Predictive Safety Analysis

Montgomery Planning

Predictive Safety Analysis

A proactive approach to identifying safety challenges and solutions

- Estimate the expected number of crashes at intersections and segments for key crash types

- Identify safety priorities and effective mitigations

- Working with UNC Highway Safety Research Center

Key Steps

1. Compile data

2. Estimate volumes

3. Identify key crash types

4. Develop Safety Performance Functions

5. Identify high-risk locations

6. Identify countermeasures

1. Compile Data

Transportation Characteristics

- Speed limit
- Number of lanes
- Roadway slope
- Presence and type of crosswalk
- Presence and type of bicycle facility
- Roadway classification
- Intersection control
- Lighting
- Transit service

Land Use Characteristics

- Parks
- Hospitals
- Gas stations
- Parking lots
- Schools
- Government facilities
- Shopping centers
- Alcohol-serving locations
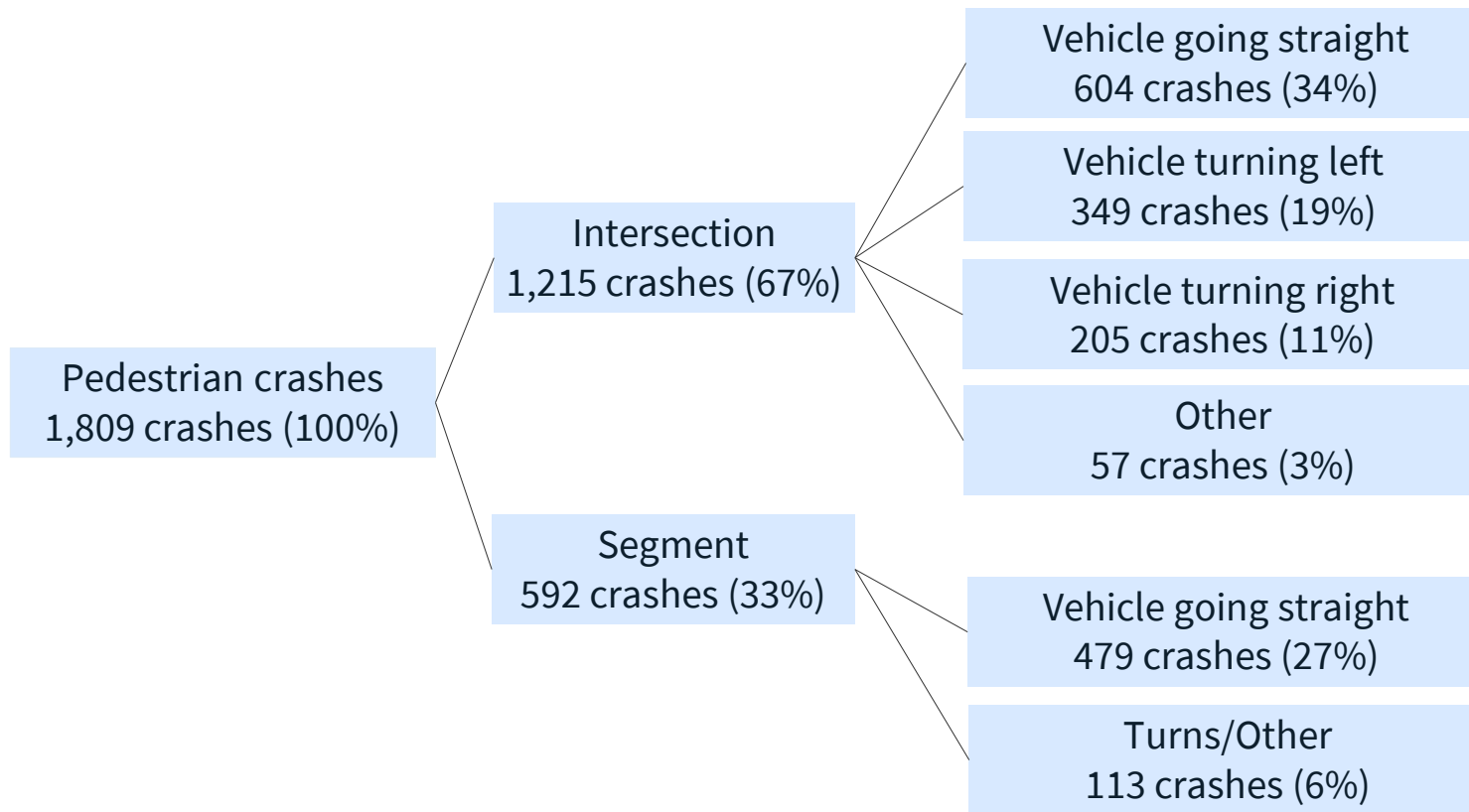- Population density
- Employment density

Demographic Characteristics

- Equity focus areas
- Income distribution
- Race/ethnicity distribution

2. Estimate Volumes

- Pedestrian, bicycle, and driver activity is referred to as exposure

- Exposure is a common variable in estimating crashes

- Compiled counts from development projects, MCDOT, and SHA

- Standardize counts based on time of day, day of week, season

- Estimate counts at all intersections and segments based on transportation, land use, and demographic attributes

3. Identify Key Crash Types

Pedestrian crashes
1,809 crashes (100%)

Intersection
1,215 crashes (67%)

Vehicle going straight
604 crashes (34%)

Vehicle turning left
349 crashes (19%)

Vehicle turning right
205 crashes (11%)

Other
57 crashes (3%)

Segment
592 crashes (33%)

Vehicle going straight
479 crashes (27%)

Turns/Other
113 crashes (6%)

Balance capturing most crashes with crash types linked to countermeasures

3. Identify Key Crash Types

- Pedestrian crashes after dark at intersections

- Pedestrian crashes along segments with vehicles going straight

- Bicycle crashes at intersections

- Left-turn crashes at intersections (all modes)

- Motor vehicle straight/angle crashes at intersections

- Single vehicle crashes along segments

Left-Turn Crashes

Straight/ Angle Crashes
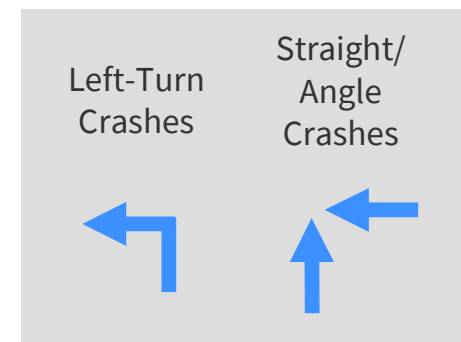
3. Identify Key Crash Types

Crash types address crashes of all severities to provide a large same size of locations. These crash types were selected given their high injury rates, and overall, they capture a large percentage of severe injuries and fatalities.

Crash Types Summary (2015-2019)

Crash Type	% Severe Injuries & Fatalities
Pedestrian Crashes	73%
Bicycle Crashes	65%
Motor Vehicle Crashes	41%
All Crash Types	**49%**

4. Develop Safety Performance Functions

Annual Pedestrian Crashes at an Intersection =

A*Number of Daily Pedestrians +

B*Number of Daily Vehicles +

C*Speed Limit of Major Road +

D*Speed Limit of Minor Road +

E*Number of Intersection Approaches +

F* Number of High-Visibility Crosswalks

This is an illustrative example and not based on real data!

4. Develop Safety Performance Functions

Pedestrian segment crashes with vehicles going straight

Statistically significant variables		Relationship to crashes
Exposure	Pedestrian traffic	+
	Motor vehicle traffic	+
Transportation	Segment length	+
	Dead end	-
	Street class (state road, major road)	+
	Parking lots	+
	Number of marked crosswalks	+
	Bus routes	+
Land Use	Alcohol establishments	+
	Recreational points of interest	-
	Business points of interest	-
Demographics	Population density	+
	Income	-

4. Develop Safety Performance Functions

- **Observed Crashes** are the historical crashes. These are the basis of most crash analysis but are biased by the random nature of crashes.

- **Predicted Crashes** are the outcome of the SPFs and account for the characteristics in the SFP equation. They are useful for identifying sites which may not have many observed crashes but have the potential to be high-crash sites based on their characteristics.

- **Empirical-Bayes (EB) Crashes ("Crash Risk")** weighs both observed and predicted crashes based on 1) how well the SPF predicts crashes and 2) the number of predicted crashes at the specific location. EB crashes are the most reliable estimate of the underlying crash frequency at a given location based on all available information.

5. Identify High-Risk Locations

- **Total Annual Crash Risk** the sum of the crash risk for each crash type. This assessment determines which areas have the greatest overall crash risk.

- **Hot Spot Analysis** looks at the top 200 locations with the highest crash risk. This analysis determines the specific locations with the greatest safety challenges and can inform stand-alone capital projects.

- **Average Annual Crash Risk** applies a broader lens to understanding crash risk by dividing the number of crashes by the number of locations for each crash type. This analysis determines type of locations with the greatest safety challenges and can inform systemic improvements.

https://mcplanning.maps.arcgis.com/apps/instant/basic/index.html?appid=e098e5d417744973aee13cf3c97fa3b1

5. Identify High-Risk Locations

Equity Emphasis Areas vs. Non-Equity Emphasis Areas

EEA	# Ints.	Intersection Crashes				# Segs.	Segment Crashes	
		Ped Dark	Bike	Left Turn	Angle		Ped Seg	Single Veh
Total Crash Risk (# Annual Crashes)								
EEA	3,087	49	25	253	280	5,049	32	125
Non-EEA	13,606	58	62	482	595	26,033	51	663
Hot Spot Analysis (# Locations within the Top 200)								
EEA	3,087	107	67	80	75	5,049	133	26
Non-EEA	13,606	93	133	120	125	26,033	67	174
Average Crash Risk (# Annual Crashes)								
EEA	3,087	0.02	0.01	0.08	0.36	5,049	.007	.025
Non-EEA	13,606	0.00	0.00	0.04	0.20	26,033	.002	.026

Highlighted cells have the highest value for any column.

5. Identify High-Risk Locations

Equity Emphasis Areas vs. Non-Equity Emphasis Areas

EEA	# Ints.	Intersection Crashes				# Segs.	Segment Crashes	
		Ped Dark	Bike	Left Turn	Angle		Ped Seg	Single Veh
Total Crash Risk (# Annual Crashes)								
EEA	3,087	49	25	253	280	5,049	32	125
Non-EEA	13,606	58	62	482	595	26,033	51	663
Hot Spot Analysis (# Locations within the Top 200)								
EEA	3,087	107	67	80	75	5,049	133	26
Non-EEA	13,606	93	133	120	125	26,033	67	174
Average Crash Risk (# Annual Crashes)								
EEA	3,087	0.02	0.01	0.08	0.36	5,049	.007	.025
Non-EEA	13,606	0.00	0.00	0.04	0.20	26,033	.002	.026

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		+270%	+75%	+130%	+82%		+226%	-4%

5. Identify High-Risk Locations

Complete Streets Design Guide Area Type

CSDG Area Type	# Ints.	Intersection Crashs				# Segs.	Segment Crashes	
		Ped Dark	Bike	Left Turn	Angle		Ped Seg	Single Veh
Total Crash Risk (# Annual Crashes)								
Downtown	372	32	12	87	87	786	13	42
Town Center	810	20	11	132	132	1,722	17	83
Suburban	12,187	37	49	340	474	22,602	39	430
Country	1,027	0	2	22	20	1,898	3	155
Hot Spot Analysis (# Locations within the Top 200)								
Downtown	372	88	47	22	27	786	53	3
Town Center	810	45	36	42	43	1,722	75	20
Suburban	12,187	40	87	87	97	22,602	34	95
Country	1,027	0	0	1	4	1,898	1	67
Average Crash Risk (# Annual Crashes)								
Downtown	372	0.09	0.03	0.24	0.73	786	0.02	0.06
Town Center	810	0.03	0.01	0.18	0.75	1,722	0.01	0.05
Suburban	12,187	0.00	0.00	0.03	0.17	22,602	0.00	0.02
Country	1,027	0.00	0.00	0.02	0.16	1,898	0.00	0.08

Highlighted cells have the highest value for any column.

5. Identify High-Risk Locations

Portion of Total Annual Crash Risk included in Top 200 Locations

Crash Type	Total Annual Crash Risk	% Crash Risk in Top 200
Pedestrian crashes after dark at intersections	106	47%
Pedestrian crashes along segments with vehicles going straight	83	23%
Bicycle crashes at intersections	86	25%
Left-turn crashes at intersections (all modes)	734	46%
Motor vehicle straight/angle crashes at four-legged intersections	875	48%
Single vehicle crashes along segments	787	27%

Predictive Safety Analysis

5. Identify High-Risk Locations

Key Takeaways

- Investments need to balance location types with high total crash risk, hot spots, and location types with high average crash risk.

- Prioritization needs to look beyond crash history, as only 55% of fatalities and 46% of severe injuries occurred in top 200 intersections and roadway segments.

- Safety improvements in Equity Emphasis Areas should be prioritized.

- While much of the county is suburban, downtown and town center area types (and their associated street types) have high average crash risk.

6. Identify Countermeasures

Speed Management
- Automated Enforcement – Speed Cameras
- Lower Speed Limit by 5 MPH
- Speed Humps

Pedestrian Crossings
- High-Visibility Crosswalks
- Raised Pedestrian Crosswalk
- Pedestrian Hybrid Beacon

Intersection Control
- Convert Side-Street Stop to All-Way Stop
- Install Traffic Signal
- Convert Median to a "Left-In-Only" Median

Signal Timing
- Increase All-Red Clearance Interval
- Implement Protected/Permissive Left Turn
- Implement Fully Protected Left Turn
- Leading Pedestrian Interval

Other Countermeasures
- Centerline Rumble Strips
- Lighting

6. Identify Countermeasures

Dynamic tools to evaluate different countermeasure scenarios through the following metrics:

- Potential Crash Reduction

- Potential Crash Reduction per Location

- Cost per Crash Reduced

- Percent of Locations in Equity Emphasis Area

Print a list of top-ranked location for each scenario.

6. Identify Countermeasures

Example 1: Determining which Countermeasures to Implement

Example Scenarios for Reducing Angle Crashes with $350,000 (10-Year Impact)

Scenarios	Increase All Red Clearance*	All-Way Stop	Traffic Signal
Number of Locations	116	70	1
Total Estimated Cost	$348,000	$350,000	$350,000
Predicted Crash Reduction	2,557	311	47
Crash Reduction per Location	22.0	4.4	47.4
Cost per Crashes Reduced	$140	$1,130	$7,380
% of Locations in Equity Emphasis Areas	47%	21%	0%

* on Boulevards, Downtown Boulevards, Town Center Boulevards, Major Highways

6. Identify Countermeasures

Example 2: Assessing How Many Locations to Improve

Example Scenarios for Improving Lighting at Signalized Intersections (10-Year Impact)

Scenarios	20 Locations	40 Locations	60 Locations
Total Estimated Cost	$100,000	$200,000	$300,000
Predicted Crash Reduction	48	87	109
Crash Reduction per Location	2.4	2.2	1.8
Cost per Crashes Reduced	$2,100	$2,300	$2,700
% of Locations in Equity Emphasis Areas	55%	48%	38%

Applications

Data-driven approach to recommendations, mitigation, and prioritization

- CIP Project Funding

- Systemic Projects Prioritization

- Master Planning

- Regulatory Review

- Grant Applications

Questions?

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Report Link: https://montgomeryplanningboard.org/wp-content/uploads/2022/07/Attachment-A.-PSA-Final-Report-July-2022.pdf

Screenshot: Excel Dashboard Tool

Instructions: Fill in the light yellow cells using the drop down menu or typing a number

	Scenario 1	Scenario 2	Scenario 3
Location Type	Intersection	Intersection	Intersection
Crash Type	Motor vehicle angle crashes at four legged intersections	Motor vehicle angle crashes at four legged intersections	Motor vehicle angle crashes at four legged intersections
Countermeasure	Increase All Red Clearance Time- Boulevards, Downtown Boulevards, Town Center Boulevards, Major Highways	Convert Side-Street Stop Control to All-Way Stop	Install a Traffic Signal
Total Applicable Locations in Montgomery County	306	148	76
Select # of Locations to Apply Countermeasure	116	70	1
% of Locations in Equity Emphasis Areas	47%	21%	0%
Time Horizon (Years)	10	10	10

		Cost Summary	
Estimated Cost per Countermeasure	$3,000	$5,000	$350,000
Total Estimated Cost	$348,000	$350,000	$350,000

			Overall Results	
Total	Annual Predicted Crashes	1266	46	11
	Potential Crash Reduction	256	31	5
	Potential Crash Reduction per Location	2.20	0.44	4.74
	Cost per Annual Crash Reduced	$1,400	$11,300	$73,800
	Total Years Crash Reduction per Location	22.05	4.44	47.40
	Total Years Cost per Crashes Reduced	$140	$1,130	$7,380

			Detailed Results	
Selected Crash Type	Annual Predicted Crashes	281	17	2
	Potential Crash Reduction	57	12	1
	Potential Crash Reduction per Location	0.49	0.17	1.19
Other Crashes at Relevant Locations	Annual Predicted Crashes	984	28	9
	Potential Crash Reduction	199	19	4
	Potential Crash Reduction per Location	1.71	0.27	3.55

Screenshot: Excel Table Tool

The table below summarizes a countermeasure and its impacts. Fill in the light yellow cells.

Fill in the the different location rank categories. The ranking represents the locations with the highest predicted crash risk for that crash type given the noted context.

Group 1 Max	10
Group 2 Max	20
Group 3 Max	30
Group 4 Max	40
Group 5 Max	50

Select the # of years for the improvement's benefit and amortized cost.

20

Explore where we could recommend implementation of the countermeasures. Cells highlighted in blue meet crash reduction threshold, pink meet cost threshold, and purple meet both.

Thresholds for Prioritization

Crash Reduction per Location	5
Cost per Crash Reduced	$1,500

Countermeasure		Centerline Rumble Strip
Context	Roads in Country areas with two lanes	
Primary Crash Type	SV	
Unit Cost	$2 per foot Source: MCDOT	
CMF	0.81 (19% reduction) for single-vehicle crashes in rural areas; 0.86 (14% reduction) for all modes in rural areas	
Locations	1,850	

Ranked Locations	Crash Type: SV			Other Crashes			Total Crashes			Countermeasure Cost		20-Year Summary		Percent of Locations in EEA
	Annual Crashes	Potential Crash Reduction	Potential Crash Reduction per Location	Annual Crashes	Potential Crash Reduction	Potential Crash Reduction per Location	Annual Crashes	Potential Crash Reduction	Potential Crash Reduction per Location	Total	Cost per Crash Reduced	Potential Crash Reduction per Location	Cost per Crash Reduced	
1-10	18	3	0.34	8	1	0.11	26	5	0.45	$123,800	$27,400	9.0	$1,370	0%
11-20	13	2	0.24	2	0	0.02	14	3	0.26	$141,600	$53,700	5.3	$2,680	0%
21-30	10	2	0.20	1	0	0.02	12	2	0.22	$117,100	$54,200	4.3	$2,710	0%
31-40	9	2	0.17	5	1	0.07	14	2	0.24	$87,200	$37,100	4.7	$1,850	0%
41-50	7	1	0.14	5	1	0.06	12	2	0.21	$118,100	$57,300	4.1	$2,870	0%
>50	116	22	0.00	101	14	0.00	217	36	0.00	$3,624,800	$99,400	0.0	$4,970	0%
Total	173	33	0.66	121	17	0.34	294	50	1.00	$4,212,600	$83,900	1.0	$4,200	0%

Screenshot: Locations (from Table Tool)

Countermeasure	Centerline Rumble Strip		
Rank	Location	Location ID	Jurisdiction
1	DARNESTOWN RD BETWEEN DICKERSON RD/MARTINSBURG RD & HUNTER RD	S29457	County Jurisdiction
2	CLARKSBURG RD BETWEEN LEWISDALE RD & HYATTSTOWN MILL RD/KINGSLEY RD	S29187	County Jurisdiction
3	GEORGIA AVE BETWEEN NEW HAMPSHIRE AVE/DAMASCUS RD & GREGG RD	S32094	County Jurisdiction
4	BUCKLODGE RD BETWEEN MOORE RD & DARNESTOWN RD	S31874	County Jurisdiction
5	RIVER RD BETWEEN MAIDENS BOWER DR/LONGACRES PRESERVE CT & PETTIT WAY	S27884	County Jurisdiction
6	GERMANTOWN RD BETWEEN BLACK ROCK RD & CITIZENS LN	S31559	County Jurisdiction
7	DARNESTOWN RD BETWEEN BUCKLODGE RD & CATTAIL RD	S30441	County Jurisdiction
8	CLARKSBURG RD BETWEEN HYATTSTOWN MILL RD/KINGSLEY RD & SNOWDEN FARM PKWY	S29618	County Jurisdiction
9	DARNESTOWN RD BETWEEN BELLINGHAM DR & WHITES FERRY RD	S29517	County Jurisdiction
10	DARNESTOWN RD BETWEEN BUCKLODGE RD & WHITE GROUND RD	S28811	County Jurisdiction
11	SLIDELL RD BETWEEN COMUS RD & OLD BALTIMORE RD	S31513	County Jurisdiction
12	BUCKLODGE RD BETWEEN WHITES STORE RD & MOORE RD	S31827	County Jurisdiction
13	DARNESTOWN RD BETWEEN JERUSALEM RD & BEALLSVILLE RD	S29600	County Jurisdiction
14	PARTNERSHIP RD BETWEEN WHITES FERRY RD & SUGARLAND RD	S31788	County Jurisdiction
15	DAMASCUS RD BETWEEN FARM ACCESS RD & WINDCREST LN	S31698	County Jurisdiction
16	WHITES STORE RD BETWEEN BUCKLODGE RD & PEACH TREE RD	S31889	County Jurisdiction
17	ELMER SCHOOL RD at WHITES FERRY RD	S29754	County Jurisdiction
18	RIVER RD BETWEEN HUNTING QUARTER RD & HUNTING QUARTER RD/HUGHES RD	S28058	County Jurisdiction
19	RIVER RD BETWEEN PARTNERSHIP RD & HUNTING QUARTER RD	S31635	County Jurisdiction
20	MARTINSBURG RD BETWEEN DICKERSON CP ENT & WHITES FERRY RD	S30242	County Jurisdiction
21	WHITES FERRY RD BETWEEN MORROW RD & PARTNERSHIP RD	S31883	County Jurisdiction
22	BARNESVILLE RD BETWEEN SUGAR RIDGE TER & PEACH TREE RD	S31695	County Jurisdiction
23	PEACH TREE RD BETWEEN BETH FARM CUT THRU CUT/MOORE RD & DARNESTOWN RD	S29530	County Jurisdiction
24	PARTNERSHIP RD BETWEEN SUGARLAND RD & RIVER RD	S31524	County Jurisdiction
25	SLIDELL RD BETWEEN OLD BALTIMORE RD & BARNESVILLE RD	S31748	County Jurisdiction
26	PEACH TREE RD BETWEEN COMUS RD & OLD BALTIMORE RD	S31636	County Jurisdiction
27	HUNTER RD BETWEEN DARNESTOWN RD & WASCHE RD	S32170	County Jurisdiction

5. Identify High-Risk Locations

Complete Streets Design Guide Street Type:
Total Crash Risk (# Annual Crashes)

CSDG Street Type	# Ints.	Intersection Crash Types				# Segs.	Segment Crash Types	
		Ped Dark	Bike	Left Turn	Angle		Ped Seg	Single Veh
Major Highway	18	1	1	11	13	12	0	13
Boulevard	1,191	29	33	334	359	1,145	15	145
Downtown Blvd	134	20	6	57	58	161	7	14
Town Center Blvd	225	13	6	70	89	272	9	26
Downtown Street	210	13	4	26	26	339	5	10
Town Center Street	138	1	1	11	12	186	2	8
Neighborhood Conn	2,825	8	14	64	132	2,956	9	100
Country Conn	280	0	1	14	13	213	1	47
Country Road	90	0	0	1	1	60	0	4
Industrial Street	50	0	0	5	1	58	0	2
Neighborhood Street	9,132	9	6	21	55	21,357	23	311
Rustic Road*	183	0	0	2	4	317	1	36

Highlighted cells have the highest value for any column.

5. Identify High-Risk Locations

Complete Streets Design Guide Street Type:
Hot Spot Analysis (# Locations within the Top 200)

CSDG Street Type	# Ints.	Intersection Crash Types				# Segs.	Segment Crash Types	
		Ped Dark	Bike	Left Turn	Angle		Ped Seg	Single Veh
Major Highway	18	1	0	2	5	12	2	7
Boulevard	1,191	50	109	109	104	1,145	35	37
Downtown Blvd	134	48	29	18	16	161	32	0
Town Center Blvd	225	35	21	22	25	272	51	3
Downtown Street	210	40	8	3	5	339	18	0
Town Center Street	138	0	0	2	3	186	5	1
Neighborhood Conn	2,825	2	7	5	17	2,956	5	3
Country Conn	280	0	0	2	2	213	0	23
Country Road	90	0	0	0	0	60	0	0
Industrial Street	50	0	0	2	0	58	0	0
Neighborhood Street	9,132	1	6	1	1	21,357	16	101
Rustic Road*	183	0	0	2	0	317	0	10

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Complete Streets Design Guide Street Type:
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CSDG Street Type	# Ints.	Intersection Crash Types				# Segs.	Segment Crash Types	
		Ped Dark	Bike	Left Turn	Angle		Ped Seg	Single Veh
Major Highway	18	0.05	0.03	0.60	1.08	12	0.02	1.06
Boulevard	1,191	0.02	0.03	0.28	0.81	1,145	0.01	0.13
Downtown Blvd	134	0.16	0.05	0.43	1.09	161	0.04	0.09
Town Center Blvd	225	0.06	0.03	0.31	1.33	272	0.03	0.10
Downtown Street	210	0.06	0.02	0.12	0.33	339	0.01	0.03
Town Center Street	138	0.01	0.01	0.08	0.32	186	0.01	0.05
Neighborhood Conn	2,825	0.00	0.00	0.02	0.15	2,956	0.00	0.03
Country Conn	280	0.00	0.00	0.05	0.22	213	0.00	0.22
Country Road	90	0.00	0.00	0.01	0.12	60	0.00	0.06
Industrial Street	50	0.01	0.01	0.10	0.28	58	0.01	0.04
Neighborhood Street	9,132	0.00	0.00	0.00	0.03	21,656	0.00	0.02
Rustic Road*	183	0.00	0.00	0.01	0.26	317	0.00	0.12

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