Crash Analysis Process

January 2016

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Southeast Michigan Council of Governments

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Mission

SEMCOG's mission is solving regional planning problems — improving the efficiency and effectiveness of the region's local governments as well as the quality of life in Southeast Michigan. Essential functions are:

- providing a forum for addressing issues which extend beyond individual governmental boundaries by fostering collaborative regional planning, and
- facilitating intergovernmental relations among local governments and state and federal agencies.

As a regional planning partnership in Southeast Michigan, SEMCOG is accountable to local governments who join as members. Membership is open to all counties, cities, villages, townships, intermediate school districts, community colleges and public universities in Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw, and Wayne Counties.

Responsibilities

SEMCOG's primary activities support local planning through use of SEMCOG's technical, data, and intergovernmental resources. In collaboration with local governments, SEMCOG has responsibility for adopting regionwide plans and policies for community and economic development, water and air quality, land use, and transportation, including approval of state and federal transportation projects. Funding for SEMCOG is provided by federal and state grants, contracts, and membership fees.

Policy decision making

All SEMCOG policy decisions are made by local elected officials, ensuring that regional policies reflect the interests of member communities. Participants serve on one or both of the policymaking bodies — the General Assembly and the Executive Committee.

Prior to policy adoption, technical advisory councils provide the structure for gaining input on transportation, environment, community and economic development, data analysis, and education. This deliberative process includes broad-based representation from local governments, the business community, environmental organizations, and other special interest and citizen groups.

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Abstract

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This report was written by SEMCOG in collaboration with representatives from various traffic safety agencies, including Michigan State Police Office of Highway Safety Planning (OHSP), Criminal Justice Information Center (CJIC), and the University of Michigan Transportation Research Institute (UMTRI).

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1. Introduction

1.1 Background

SEMCOG produced the traffic safety manual in 1997. This manual describes a comprehensive approach to traffic safety analysis, from collecting potentially useful information to ranking tentative solutions. The SEMCOG traffic safety manual includes great detail on data collection and maintenance, identification of high-crash locations, determination of countermeasures, crash reduction factors and costs, benefit/cost analysis.

Identifying high-crash locations is a vital first step in achieving cost-effective reductions in highway crash losses. This document covers the selection of locations to be evaluated, number of years of crash data which should be analyzed, length considerations in defining locations and commonly used methods for identifying high-crash locations.

SEMCOG has updated the high crash analysis for each of the peer groups. The traffic crash data from 2012-2014 was used to calculate a crash probability index (CPI) to identify high-crash locations. There are new tables (2 and 3) in Appendix B and C that were added for road segment analysis and road segments without intersections to complement the intersection analysis along with an updated peer group analysis. The intersections tables (Tables 1.1 through 1.4) that are used for this analysis only encompass the crashes in a one hundred and fifty foot radius from the center of the bisecting federal aid roads, the road segments tables (Tables 2.1 through 2.4) used in the this analysis will include the intersections on either end, the road segments without intersections tables (Tables 3.1 through 3.4) used in the this analysis will not include the intersections on either end.

The peer groups are broken down into natural volume groupings in which the data help dictate. The data is further grouped by functional class, lane miles, and un-signalized and signalized intersections and segments with three years of crash data being used to fill the tables. These tables are attached in Appendix A, B, and C and can be used to with further analysis.

For each location for which volume data was available, a CPI was calculated. The CPI is the sum of points assigned for a **crash frequency, crash rate, or casualty ratio** that falls above a critical value for each measure. Critical values for frequency and for casualty ratio are one standard deviation above the mean of each sample.

In SEMCOG's analysis, five points were assigned to an intersection or segment if its crash frequency exceeded a critical value, five points were assigned if the crash rate exceeded a critical value, and ten points were assigned to a location with a casualty ratio above a critical level. An intersection or segment with all three measures exceeding critical values would have a CPI of twenty.

1.2 Purpose

The purpose of this work is to develop a method for conducting a regional peer analysis for determining if intersections and segments are "high-crash" compared to other similar intersections and segments throughout the region.

2. Procedure

Crash data for the most recent one- to three-year period are normally used. The roadway network is divided into spots and segments. Isolated curves, bridges, railroad crossings and intersections are examples of spots. Segments are defined by a particular section length (typically in the range of one to five miles) or as the section of roadway between two spots. Spots should be defined to include the area of influence of the feature in question.

Information needed for the segment and intersection being studied to calculate a Crash Probability Index (CPI) requires:

As many of the following features as possible:

a. area type (urban/rural),
b. roadway functional class (arterial/collector/local) — for an intersection, the higher or highest functional class of the intersecting roadways, where an arterial is the highest class (meant primarily to carry through traffic) and a local is the lowest class (meant primarily to provide access to abutting properties);
c. number of lanes — for an intersection, the number of through lanes on the widest approach;
d. predominant traffic control — for an intersection, the presence or absence of signalization and for a segment, the speed limit; and
e. average annual daily traffic (AADT) volume (the 10,000 vehicle per day range within which the location's AADT falls; e.g., 0 to 10,000, 10,001 to 20,000, etc.) — for an intersection, the sum of the volumes on all approaches.

3. Methods for Identifying High-Crash Intersections and Segments

There are three methods for identify high crash location – crash frequency, crash rate and casualty ratio method.

3.1 Crash Frequency Method

This method ranks locations by the number of reported crashes (or crashes per mile), with frequencies listed in descending order. The spot critical crash frequency is calculated by adding the number of crashes for the evaluation period and dividing by the number of years being evaluated.

Spot Critical Crash Frequency = Total Number of crashes/Number of years Eq. (3-1)

Preferably three years of data should be evaluated, however, if three years' data are unavailable or there is a desire to examine a shorter period, as little as one year of data may be used with caution for locations having moderate to high traffic volumes. If a roadway segment is being studied, the crash frequency should be divided by the segment's length in miles to allow for fairer comparisons to segments of other lengths.

The Crash Frequency Method does not take into account the differing amounts of traffic at the locations compared. Hence, the method tends to rank a high-volume location as a high-crash location, even if the location has a relatively low number of crashes compared to its traffic volume. Many agencies use the Crash Frequency Method to select an initial list of suspect locations, and then evaluate the crash histories of the listed locations in greater detail using other methods (FHWA, 1986a).

3.2 Crash Rate Method

The Crash Rate Method compares the number of crashes to the volume of traffic, with the latter measured either as the number of vehicles crossing a spot in a given time period, or as the number of vehicle-miles of travel along a segment in that period. To express the associated crash rates in conveniently sized numbers, the spot rate is generally stated in terms of "crashes per million vehicles" (MV) and the segment rate in terms of "crashes per million vehicle-miles" (MVM).

The Crash Rate Method as defined in this document incorporates a technique known as the Rate Quality Control Method. This method applies an easy-to-use statistical test to determine whether the crash rate for a particular location is significantly higher than the average crash rate for other locations in the jurisdiction (or region) having similar characteristics. If it is, the location is classified as a high-crash location.

To apply the Crash Rate Method, complete the following steps for each location being studied:

- Determine the location's crash rate. Compute the crash rate using the appropriate equation below.

The equation for spot crash rate (SCRate) =

$$\frac{(1{,}000{,}000 \times spot\ critical\ crash\ frequency)}{(365 \times AADT \times Y \times L)} \qquad \text{Eq. (3-2)}$$

where, Spot critical crash frequency (calculated above is for frequency)
AADT = Average annual daily traffic for the spot (for an intersection, the sum of the volumes on all approaches).
Y = Number of years being analyzed
L = Length of the segment in miles (for intersection L is 1).

3.3 Casualty Ratio Method

The spot critical crash ratio is calculated by dividing the average number of fatal and injury a, b, and c crashes by the average number of all crashes. CR, using the following equation:

$$CR = \frac{F+A+B+C}{F+A+B+C+PDO} \qquad \text{Eq. (3-3)}$$

where, F = annual average number of fatal crashes,
A = annual average number of A-level injury crashes,
B = annual average number of B-level injury crashes,
C = annual average number of C-level injury crashes, and
PDO = annual average number of property-damage-only crashes.

4. Formulas for Calculating Average Critical Values

Presented below are formulas for computing critical crash frequency, critical crash rate and critical casualty ratio.

4.1 Critical Crash Frequency

Critical crash frequency is defined as Fcr and is computed with the equation:

$$Fcr = \text{Fav} + SF \qquad \text{Eq. (4-1)}$$

where Fav = average crash frequency for all locations of a given type,
SF = standard deviation of crash frequency for all locations of this type.

- Determine the critical crash frequency. Take one or more of the following approaches to determine a critical crash frequency for the corresponding location type:
- Look up one to four regional critical crash frequencies in tables developed by SEMCOG for intersections in Southeast Michigan (Tables 1.1 to 1.4) and compute an average value.
- These critical crash frequencies were computed with crash data for the entire SEMCOG region using the above equation. Local critical crash frequencies may be calculated using the appropriate statistical method detailed above. If a local critical crash frequency is derived, it is important to verify that the sample size is sufficient for the community.
- Choose a number of crashes per year (or per year per mile) which the community considers "high" and which is likely to be exceeded at only a few similar locations which the agency can reasonably be expected to study in detail. This number will be subjective and based primarily on community experience.

4.2 Critical Crash Rate

The Spot critical crash rate is denoted as SCCRate and is computed using the equation:

$$(Average\ Crash\ Rate) + \left((K) \sqrt{\frac{\text{Average Crash Rate}}{\frac{365 \times \text{Y} \times [\text{AADT}] \times [\text{L}]}{1{,}000{,}000}}} \right) \left(\frac{1}{\frac{2[365 \times Y \times (AADT) \times (L)]}{1{,}000{,}000}} \right)$$

Eq. (4-2)

where, Average Crash Rate = from the tables provided
AADT = Average Annual Daily Traffic
Y = Number of years being analyzed
L = Length of the segment (for intersection L is equal to 1).
K = factor based on desired confidence level for the test (Table 4.1).

A confidence level of 0.95 (or 95 percent) is the most commonly used in statistical testing. A smaller value (e.g., 0.90) will result in more locations being identified as high-crash, but it will also increase the probability that the crash frequencies for such locations are high by chance. The analyst may want to try alternative confidence levels and K values until a suitable number of high crash locations are identified for further study. The confidence level for the test is the probability that a crash rate is sufficiently large that it cannot be reasonably attributed to random occurrences.

A 95% confidence interval was used to calculate the regional critical crash rates found in this document.

Table 4.1
K Values Commonly Used in Computing Critical Values

Significant Level, alpha	0.10	0.05	0.01
Confidence Level, 1 - alpha	0.90	0.95	0.99
K Value	1.282	**1.645**	2.326

- Determine the spot critical crash rate:

  Look up one to four regional average crash rates in tables developed by SEMCOG for intersections in Southeast Michigan (Tables 1.1 to 1.4) and calculate spot critical crash rate for each of the four characteristics area type, functional class, number of lanes and traffic control by substituting values in the above equation. Local critical crash rates may be calculated using the appropriate statistical method, also detailed above. If a local critical crash rate is derived, it is important to verify that the sample size is sufficient for the community.

4.3 Critical Casualty Ratio

The casualty ratio is the proportion of all crashes that involve at least one fatality and/or non-fatality injury. The critical casualty ratio is denoted as CRcr and is computed with the equation:

$$\mathrm{CR}cr = \mathrm{CR}av + SCR \qquad \text{Eq. (4-3)}$$

where CRav = average casualty ratio for all locations of a given type,
SCR = standard deviation of the casualty ratio for all locations of this type.

The critical casualty ratio is determined for the corresponding location type by looking up one to four regional critical casualty ratios in tables developed by SEMCOG for intersections in Southeast Michigan (Tables 1.1 to 1.4) and computing an average value. These regional critical casualty ratios were computed with crash data for the entire SEMCOG region. Local critical casualty ratios may be calculated using the appropriate statistical method. If a local critical casualty ratio is derived, it is important to verify that the sample size is sufficient for the community.

Since the Crash Rate Method accounts for a location's traffic "exposure," it is less likely to unfairly condemn high-volume locations than when using the Crash Frequency Method. However, it tends to unfairly identify low-volume locations having relatively few crashes as high-crash locations. For example, a crash rate of two to three crashes per MVM is considered by some states to be an average rate for rural two-lane roads, exclusive of intersections (FHWA, 1986a). However, a one-mile segment with a traffic volume of only 300 vehicles per day and an average of only one crash per year would have a crash rate of 9.1 crashes per MVM. A rate more than three times the average makes the segment look unusually hazardous, even though only one crash occurred. Thus, the Crash Rate Method can yield misleading results for low-volume locations.

5. Crash Probability Index Method (CPI)

This method combines the Crash Frequency and Crash Rate Methods with a simplified severity method. This combination reduces the sometimes misleading results for high-volume and low-volume intersections when only one method is used. The CPI Method also allows the analyst to adjust the weights assigned to each measure according to the priorities of the community. For example, SEMCOG has concluded that severity is of great concern to the agency, so severity distribution is weighted twice as heavily as crash frequency and crash rate.

When the location's crash history is significantly worse than average for crash frequency, crash rate or severity distribution, it is assigned penalty points. These points are then summed across measures to determine an overall CPI. High-crash locations are selected from the top of a list of locations ranked in descending order by non-zero CPI.

To apply the CPI Method, complete the following steps for each location studied:

1. Determine the spot crash rate, crash frequency and casualty ratio (CR).
2. Determine the average critical crash rate, average critical crash frequency and average critical casualty ratio as described in the Crash Rate, Crash Frequency Methods, and Casualty Ratio respectively.
3. Compute the spot CPI value. Compare the spot's crash rate, crash frequency and casualty ratio to the corresponding average critical values in the following manner:

    a. If neither the spot crash rate, crash frequency nor casualty ratio equals or exceeds the corresponding average critical value, set the CPI for the location equal to zero.

    b. If the spot critical crash frequency is greater than the average critical crash frequency then assign **five** points to the spot penalty points.

    c. If the spot crash rate is greater than either spot critical crash rate for area type, functional class, number of lanes and traffic control than you assign **five** points to the spot penalty points.

    d. If the spot critical casualty ratio is greater than the average critical casualty ratio then assign **ten** points to the spot penalty points.

    e. Compute the spot CPI by summing the penalty points assessed in the preceding sub-steps.

If there is a desire to assign a greater or lesser weight to any of the measures, the penalty points for equaling or exceeding the critical rate may be set equal to any value determined by the analyst. The number of points chosen for this purpose should be the same, however, for all locations studied and ranked in a given analysis.

Appendix A

Table: 1.1

Regional Critical Intersection Crash Rates, Frequencies and Casualty Ratios: By Area Type

Average Daily Traffic Volume Entering Intersection	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Intersections Sampled
Urban[2]						
1 - 10,000	1.19	1.82	3.87	0.22	0.49	2,041
10,001 - 20,000	0.69	3.68	7.14	0.22	0.43	1,960
20,001 - 30,000	0.76	6.9	13.14	0.22	0.4	1,467
30,001 - 40,000	0.78	9.82	19.46	0.22	0.38	921
40,001 - 50,000	0.85	13.83	25.15	0.21	0.34	419
50,001 - 60,000	1.05	20.8	37.12	0.22	0.33	193
60,001 - 70,000	0.96	22.3	42.65	0.21	0.33	94
70,001 - 80,000	0.9	24	46.8	0.23	0.35	24
over 80,000	0.69	21.07	42.8	0.23	0.34	10
Rural[2]						
1 - 10,000	1.2	1.15	2.09	0.2	0.48	536
10,001 - 20,000	0.56	2.81	5.39	0.24	0.51	115
over 20,000	0.29	2.72	6.59	0.2	0.44	78

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012 - 2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 1.2

Regional Critical Intersection Crash Rates, Frequencies and Casualty Ratios: By Higher Functional Class of Roadway

Average Daily Traffic Volume Entering Intersection	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Intersections Sampled
Arterial[2]						
1 - 10,000	0.95	1.98	4.07	0.22	0.49	1,175
10,001 - 20,000	0.71	3.78	7.28	0.23	0.44	1,834
20,001 - 30,000	0.78	7.06	13.28	0.22	0.39	1,387
30,001 - 40,000	0.83	10.44	20.26	0.23	0.38	839
40,001 - 50,000	1	16.25	27.35	0.21	0.32	341
50,001 - 60,000	1.25	24.78	40.29	0.22	0.29	156
60,001 - 70,000	1.26	29.04	48.73	0.21	0.28	69
70,001 - 80,000	1.22	32.65	54.41	0.19	0.23	17
over 80,000	1.06	32.67	53.73	0.26	0.34	6
Major Collector[2]						
1 - 10,000	1.37	1.42	3.04	0.2	0.48	1,212
10,001 - 20,000	0.65	3.04	5.89	0.2	0.39	104
20,001 - 30,000	0.4	3.47	5.5	0.14	0.24	5
over 30,000	0.2	2.6	5.5	0.18	0.38	5
Collector or Local[2]						
1 - 10,000	3.44	0.56	0.88	0.25	0.64	45

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 1.3

Regional Critical Intersection Rates, Frequencies and Casualty Ratios: By No. of Through Lanes on Widest Approach

Average Daily Traffic Volume Entering Intersection	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Intersections Sampled
One Lane[2]						
1 - 10,000	2.49	1.2	2.5	0.24	0.59	41
10,001 - 20,000	0.3	1.56	2.51	0.12	0.32	6
over 20,000	0.02	0.33	0.33	0	0	1
Two Lanes[2]						
1 - 10,000	1.2	1.59	3.19	0.21	0.48	1,171
10,001 - 20,000	0.62	3.14	5.94	0.21	0.42	599
20,001 - 30,000	0.65	5.73	11.27	0.21	0.4	283
30,001 - 40,000	0.52	6.43	14.13	0.22	0.42	139
40,001 - 50,000	0.55	8.67	18.04	0.19	0.35	64
50,001 - 60,000	0.39	7.45	17.35	0.17	0.33	17
over 60,000	0.28	6.89	15.6	0.25	0.44	18
Three, Four and Five or More Lanes on Next Page						

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 1.3

Regional Critical Intersection Rates, Frequencies and Casualty Ratios: By No. of Through Lanes on Widest Approach

Three Lanes[2]						
1 - 10,000	1.33	1.82	4.12	0.2	0.47	523
10,001 - 20,000	0.69	3.67	7.41	0.23	0.45	499
20,001 - 30,000	0.72	6.59	13.08	0.22	0.41	294
30,001 - 40,000	0.74	9.35	19.39	0.21	0.36	187
40,001 - 50,000	0.6	9.9	21.01	0.24	0.42	68
50,001 - 60,000	0.73	14.38	29.53	0.24	0.43	32
60,001 - 70,000	0.43	9.81	19.27	0.16	0.28	12
over 70,000	0.69	18.25	33.17	0.26	0.36	4
Four or More Lanes[2]						
1 - 10,000	1.1	1.75	3.62	0.22	0.51	510
10,001 - 20,000	0.72	3.86	7.26	0.23	0.43	549
20,001 - 30,000	0.71	6.46	12.27	0.22	0.4	428
30,001 - 40,000	0.55	6.88	14.21	0.23	0.41	256
40,001 - 50,000	0.71	11.47	21.71	0.21	0.33	107
50,001 - 60,000	0.77	15.03	26.7	0.23	0.33	35
60,001 - 70,000	0.49	11.35	21.78	0.24	0.38	20
over 70,000	0.51	14.17	26.6	0.17	0.25	4

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table 1.4

Regional Critical Intersection Crash Rates, Frequencies and Casualty Ratios: By Presence or Absence of Signalization

Average Daily Traffic Volume Entering Intersection	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Intersections Sampled
Signalized[2]						
1 - 10,000	1.55	2.57	5.2	0.23	0.49	721
10,001 - 20,000	0.87	4.69	8.48	0.23	0.41	1,132
20,001 - 30,000	0.96	8.77	15.05	0.23	0.36	962
30,001 - 40,000	1.07	13.51	23.48	0.23	0.35	580
40,001 - 50,000	1.14	18.45	28.99	0.22	0.3	281
50,001 - 60,000	1.35	26.72	41.64	0.22	0.29	139
60,001 - 70,000	1.36	31.48	50.35	0.21	0.27	63
70,001 - 80,000	1.22	32.65	54.41	0.19	0.23	17
over 80,000	1.06	32.67	53.73	0.26	0.34	6
Unsignalized on the Next Page						

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table 1.4

Regional Critical Intersection Crash Rates, Frequencies and Casualty Ratios: By Presence or Absence of Signalization (cont'd)

Unsignalized						
1 - 10,000	1.05	1.33	2.71	0.21	0.49	1,856
10,001 - 20,000	0.46	2.36	4.71	0.22	0.46	943
20,001 - 30,000	0.37	3.32	7.65	0.21	0.45	561
30,001 - 40,000	0.27	3.44	7.73	0.21	0.42	362
40,001 - 50,000	0.28	4.41	9.94	0.19	0.39	139
50,001 - 60,000	0.28	5.55	13.08	0.22	0.41	54
over 60,000	0.14	3.56	6.59	0.23	0.41	42

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Appendix B:

Table: 2.1

Regional Critical Segment Crash Rates, Frequencies and Casualty Ratios: By Area Type

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
Urban[2]						
1 - 10,000	16.53	2.75	6.18	0.22	0.47	8,090
10,001 - 20,000	6.16	6.55	14.57	0.23	0.44	4,215
20,001 - 30,000	5.8	9.55	21.61	0.22	0.4	2,342
30,001 - 40,000	4.27	10.04	24.03	0.22	0.39	1,307
40,001 - 50,000	2.96	8.03	19.6	0.22	0.39	856
50,001 - 60,000	2.8	8.7	18.33	0.21	0.37	432
60,001 - 70,000	2.5	7.16	14.63	0.22	0.36	368
70,001 - 80,000	2.21	7.3	13.47	0.21	0.35	207
80,001 - 90,000	1.95	8.03	15.64	0.2	0.35	70
over 90,000	1.74	11.61	23.52	0.19	0.36	45
Rural[2]						
1 - 10,000	4.9	2.4	5.25	0.21	0.46	1,222
10,001 - 20,000	2.88	2.93	7	0.2	0.45	172
over 20,000	1.49	5.65	11.57	0.21	0.4	173

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 2.2

Regional Critical Segment Crash Rates, Frequencies and Casualty Ratios: By Higher Functional Class of Roadway

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
Freeway[2]						
1 - 10,000	10.9	2	4.79	0.21	0.49	1,490
10,001 - 20,000	3.26	2.79	6.78	0.2	0.45	722
20,001 - 30,000	2.29	3.92	8.66	0.19	0.41	580
30,001 - 40,000	2.09	4.64	9.47	0.23	0.45	578
40,001 - 50,000	2.29	5.6	11.29	0.22	0.4	706
50,001 - 60,000	2.03	7.11	14.34	0.21	0.38	368
60,001 - 70,000	2.26	6.47	11.44	0.22	0.36	344
70,001 - 80,000	2.21	7.37	13.58	0.21	0.35	202
80,001 - 90,000	1.95	8.03	15.64	0.2	0.35	70
over 90,000	1.8	13.79	25.86	0.17	0.26	37
Arterial[2]						
1 - 10,000	15.49	3.55	7.85	0.23	0.47	3,714
10,001 - 20,000	6.64	7.46	15.92	0.23	0.43	3,484
20,001 - 30,000	6.56	11.08	23.98	0.22	0.38	1,890
30,001 - 40,000	5.82	14.08	30.93	0.21	0.34	758
40,001 - 50,000	6.09	19.41	40.68	0.22	0.35	151
50,001 - 60,000	7.23	17.84	33.03	0.21	0.3	64
60,001 - 70,000	5.97	17.17	37.41	0.25	0.38	24
70,001 - 80,000	2.59	4.4	8.19	0.19	0.37	5
over 90,000	1.53	1.72	3.1	0.28	0.68	6

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 2.2

Regional Critical Segment Crash Rates, Frequencies and Casualty Ratios: By Higher Functional Class of Roadway (cont'd.)

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
Major Collector[2]						
1 - 10,000	16.42	2.58	5.48	0.2	0.45	3,946
10,001 - 20,000	5.28	3.52	7.84	0.21	0.45	181
over 20,000	6.04	4.88	12.18	0.22	0.39	17
Local Collector[2]						
1 - 10,000	7.15	1.69	3.18	0.19	0.44	162

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 2.3

Regional Critical Segment Rates, Frequencies and Casualty Ratios: By No. of Through Lanes on Widest Approach

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
One Lane[2]						
1 - 10,000	13.68	1.56	3.97	0.19	0.46	1,503
10,001 - 20,000	3.97	2.67	6.35	0.19	0.4	229
20,001 - 30,000	2.55	2.19	4.78	0.21	0.47	58
30,001 - 40,000	1.38	2.31	5.34	0.12	0.27	17
over 40,000	2.42	2.74	6.4	0.19	0.36	14
Two Lanes[2]						
1 - 10,000	10.13	3.18	6.86	0.22	0.46	5,716
10,001 - 20,000	4.55	6.96	15.34	0.22	0.43	1,740
20,001 - 30,000	3.26	7.52	18.55	0.2	0.4	508
30,001 - 40,000	1.82	5.59	11.62	0.23	0.44	201
40,001 - 50,000	1.13	4.27	7.8	0.22	0.44	83
50,001 - 60,000	1.19	6.27	12.45	0.14	0.26	5
over 60,000	2.41	9.11	15.31	0.21	0.31	15

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 2.3

Regional Critical Segment Rates, Frequencies and Casualty Ratios: By No. of Through Lanes on Widest Approach (cont'd.)

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
Three Lanes[2]						
1 - 10,000	25.54	2.76	6.03	0.22	0.47	1,033
10,001 - 20,000	7.13	5.66	13.04	0.21	0.42	823
20,001 - 30,000	5.52	7.72	19.15	0.2	0.39	541
30,001 - 40,000	3.39	5.79	12.89	0.22	0.42	487
40,001 - 50,000	2.45	5.83	11.68	0.21	0.38	549
50,001 - 60,000	1.91	6.24	11.52	0.21	0.36	228
60,001 - 70,000	2.45	6.52	11.53	0.22	0.38	188
over 70,000	2.3	7.99	14.84	0.21	0.35	102
Four Lanes[2]						
1 - 10,000	23.93	2.96	6.51	0.23	0.48	796
10,001 - 20,000	7.43	6.56	14.24	0.24	0.44	794
20,001 - 30,000	5.91	7.66	17.51	0.21	0.39	564
30,001 - 40,000	4.76	8.4	17.75	0.21	0.36	321
40,001 - 50,000	3.9	7.4	15.93	0.24	0.42	140
50,001 - 60,000	2.83	9.93	20.71	0.23	0.4	156
60,001 - 70,000	2.11	6.51	11.72	0.21	0.35	148
over 70,000	1.84	7.71	15.51	0.2	0.35	160

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 2.3

Regional Critical Segment Rates, Frequencies and Casualty Ratios: By No. of Through Lanes on Widest Approach (cont'd.)

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
Five or More Lanes[2]						
1 - 10,000	76.11	4.09	9.77	0.26	0.51	200
10,001 - 20,000	7.22	7.99	16.57	0.26	0.45	745
20,001 - 30,000	6.85	13.59	26.94	0.23	0.38	790
30,001 - 40,000	6.62	21.51	42.98	0.23	0.34	310
40,001 - 50,000	6.67	28.21	52.58	0.22	0.32	81
50,001 - 60,000	7.7	18.01	33.72	0.2	0.29	42
60,001 - 70,000	5.2	17.38	37.56	0.22	0.33	23
over 70,000	2.44	9.49	18.6	0.22	0.38	45

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 2.4

Regional Critical Segments with Intersections Crash Rates, Frequencies and Casualty Ratios: By Presence or Absence of Signalization

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
Unsignalized[2]						
1 - 10,000	15.14	2.7	6.04	0.21	0.46	8,874
10,001 - 20,000	6.3	5.35	11.82	0.22	0.44	3,843
20,001 - 30,000	5.78	6.62	15.11	0.21	0.4	2,109
30,001 - 40,000	4.27	7.28	16.48	0.22	0.4	1,185
40,001 - 50,000	2.91	6.93	15.66	0.22	0.39	830
over 50,000	2.48	7.62	15.28	0.21	0.36	1,105

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 2.4

Regional Critical Segments with Intersections Crash Rates, Frequencies and Casualty Ratios: By Presence or Absence of Signalization (cont'd.)

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
One-Two Signals Per Mile[2]						
1 - 10,000	4.41	7.78	14.07	0.24	0.37	196
10,001 - 20,000	3.57	18.73	32	0.25	0.34	255
20,001 - 30,000	3.62	28.96	44.51	0.23	0.3	187
over 30,000	3.46	38.25	59.74	0.24	0.3	93
Three-Four Signals Per Mile[2]						
1 - 10,000	7.82	4.88	9.32	0.29	0.49	152
10,001 - 20,000	3.87	12.64	21.91	0.27	0.41	169
20,001 - 30,000	4.52	23.01	38.02	0.24	0.34	123
over 30,000	3.95	30.47	55.99	0.22	0.31	71
Five or More Signals Per Mile[2]						
1 - 10,000	37.19	4.49	8.95	0.22	0.44	90
10,001 - 20,000	5.73	9.77	18.09	0.23	0.39	120
20,001 - 30,000	5.91	16.6	30.51	0.23	0.33	66
over 30,000	4.1	22.69	42.28	0.23	0.31	31

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Appendix C

Table: 3.1

Regional Critical Segments without Intersections Crash Rates, Frequencies and Casualty Ratios: By Area Type

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
Urban[2]						
1 - 10,000	6.83	2.09	4.7	0.23	0.52	5,136
10,001 - 20,000	2.35	4.65	10.57	0.23	0.45	3,023
20,001 - 30,000	2.65	6.71	15.25	0.23	0.44	1,746
30,001 - 40,000	1.97	7.2	16.79	0.22	0.41	1,034
40,001 - 50,000	1.74	6.44	14.78	0.22	0.4	724
50,001 - 60,000	1.75	7.51	15.41	0.21	0.37	378
60,001 - 70,000	1.84	5.99	11.56	0.22	0.39	322
70,001 - 80,000	1.81	6.3	12.18	0.21	0.37	190
80,001 - 90,000	1.73	7.17	14.01	0.21	0.36	65
over 90,000	1.29	11.24	22.36	0.15	0.26	36
Rural[2]						
1 - 10,000	2.98	1.9	4.23	0.21	0.5	1,037
10,001 - 20,000	1.55	2.14	4.87	0.19	0.46	144
over 20,000	0.81	5.2	10.79	0.21	0.41	160

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 3.2

Regional Critical Segments without Intersections Crash Rates, Frequencies and Casualty Ratios: By Higher Functional Class of Roadway

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
Freeway[2]						
1 - 10,000	6.92	1.18	2.75	0.22	0.54	929
10,001 - 20,000	1.85	2.03	4.65	0.19	0.46	561
20,001 - 30,000	1.54	3.62	8.25	0.18	0.42	500
30,001 - 40,000	1.47	4.46	9.2	0.22	0.44	489
40,001 - 50,000	1.66	5.19	10.75	0.21	0.4	614
50,001 - 60,000	1.64	6.65	13.18	0.22	0.38	330
60,001 - 70,000	1.78	5.69	10.33	0.22	0.39	306
70,001 - 80,000	1.79	6.37	12.29	0.21	0.37	185
80,001 - 90,000	1.73	7.17	14.01	0.21	0.36	65
over 90,000	1.35	11.88	22.99	0.16	0.26	34
Arterial[2]						
1 - 10,000	7.29	2.92	6.44	0.24	0.51	2,452
10,001 - 20,000	2.45	5.35	11.64	0.24	0.45	2,511
20,001 - 30,000	2.87	7.86	17.14	0.24	0.43	1,364
30,001 - 40,000	2.35	9.55	21.28	0.22	0.38	574
40,001 - 50,000	2.22	13.29	28.44	0.23	0.4	111
50,001 - 60,000	2.54	13.4	26.14	0.2	0.3	48
60,001 - 70,000	2.98	11.75	25.42	0.22	0.35	16
70,001 - 80,000	2.34	3.6	6.82	0.18	0.36	5
over 90,000	0.33	0.33	0.33	0	0	2

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 3.2

Regional Critical Segments without Intersections Crash Rates, Frequencies and Casualty Ratios: By Higher Functional Class of Roadway (cont'd)

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
Major Collector						
1 - 10,000	5.02	2.17	4.7	0.21	0.48	2,652
10,001 - 20,000	1.58	2.78	6.05	0.2	0.46	95
over 20,000	2.68	2.36	4.97	0.12	0.23	12
Local Collector						
1 - 10,000	4.15	1.59	2.93	0.19	0.45	140

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 3.3

Regional Critical Segment without Intersections Rates, Frequencies and Casualty Ratios: By No. of Through Lanes on Widest Approach

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
One Lane[2]						
1 - 10,000	8.77	0.75	1.5	0.19	0.52	883
10,001 - 20,000	2.27	1.22	3.07	0.18	0.45	159
20,001 - 30,000	2.04	1.45	3.72	0.25	0.58	47
30,001 - 40,000	1.35	2.55	5.13	0.24	0.53	11
over 40,000	1.56	3.14	8.33	0.34	0.68	7
Two Lanes[2]						
1 - 10,000	4.49	2.63	5.75	0.22	0.49	4,202
10,001 - 20,000	1.9	5.12	11.26	0.22	0.43	1,345
20,001 - 30,000	1.94	5.78	14	0.19	0.4	442
30,001 - 40,000	1.15	5.03	10.6	0.21	0.42	180
40,001 - 50,000	0.83	3.68	6.88	0.23	0.49	78
50,001 - 60,000	0.74	5.67	9.43	0.09	0.15	4
over 60,000	1.77	9.08	14.86	0.14	0.24	12

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 3.3

Regional Critical Segment without Intersections Rates, Frequencies and Casualty Ratios: By No. of Through Lanes on Widest Approach (cont'd)

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
Three Lanes[2]						
1 - 10,000	13.39	2.2	4.72	0.25	0.54	566
10,001 - 20,000	2.93	4.41	10.28	0.21	0.44	561
20,001 - 30,000	3.4	6.2	14.82	0.2	0.39	411
30,001 - 40,000	2.16	5	11.06	0.22	0.43	401
40,001 - 50,000	1.75	5.44	11.11	0.21	0.39	473
50,001 - 60,000	1.56	5.76	10.68	0.21	0.38	206
60,001 - 70,000	1.89	5.6	10.38	0.22	0.41	166
over 70,000	1.88	7.16	13.62	0.22	0.36	92
Four Lanes[2]						
1 - 10,000	5.9	2.6	5.52	0.28	0.57	349
10,001 - 20,000	2.29	4.72	10.67	0.25	0.48	549
20,001 - 30,000	2.23	5.88	13.64	0.23	0.45	387
30,001 - 40,000	2.07	5.96	13.04	0.21	0.39	248
40,001 - 50,000	2.03	6.44	14.82	0.22	0.41	110
50,001 - 60,000	2.02	8.59	17.92	0.23	0.37	139
60,001 - 70,000	1.78	5.76	10.24	0.22	0.37	135
over 70,000	1.6	6.81	14	0.19	0.34	148

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 3.3

Regional Critical Segment without Intersections Rates, Frequencies and Casualty Ratios: By No. of Through Lanes on Widest Approach (cont'd)

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
Five or More Lanes[2]						
1 - 10,000	12.82	2.66	6.01	0.29	0.58	115
10,001 - 20,000	2.27	5.26	11.06	0.26	0.47	498
20,001 - 30,000	2.17	8.82	17.84	0.25	0.44	566
30,001 - 40,000	2.1	14.56	29.34	0.24	0.37	223
40,001 - 50,000	2.37	17.68	34.71	0.23	0.35	62
50,001 - 60,000	2.05	14.99	27.09	0.19	0.29	29
60,001 - 70,000	1.68	12.62	26.32	0.25	0.37	15
over 70,000	1.89	7.6	15.96	0.23	0.41	40

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 3.4

Regional Critical Segments with Intersections Crash Rates, Frequencies and Casualty Ratios: By Presence or Absence of Signalization

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
Unsignalized[2]						
1 - 10,000	5.97	2.16	4.92	0.22	0.5	5,758
10,001 - 20,000	2.27	3.67	8.1	0.22	0.46	2,630
20,001 - 30,000	2.49	4.46	10.08	0.22	0.44	1,502
30,001 - 40,000	1.88	5.06	11.06	0.22	0.42	913
40,001 - 50,000	1.7	5.57	11.94	0.22	0.41	698
over 50,000	1.76	6.57	12.92	0.21	0.37	974

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

Table: 3.4

Regional Critical Segments with Intersections Crash Rates, Frequencies and Casualty Ratios: By Presence or Absence of Signalization (cont'd)

Average Daily Traffic Volume On Segment	Average Crash Rate	Average Crash Frequency	Critical Crash Frequency	Average Casualty Ratio	Critical Casualty Ratio	Number of Segments Sampled
One-Two Signals Per Mile[2]						
1 - 10,000	3.15	5.62	9.79	0.24	0.41	192
10,001 - 20,000	2.2	11.88	21.97	0.26	0.39	255
20,001 - 30,000	2.18	17.79	29.22	0.24	0.32	187
over 30,000	2.22	24.8	39.18	0.24	0.32	93
Three-Four Signals Per Mile[2]						
1 - 10,000	5.76	3.28	6.67	0.29	0.55	147
10,001 - 20,000	2.49	8.37	15.52	0.28	0.45	168
20,001 - 30,000	2.85	15.12	26.82	0.26	0.37	122
over 30,000	2.55	20.35	37.37	0.22	0.31	71
Five Or More Signals Per Mile[2]						
1 - 10,000	31.4	3.11	6.42	0.23	0.49	76
10,001 - 20,000	3.34	6.64	13.26	0.22	0.41	114
20,001 - 30,000	3.49	10.57	20.73	0.22	0.33	65
over 30,000	2.81	16.7	31.38	0.25	0.37	30

[1] Size of sample taken from SEMCOG crash data for Southeast Michigan, 2012-2014.
[2] Values on this line are volume-independent. Rates are in crashes per million vehicles and frequencies are annual averages.

6. Example to Calculate CPI

The intersection of Sem Road and Cog Avenue is located in an urban area. Both streets are classified as arterials, and there is a traffic signal at the intersection. There are two through lanes on the widest approach.

An evaluation of the intersection for the years 2012 to 2014 has been requested. A review of available crash data for those three years shows that 141 crashes were reported for the intersection. These 141 crashes consisted of 0 fatal crashes, 3 A-level crashes, 8 B-level crashes, 25 C-level crashes and 105 PDO crashes.

Terms used in the table's column headings are defined in earlier sections presenting the various methods for identifying high-crash locations. The values given for annual average number of crashes have been rounded to whole numbers to simplify the presentation.

Over the same years used in the crash data retrieval, two-way ADT volumes for the four legs of the Sem-Cog intersection were 9,168, 18,403, 13,385 and 15,910 vehicles. Lacking more specific data, it is reasonable to assume that the total average daily volume entering the intersection was one half of the total of these two-way volumes, or (9,168 + 18,403 + 13,385 + 15,910) / 2 = 28,433 vehicles.

6.1 Information for the Sem-Cog intersection

1. Traffic Volume = __20,000 – 30,000__
   (AADT for the segment or sum of AADT entering an intersection)
2. Number of Crashes = __141___ Number of Years = _3__
   (Preferable 3 year period)
3. Length of segment in miles = _1_
   (Intersection = 1)

4. Area type =	**Urban**		Rural	
5. Functional class =	**Arterial**		Collector/local	
6. Number of lanes =	1	**2**	3	4 or more
7. Traffic control =	**Signalized**		Unsignalized	

6.2 Calculate crash probability index (CPI)

Crash probability index is calculated by adding the penalty points for frequency, ratio and rate. Penalty points are given to a spot as described below.

6.2.1 Frequency (possible penalty points 5)

Compare the average critical crash frequency to the critical crash frequency for the spot.

- *Calculate spot critical crash frequency (ASCCFreq)*
  ASCCFreq = Total crashes / years evaluated
  ASCCFreq=141/3 = 47 crashes/year. (where 3 is number of years being evaluated).

- *Calculate average regional critical crash frequency (ARCCFreq)*
  ARCCFreq = Avg Crash Frequency + STDEV Crash Frequency
  Look up objectively determined regional critical crash frequencies in Tables 1.1 to 1.4 and compute an average value. For this intersection type, these tables provide critical frequencies 13.14, 13.28, 11.27, and 15.05 crashes per year.
  The average regional critical crash frequency (ARCCFreq) = 13.12 crashes/yr.

- *Assigning Penalty Points for* Frequency (PP Freq)
  Compare the ARCCFreq to ASCCFreq. If ASCCFreq > ARCCFreq then assign 5 points to PPFrequency, if not then assign 0 points.
  ASCCFreq (47) > ARCCFreq (13.12), penalty points for frequency = 5 points
  This method identifies the Sem-Cog intersection as a high-crash location.

6.2.2 Rate: (possible penalty points 5)

Compare the spot crash rate to the spot critical crash rate for area type, functional class, number of lanes and traffic control.

- *Calculate spot crash rate*
  Use the following formula =

$$\frac{(1{,}000{,}000 \times spot\ critical\ crash\ frequency)}{(365 \times AADT \times Y \times L)}$$

Spot critical crash frequency (calculated above for frequency= 47)
AADT = Average annual daily traffic for the spot (28,433)
Y = Number of years being analyzed (3)
L = Length of the segment (for intersection L is 1).
Substituting all the values in the above equation
Spot crash rate = 4.53 crashes/MV

- *Calculate spot critical crash rate*
  Use the following formula =

$$(Average\ Crash\ Rate) + \left((K) \sqrt{\frac{\text{Average Crash Rate}}{\frac{365 \times Y \times [AADT] \times [L]}{1{,}000{,}000}}} \right) + \left(\frac{\frac{1}{2[365 \times Y \times (AADT) \times (L)]}}{1{,}000{,}000} \right)$$

Average Crash Rate: from the tables 1.1 to 1.4 provided = 0.76 urban (U), 0.78 arterial (A), 0.65 lanes (L), and 0.96 signalized (S)
K = 1.645
AADT = Average Annual Daily Traffic = 28,433
Y = Number of years being analyzed = 3
L = Length of the segment =1 (for intersection)

Calculate spot critical crash rate for each of the four characteristics area type, functional class, number of lanes and traffic control by substituting values in the above equation. Spot critical crash rate (SCCRate) = 1.03 U, 1.05 A, 0.90 L, and 1.26 S.

- *Assigning Penalty Points for Rate (PP Rate)*
  Compare the SC rate to SCC Rate U, A, L and S. If the SC rate > either SCCRate U, A, L and S then you assign 5 points to PP Rate if not then assign 0 points.

  SC rate (4.53) > either SCCRate (1.03) U, (1.05) A, (0.9) L, and (1.26) S, penalty points for rate = 5 points. This method also identifies the Sem-Cog intersection as a high-crash location.

6.2.3 Ratio (possible penalty points 10)

Compare the average critical crash ratio to the critical crash ratio for the spot.

- *Calculate spot critical crash ratio*

  $$ASCCRatio:\ CR=\frac{F+A+B+C}{F+A+B+C+PDO}$$

  (0 fatal crashes, 3 A-level crashes, 8 B-level crashes, 25 C-level crashes and 105 PDO crashes).
  Substituting average values in the equation for the crashes
  ASCCRatio = 0.26.

- *Calculate average critical crash ratio*
  ARCCRatio: (AVG CASUALTY RATIO) + (STDEV CASUALTY RATIO)
  Look up objectively determined regional critical casualty ratio in Tables 1.1 to 1.4 and compute an average value. For this intersection type, these tables provide critical ratio 0.4, 0.39, 0.4, and 0.36 crashes per year.
  The average regional critical crash ratio (ARCCRatio) = 0.39.

- *Assigning Penalty Points for Ratio (*PP Ratio):
  Compare the ARCCRatio to ASCCRatio. If ASCCRatio > ARCCRatio then assign 10 points to PPRatio if not then assign 0 points.
  ASCCRatio (0.26) < ARCCRatio (0.39), penalty points for ratio is 0.

6.2.4 Calculate CPI

If neither the frequency, rate nor ratio equals or exceeds the corresponding average critical value, the CPI for the spot equal to 0. The CPI calculation is derived by adding all the penalty points for frequency, ratio, and rate. Possible CPI's are 0, 5, 10, 15 and 20.

CPI for Sem-Cog intersection = 5 for frequency + 5 for rate + 0 for ratio = 10

A study spot is considered "high crash" if it scores a 10 or greater CPI.