)	3.44	2.80	3.13	-0.30
Intersection 4	SR 228	Seven Fields Blvd	4.79	3.00	3.75	-1.04
Intersection 5	SR 228	Adams Ridge Blvd	3.82	5.40	4.78	0.96
Intersection 6	SR 228	Myoma Rd	1.49	3.80	2.46	0.97
Intersection 7	SR 228	heritage Creek Dr	3.71	1.20	2.32	-1.39
Intersection 8	SR 228	Sharberry Ln	0.86	0.80	0.85	-0.01
Intersection 9	SR 228	Beaver St Ext	1.74	1.60	1.71	-0.04