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# AASHTO Highway Safety Manual Illinois User Guide

## with Illinois Calibration Factor and Default Values

Prepared for
Illinois Department of Transportation • Bureau of Safety Engineering

State of Illinois
Illinois Department of Transportation

Illinois Department of Transportation

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# Table of Contents

**Appendixes**



**Figures**



**Tables**

# Acronyms and Abbreviations

| | |
|---|---|
| AADT | average annual daily traffic |
| AASHTO | American Association of State Highway and Transportation Officials |
| BSE | Bureau of Safety Engineering |
| CMF | crash modification factor |
| DD | driveway density |
| DOT | Departments of Transportation |
| EB | Empirical Bayes |
| HSM | Highway Safety Manual |
| ID | identification number |
| IDOT | Illinois Department of Transportation |
| mph | miles per hour |
| N/A | not applicable |
| PDO | property-damage-only |
| PSI | potential for safety improvement |
| RHR | roadside hazard rating |
| SHSP | Strategic Highway Safety Program |
| SPF | safety performance function |
| VBA | Visual Basic for Application |

# Introduction

The American Association of State Highway and Transportation Officials (AASHTO) published the Highway Safety Manual (HSM) ($1^{st}$ edition) in 2010, which represents the culmination of 10 years of research and development by an international team of safety experts, academics, and practitioners. The HSM is a potentially transformative document for Departments of Transportations (DOTs) and other agencies responsible for the planning, design, construction, and operation of their highway systems. It is a powerful tool that can be used to quantify the safety-related effects of changes to the roadway environment. With publication of the HSM, DOTs and other agencies for the first time have access to a proven and vetted science-based means of characterizing the explicit safety effects of the decisions or actions of an agency.

Since its establishment, the Bureau of Safety Engineering (BSE) at the Illinois Department of Transportation (IDOT) has strived to incorporate the concept of safety into planning, design, construction, and operation of the roadway system and establish a data-driven process for roadway safety management in Illinois. In current IDOT BSE engineering practices, a network screening process is conducted annually to rank the roadway sites based on the potential for safety improvement (PSI). The top 5 percent of sites under each peer group are documented in the Federal Highway Administration (FHWA) *Five Percent Report*, which are further verified and evaluated with more detailed data by IDOT engineers. Finally, appropriate treatments are proposed based on the safety performance as well as other factors such as costs, right-of-way, traffic operations, and environmental assessments. However, HSM methodology has not yet been incorporated fully into the Illinois roadway safety management process, and a knowledge gap still exists between the HSM methodology and the engineering practices in Illinois. It is necessary to bridge this gap by incorporating HSM methods into Illinois roadway safety management practices.

The purpose of this document is to develop a guideline on incorporating HSM methodology into roadway safety management practices in Illinois. The concepts of the HSM methods are discussed in detail first, followed by examples with step-by-step application of HSM methodology to roadway safety management. Meanwhile, to promote the reliability of the calculation results, IDOT BSE recently calibrated the HSM safety performance functions (SPFs) and replaced all the default values in Table A-3, Appendix A of the HSM with data from Illinois. The Illinois SPF calibration factors and replaced default values derived from the HSM calibration efforts are incorporated into the calculations in the examples.

## 1.1 Target Readers for the Document

The target readers for this document include IDOT engineers that are to practice highway safety management using HSM methodology. To best understand the material, a solid background in traffic engineering and roadway geometrics is required, while an understanding of HSM fundamentals is preferred. Engineers from other Illinois state agencies, Illinois local agencies, or consulting companies that practice traffic safety engineering in Illinois are encouraged to use this document as well.

The Illinois SPF calibration factors and replaced default values in this document were developed based on data in Illinois, and all the examples were developed in a way similar to the engineering practices in Illinois. While the principles can also be applied to engineering practices in other states, the document is more focused on highway safety management practices in Illinois. Special attention should be paid when using this document in other states.

## 1.2 Structure of the Document

The document provides a step-by-step guideline on how to incorporate HSM methodology into the roadway safety management practices in Illinois. Specifically, this document mainly focuses on the calculation of predicted and/or expected crash frequency using HSM methodology. For this purpose, the document is organized in the following way. Chapter 1 introduces the background and main contents of this document, and Chapter 2 discusses the HSM predictive method and terminology. Chapter 3 provides step-by-step procedures for calculating the predicted and expected crash frequency using HSM methodology, and Chapter 4 includes several examples that incorporate HSM methodology into the highway safety management practices with detailed procedures. The Illinois SPF calibration factors and the replaced default values that IDOT BSE derived based on Illinois data are included in Appendixes A and B, respectively, for reference purposes.

## 1.3 Disclaimer

This document is intended to help IDOT engineers incorporate HSM methodology into the highway safety management practices in Illinois. Specifically, this document will guide the IDOT engineers through the process of calculating the predicted and/or expected crash frequency using the HSM Part C predictive method. This document can be used as a companion document to the HSM; however, it is not a substitution for the HSM or a design guideline for safety projects.

This document is not a legal standard of care as to the information contained herein. As a resource, this document does not supersede any publications, guidelines, manuals, and policies by IDOT or any other federal and state agencies. Users should check the IDOT-specific approaches before applying this document to estimate the crash frequency for designated highway facilities.

# Highway Safety Manual Overview

The HSM provides analytical tools and techniques for quantifying the potential effects on crashes as a result of decisions made in planning, design, construction, and operations. The HSM (1st edition) consists of four parts. Part A describes the purpose and scope of the HSM and explains the relationship of the HSM to planning, design, and construction and operations activities. Part A also presents an overview of human factor principles for road safety and fundamentals of the processes and tools described in the HSM. Part B presents the steps that can be used to monitor and reduce crash frequency and severity on existing roadway networks. Part C provides a predictive method for estimating expected average crash frequency of a network, facility, or individual site. Part D summarizes the effects of various treatments such as geometric and operational modifications at a site.

This document focuses on the application of HSM Part C, Predictive Method, to roadway safety management practices in Illinois. The predictive method in HSM Part C is applied to a given time period, traffic volume, and constant geometric design characteristics of the roadway to estimate the crash frequency for existing conditions, alternative conditions, or proposed new roadways. To be concise, only an overview for HSM Part C is provided in the following sections. The reader may refer to the HSM for relevant information for other parts of the HSM.

## 2.1 Overview of the HSM Part C Predictive Method

The HSM Part C predictive method can facilitate the calculation of predicted and/or expected crash frequency for an individual site, facility, or network. Before the application of the predictive method, the entire roadway is divided into individual sites that are either homogenous roadway segments or intersections. The roadway is converted into a contiguous set of individual intersections and roadway segments, each referred to as a “site”. The facility type for different sites is then determined based on surrounding land use, roadway cross-section, and degree of access, and so forth, such as rural two-lane two-way roads, rural multilane highways, and urban and suburban arterials. Furthermore, for each facility type, a number of different site types may exist, such as divided and undivided roadway segments, or signalized and unsignalized intersections. Based on the roadway geometric and traffic control information, a specific site type can be designated for each site, such as “undivided roadway segment on rural two-lane two-way roads” or “four-leg signalized intersection on urban and suburban arterials”.

The predictive method is used to estimate the predicted and/or expected average crash frequency of an individual site. The predicted crash frequency of an individual site, $N_{predicted}$, is estimated using the SPF, crash modification factor (CMF), and calibration factors based on the geometric design, traffic control features, and traffic volumes of that site. However, the results are only for the general population of the specific facility types and cannot consider their specific characteristics that are not included in the models. To improve the statistical reliability of the estimate for an existing site or facility, the observed crash frequency, $N_{observed}$, for that specific site or facility is then combined with $N_{predicted}$, the predicted crash frequency using the Empirical Bayes (EB) method. The result from the predictive method is the expected average crash frequency, $N_{expected}$. This is an estimate of the long-term average crash frequency that would be expected, given sufficient time to make a controlled observation. More details for calculating the predicted and/or expected crash frequency are discussed in Chapter 3 and illustrated step-by-step in Chapter 4.

The estimate described above is for a given time period of interest (in years) during which the geometric design and traffic control features are unchanged and traffic volumes are known or forecast. Once the predicted and/or expected crash frequencies have been determined for all the individual sites that make up a facility or network, the sum of the crash frequencies for all of the sites is used as the estimate of the predicted and/or expected crash frequency for an entire facility or network.

## 2.2 Terminology

The following terms are critical for understanding the HSM Part C predictive method and are included here for the reader's reference.

- Homogeneous roadway segment − A portion of a roadway with similar average daily traffic volumes (vehicles per day), geometric design, and traffic control features.
- Safety performance function (SPF) − An equation used to estimate the predicted average crash frequency per year at a location as a function of traffic volume and in some cases roadway or intersection characteristics (such as number of lanes, traffic control, or type of median).
- Crash modification factor (CMF) − An index of how much crash experience is expected to change following a modification in design or traffic control. CMF is the ratio between the numbers of crashes per unit of time expected after a modification or measure is implemented and the number of crashes per unit of time estimated if the change does not take place.
- Calibration factor − A factor to adjust crash frequency estimates produced from a safety prediction procedure to approximate local conditions. The factor is computed by comparing existing crash data at the state, regional, or local level to estimates obtained from predictive models.

  Calibration factor is also referred as "local calibration factor." However, the HSM does not distinguish between the state and local roadway system, and calibration factor (or local calibration factor) is not limited to a local roadway system only. For clarification purposes, the calibration factor is referred to as the "Illinois SPF calibration factor" in this document.
- Predicted crash frequency – The estimate of long-term average crash frequency, which is forecast to occur at a site using a predictive model found in HSM Part C. The predictive models in the HSM involve the use of regression models, known as SPFs, in combination with CMFs and calibration factors to adjust the model to site-specific and local conditions.
- EB methodology − Method used to combine observed crash frequency data for a given site with predicted crash frequency data from many similar sites to estimate its expected crash frequency.
- Expected crash frequency − The estimate of long-term expected average crash frequency of a site, facility, or network under a given set of geometric conditions and average annual daily traffic (AADT) volumes in a given period of years. In the EB methodology, this frequency is calculated from observed crash frequency at the site and predicted crash frequency at the site based on crash frequency estimates at other similar sites.

For any other terms not listed above, the reader may refer to the HSM glossary.

# Crash Frequency Calculation with HSM Part C Predictive Method

The HSM Part C predictive method can determine both the predicted and expected crash frequency for a roadway site, facility, and network. The predicted crash frequency is widely used in safety practices, especially when comparing different improvement alternatives. Meanwhile, it is also the basis for calculating the expected crash frequency. With the ability to consider the site-specific characteristics not included in the crash predictive models and solve the “regression to mean” bias by combining the predicted and observed crash frequency using the EB method, the expected crash frequency is a more reliable estimator of the crash frequency; and it can be calculated for both a past and future time period. The methods for calculating the predicted and expected crash frequencies are discussed in the following sections.

## 3.1 Calculation of the Predicted Crash Frequency

The general methodology for the predicted crash frequency calculation is discussed first, followed by a step-by-step description of the calculation procedures.

### 3.1.1 Methodology

The predicted crash frequency for a roadway site can be determined based on the AADT(s), roadway geometric characteristics, and traffic control data using the SPF, CMF, and calibration factor. The predictive models used in HSM Part C to determine the predicted crash frequency, $N_{predicted}$, are of the general form shown in Equation (C-1) on page C-4 of the HSM, as shown below.

$$N_{predicted} = N_{spf\ x} \times (CMF_{1x} \times CMF_{2x} \times \cdots \times CMF_{yx}) \times C_x \tag{3-1}$$

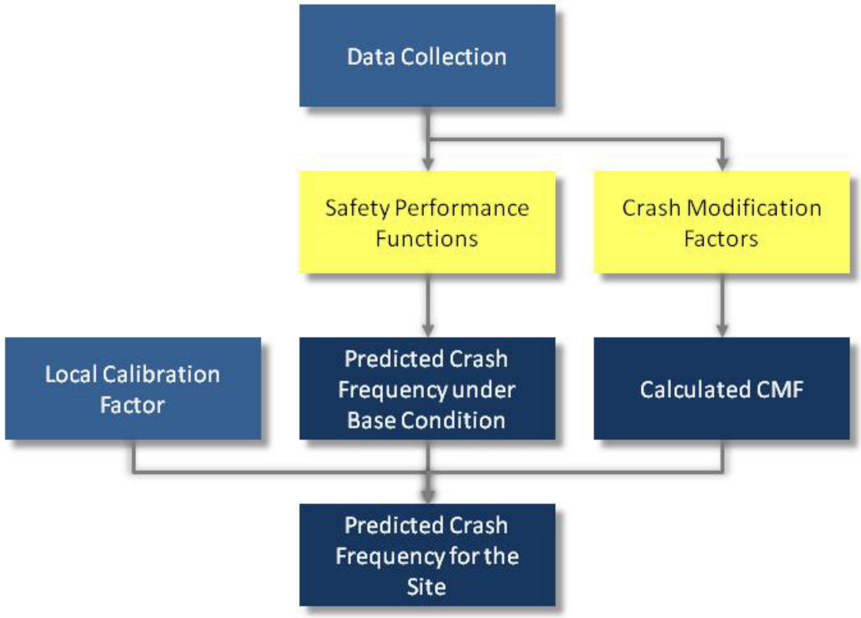
where:

| | | |
|---|---|---|
| $N_{predicted}$ | = | predicted crash frequency for a specific year for site type $x$ |
| $N_{spf\ x}$ | = | predicted crash frequency determined for base conditions of the SPF developed for site type $x$ |
| $CMF_{yx}$ | = | CMFs specific to SPF for site type $x$ |
| $C_x$ | = | calibration factor to adjust SPF for local conditions for site type $x$ |

### 3.1.2 Step-by-step Procedure

The calculation of predicted crash frequency can be divided into several steps, starting from data collection and selection of SPFs, CMFs, and calibration factor, respectively, followed by the calculation of predicted crash frequency under base conditions and CMFs. The final predicted crash frequency for the site can be determined when multiplying the predicted crash frequency under base conditions with the calibration factor and all the CMFs, as illustrated in Figure 3-1.

FIGURE 3-1
**Flowchart for Predicted Crash Frequency Calculation**




#### 3.1.2.1 Data Collection

Numerous data are collected for calculating the predicted crash frequency. The appropriate source for the data collection efforts can be determined on a case-by-case condition. Generally speaking, most AADT, roadway geometric, and traffic control data can be collected from the IDOT database. The reader can use commercial aerial map tools for the data collection efforts as well. Visiting a site is also a feasible and efficient data collection method under some circumstances. For corridors with multiple roadway segments and intersections, data need to be collected for each site separately.

#### 3.1.2.2 Selection of Safety Performance Functions

Based on the facility type and site type for the designated site, appropriate SPFs should be selected from relevant chapters in the HSM. The coefficients for the SPFs should be selected from appropriate tables in the HSM as well. All the selected SPFs and coefficients are used for calculating the predicted crash frequency under base conditions in the following steps.

#### 3.1.2.3 Selection of Crash Modification Factors

CMFs are used to quantify the impacts of the site's non-base conditions on predicted crash frequency. For each chapter, the HSM listed all the relevant CMFs for segments and intersections separately. The reader should select all the CMFs applicable for the site from the list in HSM correspondingly.

#### 3.1.2.4 Selection of Calibration Factors

IDOT BSE calibrated the HSM Part C SPFs using the Illinois data and derived all the Illinois SPF calibration factors. Considering the differences in crash pattern and crash frequency level, IDOT BSE calibrated the HSM Part C SPFs for different IDOT jurisdictions and calendar years separately, as listed in Table A-1 to A-4 in Appendix A of this document. Correspondingly, when applied to a specific site, the Illinois SPF calibration factor should be selected from the appropriate table based on the site type, IDOT jurisdiction for the site, and the time period for the analysis. For example, to calculate the predicted crash frequency for a two-lane, two-way roadway segment in 2006, if the segment is within IDOT District 1, the Illinois SPF calibration factor for that facility type in Table A-1 of this document, 1.72, should be selected; however, if it is within IDOT District 5, the Illinois SPF calibration factor for that facility type in Table A-3 of this document, 1.78, should be applied.

In addition to the Illinois SPF calibration factors, IDOT BSE also replaced all the default values listed in Table A-3, Appendix A of the HSM based on data in Illinois. All the replaced default values are included in Appendix B of this document based on the facility type, the IDOT jurisdiction, and the year. Based on

HSM methodology, parts of the replaced default values are used in the predicted crash frequency calculation. For example, the bicycle crash adjustment factor is used to calculate the vehicle-bicycle crashes for all facility types in HSM Chapter 12.

To obtain a more reliable result, the replaced default values should be used in the crash frequency calculation. Similarly, for a specific site, the replaced default values from appropriate tables in this document should be selected based on the facility type, the IDOT jurisdiction for the site, and the targeted time period for analysis. For example, when calculating the bicycle crash frequency for a four-leg signalized intersection on urban and suburban arterial in 2006, if the site is located in IDOT District 1, the bicycle crash adjustment factor in Table B-3-17 in Appendix B-3 of this document, 0.012, should be used; however, if the site is located in IDOT District 5, the value in Table B-6-17 in Appendix B-6 of this document, 0.008, should be used.

#### 3.1.2.5 Calculation of Predicted Crash Frequency under Base Conditions

The predicted crash frequency under base conditions can be determined using SPFs based on the AADT and segment length (for a roadway segment), or AADTs for major and minor roads (for an intersection). The reader can refer to the HSM for detailed information on the SPFs and their associated coefficients for different facility types.

#### 3.1.2.6 Calculation of Crash Modification Factors

The HSM used the CMFs to accommodate the non-base conditions for the roadway sites. For a given site, each CMF can be determined based on the collected data using the relevant equations, tables, and figures in the HSM.

#### 3.1.2.7 Calculation of Predicted Crash Frequency for the Site

The predicted crash frequency under site prevailing conditions can be determined by multiplying the predicted crash frequency under base conditions with the Illinois SPF calibration factor and all the CMFs calculated. As mentioned previously, the Illinois SPF calibration factor should be selected from the appropriate table in Appendix A of this document based on the facility type, the IDOT jurisdiction for the site, and the targeted calendar year for the analysis.

## 3.2 Calculation of the Expected Crash Frequency for a Past Time Period

The general methodology for calculating the expected crash frequency for a past time period is discussed first, followed by a step-by-step description of the calculation procedures.

### 3.2.1 Methodology

Compared to the predicted crash frequency, the expected crash frequency is a more reliable estimator for crash frequency. The procedure for calculating the expected crash frequency for a past time period can be divided into two stages:

- Stage 1: The calculation of predicted crash frequency for site prevailing conditions
- Stage 2: The calculation of expected crash frequency for a past time period by combining the predicted and observed crash frequency using the EB method

The procedures for calculating the predicted crash frequency (Stage 1) were discussed in Section 3.1. The following discussion mainly focuses on the calculation of expected crash frequency for a past time period using the EB method (Stage 2).

Based on Equation (A-4) in Appendix A on page A-19 of the HSM, the expected crash frequency for a past time period can be determined based on the observed and predicted crash frequency, as shown below:

$$N_{expected} = w \times N_{predicted} + (1 - w) \times N_{observed} \qquad (3\text{-}2)$$

where:

| | | |
|---|---|---|
| $N_{expected}$ | = | expected crash frequency for the sites |
| $N_{predicted}$ | = | predicted crash frequency for the sites |
| $N_{observed}$ | = | observed crash frequency for the sites |

The weighted adjustment $w$ to be placed on the predictive model estimate can be determined with the following equation:

$$w = \frac{1}{1 + k \times \sum_{all\ study\ years} N_{predicted}} \quad (3\text{-}3)$$

In Equation (3-3), $k$ is the overdispersion parameter of the associated SPF used to estimate $N_{predicted}$, which can be found from the relevant HSM chapter. The reader can refer to HSM Appendix A for more details about the EB method and the expected crash frequency calculation.

## 3.2.2 Step-by-step Procedure

The expected crash frequency calculation can be divided into several steps, starting from data collection and selection of SPFs, CMFs, and calibration factor, followed by calculation of predicted crash frequency under base conditions and CMFs. The predicted crash frequency for the site can be determined by multiplying the predicted crash frequency under base conditions with the calibration factor and all the CMFs. Using the EB method, the final expected crash frequency can be further determined by combining the predicted and observed crash frequencies, as illustrated in Figure 3-2.

The procedures for determining the predicted crash frequency are discussed in Section 3.1. The following step-by-step procedure focuses on the last two steps specifically for the calculation of expected crash frequency, observed crash data, and the expected crash frequency for the site.

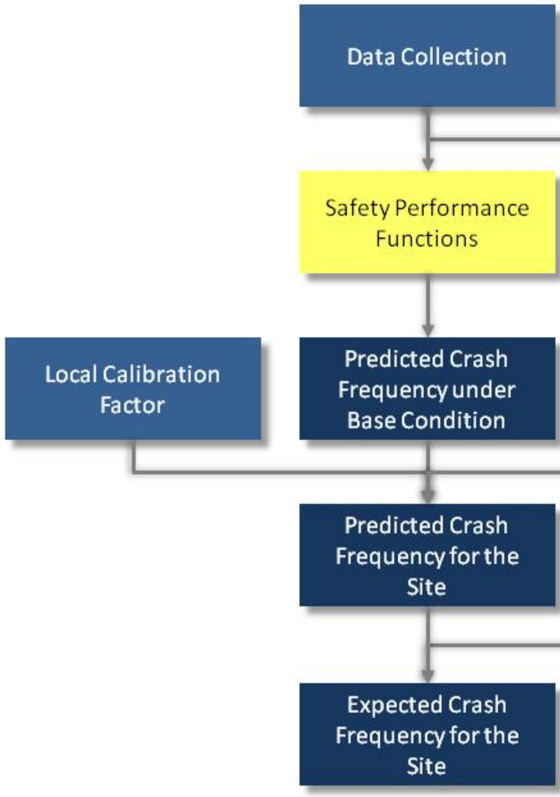
### 3.2.2.1 Observed Crash Data

The observed crash data for the sites are collected in this step. Once the roadway site is identified, the crash data for the targeted calendar years can be collected from the IDOT crash database. A procedure for assigning crashes to individual roadway segments and intersections is provided on pages A-17 to A-18 in HSM Appendix A. The reader should follow the principles for assigning segment and intersection crashes when collecting the observed crash data. Generally only the total crash frequency is needed.

### 3.2.2.2 Expected Crash Frequency for the Site

The expected crash frequency for the site can be determined with two steps. The first step is to determine the weighted adjustment with Equation (3-3) based on the overdispersion parameter and the predicted crash frequency for all calendar years; and the second step is to calculate the expected crash frequency with the weighted adjustment, the observed crash frequency as well as the predicted crash frequency, using Equation (3-2).

FIGURE 3-2
**Flowchart for Expected Crash Frequency Calculation**




# 3.3 Calculation of Expected Crash Frequency for Future Time Period

The general methodology for calculating the expected crash frequency for a future time period is discussed first, followed by a step-by-step description of the calculation procedures.

## 3.3.1 Methodology

The expected crash frequency for a roadway site in a future time period can be determined based on the AADTs, roadway geometric characteristics, and traffic control in the past and future time periods, as well as the observed crash data for the past time period. Based on Equation (A-15) on page A-23 of the HSM, the expected crash frequency for a future time period can be calculated with the following equation:

$$N_f = N_p \left(\frac{N_{bf}}{N_{bp}}\right)\left(\frac{CMF_{1f}}{CMF_{1p}}\right)\left(\frac{CMF_{2f}}{CMF_{2p}}\right)\cdots\left(\frac{CMF_{nf}}{CMF_{np}}\right) \tag{3-4}$$

where:

| | |
|---|---|
| $N_f$ | = expected average crash frequency during the future time period for which crashes are being forecast for the segment or intersection in question |
| $N_p$ | = expected average crash frequency for the past time period for which observed crash history data were available |
| $N_{bf}$ | = number of crashes forecast by the SPF using the future AADT data, the specified nominal values for geometric parameters, and the actual length of the segment |
| $N_{bp}$ | = number of crashes forecast by the SPF using the past AADT data, the specified nominal values for geometric parameters, and the actual length of the segment |
| $CMF_{nf}$ | = value of the nth CMF for the geometric conditions planned for the future design |
| $CMF_{np}$ | = value of the nth CMF for the geometric conditions for the past design |

### 3.3.2 Step-by-step Procedure

As shown in Equation (3-4), calculation of expected crash frequency for a future time period includes the calculation of expected crash frequency for the past time period ($N_p$), the calculation of predicted crash frequencies under base conditions for past and future time periods ($N_{bf}$ and $N_{bp}$), and the calculation of CMFs for past and future time periods ($CMF_{nf}$ and $CMF_{np}$). The final expected crash frequency for a future time period can be determined by multiplying all the calculated results together with Equation (3-4).

#### 3.3.2.1 Expected Crash Frequency for Past Time Period

The expected crash frequency for a past time period can be calculated with the methods described in Section 3.2 and will not be reiterated here. The AADT(s), roadway geometric characteristics, traffic control, and observed crash data for the past time period are required for the calculation.

#### 3.3.2.2 Predicted Crash Frequencies under Base Conditions for Past and Future Time Periods

The predicted crash frequencies under base conditions for past and future time periods can be calculated with the method described in Section 3.1.2.5 and will not be reiterated here. The AADT(s) and segment length (for roadway segment only) for past and future time periods are required for the calculation.

#### 3.3.2.3 Crash Modification Factors for Past and Future Time Periods

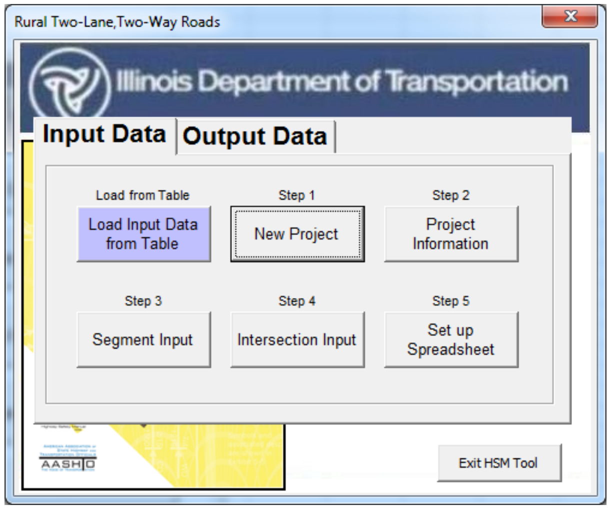
The CMFs for past and future time periods can be calculated with the method described in Section 3.1.2.6 and will not be reiterated here. The geometric characteristics and traffic control for the roadway site in past and future time periods are required for the calculation.

## 3.4 Calculation of Crash Frequency Using the IDOT HSM Crash Prediction Tool

Sections 3.1, 3.2, and 3.3 discuss the procedures for calculating the predicted and expected crash frequency using the HSM Part C predictive method. Following the step-by-step procedures, the predicted and/or expected crash frequency for a site, facility, and network can be calculated based on the AADT, roadway geometric, and traffic control data. However, a thorough understanding of the HSM Part C predictive method is necessary, and the calculation is time-consuming. Most engineers still find it difficult to apply the HSM Part C predictive method in their engineering practices.

To promote the implementation of the HSM in Illinois, IDOT BSE developed the **IDOT HSM Crash Prediction Tool**, a Visual Basic for Application (VBA)-based software for calculating the predicted and expected crash frequency for different facility types, as shown in Figure 3-3. All the detailed procedures for crash frequency calculation have been incorporated into the tools, and only brief data input is required. With this tool, the predicted and/or expected crash frequency for a site, facility, and network can be calculated automatically without any detailed knowledge about the HSM Part C predictive model. Therefore the workload is greatly reduced. Currently, the **IDOT HSM Crash Prediction Tool** does not include the module for calculating the expected crash frequency for a future time period. Version 3.0 of the **IDOT HSM Crash Prediction Tool** includes all the Illinois SPF calibration factors and the replaced default values in this document. For more details, the reader can refer to the **IDOT HSM Crash Prediction Tool Users Manual** (http://www.dot.il.gov/illinoisshsp/hsip.html).

FIGURE 3-3
**Interface for the IDOT HSM Crash Prediction Tool**




To facilitate the application of the tool, a step-by-step illustration of calculating the predicted and/or expected crash frequency using the **IDOT HSM Crash Prediction Tool** is included in the examples in Chapter 4. A description of the process and screen shots of key steps are provided in the examples as well.

# Examples

The HSM Part C predictive method provides the methodology for calculating the predicted and expected crash frequency for all facility types. To promote the application of the HSM in engineering practices, many training materials have been developed. However, to meet the requirements for HSM application in most states, the available HSM training materials were developed only for the most general application purposes and did not incorporate those applications specific for some states. Furthermore, the current HSM training materials were developed based on the SPFs and the default values included in the HSM. Only a brief description about the application of the calibrated SPFs and default values in crash frequency calculation was included, if any.

IDOT BSE has strived to promote the application of the HSM during different stages of the project development process in Illinois. As a result, Illinois has been a leading state on HSM implementation and has generated many specific needs on HSM applications. Furthermore, to get a more reliable calculation result, IDOT BSE calibrated the HSM Part C SPFs and replaced all the default values listed in Table A-3 of HSM Appendix A with Illinois data. No clues for those questions can be found from the available HSM training materials, and a knowledge gap exists between the theory and the engineering practice on the application of the HSM Part C predictive method in Illinois.

To fill the aforementioned knowledge gap, examples that incorporate the HSM Part C predictive method into the calculation of predicted and/or expected crash frequency in Illinois were developed. To reflect the specialty of HSM application in Illinois, all the examples were developed in a way similar to IDOT engineering practices, starting from the identified FHWA Five Percent locations and moving the discussion along the whole process from data collection to the final predicted and/or expected crash frequency calculation. In addition, the Illinois SPF calibration factor and replaced default values were incorporated into the crash frequency calculation in the examples as well.

To reflect the diversity of the application of the HSM Part C predictive method in Illinois, roadway sites under different facility types were selected. Specifically, Example 1 is for rural two-lane, two-way roadway segment; Example 2 is for an urban and suburban arterial; Example 3 is for a three-leg intersection with stop control on a rural two-lane, two-way road; and Example 4 is for a four-leg signalized intersection on an urban and suburban arterial. Meanwhile, different crash frequencies were calculated. Specifically, predicted crash frequencies were calculated in Examples 1 and 2 for comparing different improvement alternatives, while expected crash frequency was calculated in Examples 3 and 4 using the EB method.

# 4.1 Example 1: Calculation of Predicted Crash Frequency for Segments on Rural Two-lane, Two-way Roads

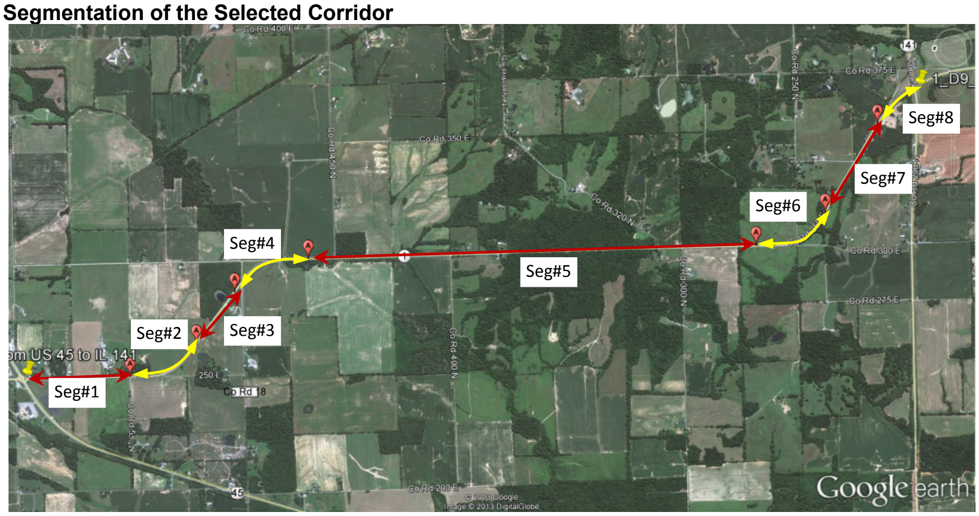
## 4.1.1 Introduction

The corridor of Illinois Route X from US Route A to Illinois Route B, as shown in Figure 4-1, is a 4.5-mile rural two-lane, two-way undivided roadway facility located in IDOT District 9. Based on the historical crash data and the adopted network screening process, the FHWA Five Percent Report identified the corridor as a "Five Percent" location under the peer group "rural two-lane highway" and recommended it for further safety improvements.

IDOT is to apply the Strategic Highway Safety Program (SHSP) funding for safety improvements on the corridor. Multiple improvement alternatives were proposed based on historical crash data, results from field visits, input from IDOT engineers, and IDOT policy. A comparison on predicted crash frequency among different improvement alternatives (including the "no build" plan) is necessary to quantify the safety effects of different alternatives and finalize the safety improvements. In addition to the safety concerns, other issues related to costs, right-of-way, traffic operations, environmental assessment, and others also should be considered during the alternative selection process.

This example illustrates how to calculate the predicted crash frequency for rural two-lane, two-way roadway segments using the HSM Part C predictive method. The predicted crash frequencies for different improvement alternatives are calculated manually first, followed by the calculation using the **IDOT HSM Crash Prediction Tool**.

FIGURE 4-1
**Segmentation of the Selected Corridor**




## 4.1.2 Manual Calculation of Predicted Crash Frequency

This section describes how to manually calculate the predicted crash frequency for different improvement alternatives (including the "no build" plan). To make the example concise, the calculation mainly focuses on the "no build" plan, while the calculation procedures for different improvement alternatives are described briefly later with all the results summarized in tables. For the purpose of cross-sectional comparison, the AADTs for planning year 2015 are used.

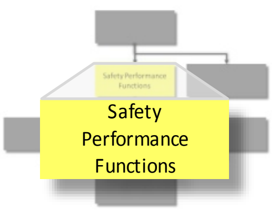
#### 4.1.2.1 Calculation of Predicted Crash Frequency for "No Build" Plan

As discussed previously, the predicted crash frequency calculation can be divided into data collection, the selection of SPFs, the selection of CMFs, the selection of calibration factors, calculation of predicted crash frequency under base conditions, calculation of CMFs, and calculation of predicted crash frequency under site prevailing conditions. The predicted crash frequency for the "no build" plan can be determined with the following steps.

**Step 1: Data Collection**


The corridor was divided into eight homogeneous segments, as illustrated in Figure 4-1. All the data required for the predicted crash frequency calculation were collected for different segments separately, as presented in Table 4-1. The level of roadside design is represented by the roadside hazard rating. Photographic examples and quantitative definitions for each roadside hazard rating (1-7) as a function of roadside design features are presented in Appendix 13A of the HSM. For this corridor, both the IDOT database and Google Earth Pro were used for the data collection efforts. All the data in Table 4-1 are for illustration purposes only and do not necessarily represent the real conditions of the selected sites.

**Step 2: Selection of Safety Performance Functions**



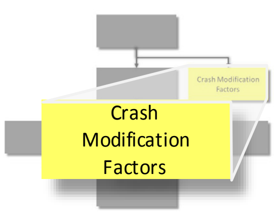

To calculate the predicted crash frequency under base conditions, the SPFs were selected in this step based on the facility type, which is "undivided roadway segment (2U) on rural two-lane, two-way roads" for all the segments in the corridor. Therefore, Equation (10-6) on Page 10-15 of the HSM, was selected, as shown below. This SPF can be used to calculate the predicted total crash frequency under base conditions.

$$N_{spf\ rs} = AADT \times L \times 365 \times 10^{-6} \times e^{(-0.312)} \qquad (4\text{-}1)$$

where:

$N_{spf\ rs}$ = predicted total crash frequency for roadway segment base conditions
$AADT$ = average annual daily traffic volume (vehicles)
$L$ = length of roadway segment (miles)

**Step 3: Selection of Crash Modification Factors**




Altogether, there are 12 CMFs for undivided roadway segment on rural two-lane, two-way roads—that is, the CMFs for lane width; shoulder width and type; horizontal curves; superelevation; grades; driveway density; centerline rumble strips; passing lanes; two-way left-turn lanes, roadside design; lighting; and automated speed enforcement, as listed in HSM pages 10-23 to 10-31. All the CMFs are applicable for the roadway segments in the corridor and all were selected.

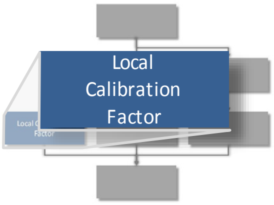
TABLE 4-1

**List of Data Collected for Predicted Crash Frequency Calculation**

| Data Item | Segment ID | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **Data for Calculating Predicted Crash Frequency under Base Conditions** | | | | | | | | |
| Segment length (mile) | 0.47 | 0.35 | 0.29 | 0.38 | 1.97 | 0.36 | 0.45 | 0.23 |
| AADT (vehicles/day) | 1,850 | 1,850 | 1,850 | 1,850 | 1,700 | 1,700 | 1,700 | 1,700 |
| **Data for Calculating the Crash Modification Factors** | | | | | | | | |
| Lane width (feet) | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Shoulder width (feet) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Shoulder type | Gravel | Gravel | Gravel | Gravel | Gravel | Gravel | Gravel | Gravel |
| Horizontal alignment | Tangent | Curve | Tangent | Curve | Tangent | Curve | Tangent | Curve |
| Length of horizontal curve (mile) | 0 | 0.35 | 0 | 0.38 | 0 | 0.36 | 0 | 0.23 |
| Radius of curvature (feet) | N/A | 1,162 | N/A | 1,132 | N/A | 987 | N/A | 2,936 |
| Spiral transition curve | N/A | Not present | N/A | Not present | N/A | Not present | N/A | Not present |
| Super elevation variance | N/A | 0 | N/A | 0 | N/A | 0 | N/A | 0 |
| Grades (%) | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% |
| Driveway density (per mile) | 12.8 | 8.6 | 3.4 | 7.9 | 4.1 | 5.6 | 6.7 | 8.7 |
| Centerline rumble strips | Not present | Not present | Not present | Not present | Not present | Not present | Not present | Not present |
| Passing lanes | Not present | Not present | Not present | Not present | Not present | Not present | Not present | Not present |
| Two-way left-turn lanes | Present | Present | Not present | Not present | Not present | Not present | Not present | Not present |
| Roadside hazard rating | 5 | 3 | 3 | 3 | 3 | 3 | 6 | 3 |
| Lighting | Not present | Not present | Not present | Not present | Not present | Not present | Not present | Not present |
| Automated speed enforcement | Not present | Not present | Not present | Not present | Not present | Not present | Not present | Not present |
| **Illinois Safety Performance Function Calibration Factor and Replaced Default Values** | | | | | | | | |
| $C_r$ | 1.47 | | | | | | | |
| $p_{ra}$ | 37.2% | | | | | | | |
| $p_{nr}$ | 0.715 | | | | | | | |
| $p_{inr}$ | 0.208 | | | | | | | |
| $p_{pnr}$ | 0.792 | | | | | | | |

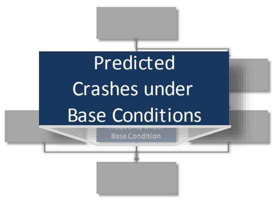
Notes:
ID = Identification number
N/A = not applicable

### Step 4: Selection of Illinois Safety Performance Function Calibration Factor




The Illinois SPF calibration factor was selected in this step. For this example, Table A-4 in Appendix A of this document was used because the corridor is located within IDOT District 9 and the calendar year for the analysis is 2015. Based on Table A-4, the Illinois SPF calibration factor for rural two-lane, two-way roadway segments is 1.47.

### Step 5: Calculation of Predicted Crash Frequency under Base Conditions




The predicted crash frequency for different segments under base conditions was calculated. For illustration purposes, only the predicted crash frequency under base conditions for Segment 1 is calculated in the following section. The predicted crash frequency for the rest of the segments under base conditions can be calculated with similar procedures, as summarized in Table 4-2.

Based on data in Table 4-1, the segment length and AADT for Segment 1 were 0.47 mile and 1,850 vehicles per day, respectively. Therefore, the predicted crash frequency for Segment 1 under base conditions is:

$$\begin{aligned} N_{spf\ rs} &= AADT \times L \times 365 \times 10^{-6} \times e^{(-0.312)} \\ &= 1850 \times 0.47 \times 365 \times 10^{-6} \times e^{(-0.312)} \\ &= 0.232\ crashes/year \end{aligned} \tag{4-2}$$

### Step 6: Calculation of Crash Modification Factors


The CMFs for different segments of the corridor can be determined based on the roadway characteristics on geometric and traffic control using the tables, equations, and figures included in the HSM. For illustration purposes, only the CMFs for Segment 1 are calculated here. The CMFs for the rest of the segments can be calculated with similar procedures, as summarized in Table 4-2.

1) CMF for lane width ($CMF_{1r}$)

The CMF for lane width can be determined with Equation (10-11) on page 10-24 of the HSM, as shown below:

$$CMF_{1r} = (CMF_{ra} - 1.0) \times p_{ra} + 1.0 \tag{4-3}$$

For Segment 1, the lane width is 12 feet, which is exactly the base condition of lane width for this facility type. Therefore, the CMF for lane width is 1.0.

2) CMF for shoulder width and type ($CMF_{2r}$)

The CMF for shoulder width and type can be determined with Equation (10-12) on page 10-27 of the HSM, as shown below:

$$CMF_{2r} = (CMF_{wra} \times CMF_{tra} - 1.0) \times p_{ra} + 1.0 \tag{4-4}$$

As listed in Table 4-1, Segment 1 has a gravel shoulder with a width of 2 feet. Based on Table 10-10 on page 10-26 of the HSM, the $CMF_{tra}$ for Segment 1 is 1.01. Based on Table 10-9 on page 10-25 of the HSM, the $CMF_{wra}$ for Segment 1 is:

$$CMF_{wra} = 1.07 + 1.43 \times 10^{-4} \times (AADT - 400) \quad (4\text{-}5)$$
$$= 1.07 + 1.43 \times 10^{-4} \times (1850 - 400)$$
$$= 1.28$$

The $p_{ra}$ is the proportion of total crashes constituted by related crashes; that is, single-vehicle run-off-the-road, multiple-vehicle head-on, and multiple-vehicle sideswipe crashes. A value of 57.4 percent was provided for $p_{ra}$ by the HSM. However, the HSM recommended that “the value may be updated from local data as part of the calibration process.” Based on the default values in Table B-4-4 in Appendix B-4 of this document, the value of $p_{ra}$ was determined to be 37.2 percent. The default table was selected based on the IDOT jurisdiction for the corridor (IDOT District 9) and the calendar year for the analysis (2015).

Therefore, for Segment 1, the final CMF for shoulder width and type is:

$$CMF_{2r} = (CMF_{wra} \times CMF_{tra} - 1.0) \times p_{ra} + 1.0 \quad (4\text{-}6)$$
$$= (1.28 \times 1.01 - 1.0) \times 0.372 + 1.0$$
$$= 1.11$$

3) CMF for horizontal curves ($CMF_{3r}$)

The CMF for horizontal curves can be determined with Equation (10-13) on page 10-27 of the HSM, as shown below.

$$CMF_{3r} = \frac{1.55 \times L_C + \frac{80.2}{R} - 0.012 \times S}{1.55 \times L_C} \quad (4\text{-}7)$$

Since there are no horizontal curves on Segment 1, the CMF for horizontal curves is 1.0.

4) CMF for super elevation ($CMF_{4r}$)

The CMF for super elevation can be determined with Equations (10-14) to (10-16) on page 10-28 of the HSM. Since there are no horizontal curves on Segment 1, the CMF for super elevation is 1.0.

5) CMF for grades ($CMF_{5r}$)

The CMF for grades can be determined with Table 10-11 on page 10-28 of the HSM. The grade for Segment 1 is 2 percent. Therefore, for Segment 1, the CMF for grades is 1.00.

6) CMF for driveway density ($CMF_{6r}$)

The CMF for driveway density can be determined with Equation (10-17) on page 10-28 of the HSM, as shown below:

$$CMF_{6r} = \frac{0.322 + DD \times [0.05 - 0.005 \times ln(AADT)]}{0.322 + 5 \times [0.05 - 0.005 \times n(AADT)]} \quad (4\text{-}8)$$

The driveway density for Segment 1 is 12.8 driveways per mile. Therefore, the CMF for driveway density is:

$$CMF_{6r} = \frac{0.322 + DD \times [0.05 - 0.005 \times ln(AADT)]}{0.322 + 5 \times [0.05 - 0.005 \times ln(AADT)]} \quad (4\text{-}9)$$
$$= \frac{0.322 + 12.8 \times [0.05 - 0.005 \times ln(1850)]}{0.322 + 5 \times [0.05 - 0.005 \times ln(1850)]}$$
$$= 1.25$$

7) CMF for centerline rumble strips ($CMF_{7r}$)

The CMF for centerline rumble strips can be determined with the description on page 10-29 of the HSM. No centerline rumble strips were installed on Segment 1. Therefore, a CMF of 1.00 is applied here.

8) CMF for passing lanes ($CMF_{8r}$)

The CMF for passing lanes can be determined with the description on page 10-29 of the HSM. No passing lanes are provided for Segment 1. Therefore, a CMF of 1.00 is applied here.

9) CMF for two-way left-turn lanes ($CMF_{9r}$)

The CMF for two-way left-turn lanes can be determined with Equation (10-18) on page 10-30 of the HSM, as shown below:

$$CMF_{9r} = 1.0 - \left(0.7 \times p_{dwy} \times p_{LT/D}\right) \tag{4-10}$$

Where $p_{LT/D}$ is estimated as 0.5 by HSM and $p_{dwy}$ can be determined with Equation (10-19) on page 10-30 of the HSM, as shown below:

$$p_{dwy} = \frac{(0.0047 \times DD) + \left(0.0024 \times DD^2\right)}{1.199 + (0.0047 \times DD) + \left(0.0024 \times DD^2\right)} \tag{4-11}$$

DD in Equation (4-10) refers to the driveway density considering driveways on both sides of the highway.

As listed in Table 4-1, two-way left-turn lane is provided for Segment 1, and its driveway density is 12.8 driveways per mile; therefore, the $p_{dwy}$ is:

$$\begin{aligned} p_{dwy} &= \frac{(0.0047 \times DD) + \left(0.0024 \times DD^{(2)}\right)}{1.199 + (0.0047 \times DD) + \left(0.0024 \times DD^{(2)}\right)} \\ &= \frac{(0.0047 \times 12.8) + \left(0.0024 \times (12.8)^{(2)}\right)}{1.199 + (0.0047 \times 12.8) + \left(0.0024 \times (12.8)^{(2)}\right)} \\ &= 0.274 \end{aligned} \tag{4-12}$$

Therefore, for Segment 1, the CMF for two-way left-turn lanes is:

$$\begin{aligned} CMF_{9r} &= 1.0 - \left(0.7 \times p_{dwy} \times p_{\frac{LT}{D}}\right) \\ &= 1.0 - (0.7 \times 0.274 \times 0.5) \\ &= 0.90 \end{aligned} \tag{4-13}$$

10) CMF for roadside design ($CMF_{10r}$)

The CMF for roadside design can be determined with Equation (10-20) on page 10-30 of the HSM, as shown below:

$$CMF_{10r} = \frac{e^{(-0.6869 + 0.0668 \times RHR)}}{e^{(-0.4865)}} \tag{4-14}$$

where:
RHR = roadside hazard rating

The RHR for Segment 1 is 5; therefore, the CMF for roadside design is:

$$\begin{aligned} CMF_{10r} &= \frac{e^{(-0.6869 + 0.0668 \times RHR)}}{e^{(-0.4865)}} \\ &= \frac{e^{(-0.6869\ +\ 0.0668 \times 5)}}{e^{(-0.4865)}} \\ &= 1.14 \end{aligned} \tag{4-15}$$

11) CMF for lighting ($CMF_{11r}$)

The CMF for lighting can be determined with Equation (10-21) on page 10-31 of the HSM, as shown below:

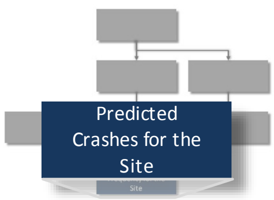
$$CMF_{11r} = 1.0 - [(1.0 - 0.72 \times p_{inr} - 0.83 \times p_{pnr}) \times p_{nr}] \quad (4\text{-}16)$$

Since lighting is not present along the segment, a CMF of 1.00 is applied here.

CMF for automated speed enforcement ($CMF_{12r}$)

The CMF for automated speed enforcement can be determined with the description on page 10-31 of the HSM. Since no automated speed enforcements are proposed, a CMF of 1.00 is applied here.

**Step 7: Calculation of Predicted Crash Frequency under Site Prevailing Conditions**




The final step is to calculate the predicted crash frequency for the segments under site prevailing conditions, which can be determined with Equation (10-2) on page 10-3 of the HSM based on the predicted crash frequency under base condition, the Illinois SPF calibration factor, and all the CMFs calculated in previous steps, as shown below:

$$N_{predicted\ rs} = N_{spf\ rs} \times C_r \times (CMF_{1r} \times CMF_{2r} \times \cdots \times CMF_{12r}) \quad (4\text{-}17)$$

where:
$N_{spf\ rs}$ = the predicted crash frequency for an individual roadway segment under base conditions
$C_r$ = the calibration factor for roadway segment of a specific type developed for a particular jurisdiction or geographical area
$CMF_{1r}, CMF_{2r}, \cdots, CMF_{12r}$ = the CMFs for rural two-lane, two-way roadway segments, respectively

All the CMFs, the Illinois SPF calibration factor, and predicted crash frequency under base conditions have been calculated or selected in the previous steps. For planning year 2015, the predicted crash frequency for roadway Segment 1 under site prevailing conditions is:

$$\begin{aligned} N_{predicted\ rs} &= N_{spf\ rs} \times C_r \times (CMF_{1r} \times CMF_{2r} \times \cdots \times CMF_{12r}) \quad (4\text{-}18) \\ &= 0.232 \times 1.47 \times 1.0 \times 1.11 \times 1.0 \times 1.0 \times 1.0 \times 1.25 \times 1.0 \times 1.0 \times 0.90 \times 1.14 \times 1.0 \times 1.0 \\ &= 0.489\ crashes/year \end{aligned}$$

The predicted crash frequencies for the rest segments under site prevailing conditions can be determined with similar procedures. To make the example concise, the calculation procedures are omitted, and the final results are summarized in Table 4-2. In summary, the predicted crash frequency for the corridor under site prevailing conditions ("no build" plan) in 2015 would be 3.819, or approximately one crash in every 96 days.

TABLE 4-2
**Summary of Crash Modification Factors and Predicted Crash Frequencies (“No Build” Plan)**

| Data Item | Segment ID | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| $N_{spf\ rs}$ | 0.232 | 0.173 | 0.143 | 0.188 | 0.895 | 0.164 | 0.204 | 0.104 |
| $CMF_{1r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{2r}$ | 1.11 | 1.11 | 1.11 | 1.11 | 1.10 | 1.10 | 1.10 | 1.10 |
| $CMF_{3r}$ | 1.00 | 1.13 | 1.00 | 1.12 | 1.00 | 1.15 | 1.00 | 1.08 |
| $CMF_{4r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{5r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{6r}$ | 1.25 | 1.12 | 1.00 | 1.09 | 1.00 | 1.02 | 1.06 | 1.12 |
| $CMF_{7r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{8r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{9r}$ | 0.90 | 0.95 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{10r}$ | 1.14 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.22 | 1.00 |
| $CMF_{11r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{12r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $N_{predicted\ rs}$ | 0.489 | 0.335 | 0.233 | 0.375 | 1.447 | 0.309 | 0.427 | 0.204 |

#### 4.1.2.2 Proposed Improvement Alternatives for the Corridor

To improve the safety performance of the corridor, multiple improvement alternatives were developed based on the historical crash data, field visit results, input from IDOT engineers, and IDOT policy, as listed below:

- Improvement Alternative 1: Install centerline rumble strips on all segments along the corridor and redesign the roadside for Segments 1 and 7 to change the RHR for both segments to 3
- Improvement Alternative 2: Increase the shoulder width for all the segments from 2 feet to 6 feet, and convert the shoulder type from gravel shoulder into paved shoulder
- Improvement Alternative 3: Apply all the safety improvements in Improvement Alternatives 1 and 2 to the corridor

All the improvement alternatives proposed here are only for illustration purposes and do not necessarily represent the actual improvement alternatives developed in IDOT engineering practice.

#### 4.1.2.3 Calculation of Predicted Crash Frequency for Different Improvement Alternatives

The predicted crash frequency for the corridor under different improvement alternatives was calculated with similar procedures. For the purpose of cross-sectional comparison, the AADTs for the same planning year, 2015, were used. To make the example concise, only the calculation of CMFs related with different improvement alternatives are discussed, and all the calculated CMFs and predicted crash frequencies are summarized in tables, as listed below.

- Calculation of predicted crash frequency for Improvement Alternative 1

Improvement Alternative 1 would install centerline rumble strips on all segments along the corridor and redesign the roadside for Segments 1 and 7 to change the RHR for both segments to 3. Under this alternative, the CMFs for centerline rumble strips ($CMF_{7r}$) would be 0.94; and the roadside redesign would change the CMFs for roadside design ($CMF_{10r}$) for Segments 1 and 7 to be 1.00, as shown in bold in Table 4-3. The predicted crash frequency for all the segments under Improvement Alternative 1 can be calculated, as shown in bold in Table 4-3. The total predicted crash frequency for the corridor under Improvement Alternative 1 in 2015 is 3.460, or approximately one crash in every 105 days.

TABLE 4-3
**Summary of Crash Modification Factors and Predicted Crash Frequencies (Improvement Alternative 1)**

| Data Item | Segment ID | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| $N_{spf\ rs}$ | 0.232 | 0.173 | 0.143 | 0.188 | 0.895 | 0.164 | 0.204 | 0.104 |
| $CMF_{1r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{2r}$ | 1.11 | 1.11 | 1.11 | 1.11 | 1.10 | 1.10 | 1.10 | 1.10 |
| $CMF_{3r}$ | 1.00 | 1.13 | 1.00 | 1.12 | 1.00 | 1.15 | 1.00 | 1.08 |
| $CMF_{4r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{5r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{6r}$ | 1.25 | 1.12 | 1.00 | 1.09 | 1.00 | 1.02 | 1.06 | 1.12 |
| $CMF_{7r}$ | **0.94** | **0.94** | **0.94** | **0.94** | **0.94** | **0.94** | **0.94** | **0.94** |
| $CMF_{8r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{9r}$ | 0.90 | 0.95 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{10r}$ | **1.00** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | **1.00** | 1.00 |
| $CMF_{11r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{12r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $N_{predicted\ rs}$ | **0.402** | **0.315** | **0.219** | **0.352** | **1.360** | **0.290** | **0.328** | **0.192** |

- Calculation of predicted crash frequency for Improvement Alternative 2

Improvement Alternative 2 would change the shoulder width and shoulder type for all the segments. After that, the CMFs for shoulder width and type ($CMF_{2r}$) for all the segments would be 1.00, as shown in bold in Table 4-4. The predicted crash frequency for all sites under Improvement Alternative 2 can be calculated, as shown in bold in Table 4-4. The total predicted crash frequency for the corridor under Improvement Alternative 2 for planning year 2015 is 3.463, or approximately one crash in every 105 days.

TABLE 4-4
**Summary of Crash Modification Factors and Predicted Crash Frequencies (Improvement Alternative 2)**

| Data Item | Segment ID | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| $N_{spf\ rs}$ | 0.232 | 0.173 | 0.143 | 0.188 | 0.895 | 0.164 | 0.204 | 0.104 |
| $CMF_{1r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{2r}$ | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** |
| $CMF_{3r}$ | 1.00 | 1.13 | 1.00 | 1.12 | 1.00 | 1.15 | 1.00 | 1.08 |
| $CMF_{4r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{5r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{6r}$ | 1.25 | 1.12 | 1.00 | 1.09 | 1.00 | 1.02 | 1.06 | 1.12 |
| $CMF_{7r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{8r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{9r}$ | 0.90 | 0.95 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{10r}$ | 1.14 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.22 | 1.00 |
| $CMF_{11r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{12r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $N_{predicted\ rs}$ | **0.442** | **0.303** | **0.211** | **0.338** | **1.315** | **0.281** | **0.388** | **0.186** |

- Calculation of predicted crash frequency for Improvement Alternative 3

Improvement Alternative 3 would apply all the treatments in Improvement Alternatives 1 and 2. The relevant CMFs for Improvement Alternative 3 were calculated, as shown in bold in Table 4-5. The predicted crash frequency for all sites under Improvement Alternative 3 can be calculated, as shown in bold in Table 4-5. The total predicted crash frequency for the corridor under Improvement Alternative 3 for planning year 2015 was 3.137, or approximately one crash in every 116 days.

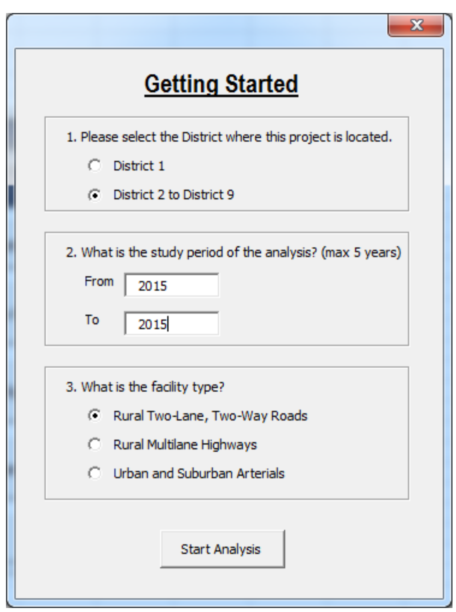
TABLE 4-5
**Summary of Crash Modification Factors and Predicted Crash Frequencies (Improvement Alternative 3)**

| Data Item | Segment ID | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| $N_{spf\ rs}$ | 0.232 | 0.173 | 0.143 | 0.188 | 0.895 | 0.164 | 0.204 | 0.104 |
| $CMF_{1r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{2r}$ | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** |
| $CMF_{3r}$ | 1.00 | 1.13 | 1.00 | 1.12 | 1.00 | 1.15 | 1.00 | 1.08 |
| $CMF_{4r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{5r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{6r}$ | 1.25 | 1.12 | 1.00 | 1.09 | 1.00 | 1.02 | 1.06 | 1.12 |
| $CMF_{7r}$ | **0.94** | **0.94** | **0.94** | **0.94** | **0.94** | **0.94** | **0.94** | **0.94** |
| $CMF_{8r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{9r}$ | 0.90 | 0.95 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{10r}$ | **1.00** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | **1.00** | 1.00 |
| $CMF_{11r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{12r}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $N_{predicted\ rs}$ | **0.363** | **0.285** | **0.198** | **0.318** | **1.236** | **0.264** | **0.298** | **0.174** |

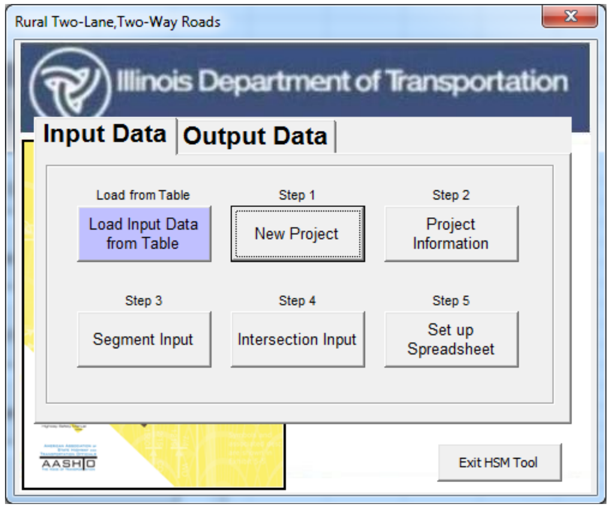
### 4.1.3 Calculation of Predicted Crash Frequency Using the IDOT HSM Crash Prediction Tool

The predicted crash frequency for this corridor was calculated using the **IDOT HSM Crash Prediction Tool**. For illustration purposes, only the procedures for the "no build" plan are described, while the predicted crash frequency for different improvement alternatives can be calculated with similar procedures. The predicted crash frequency calculation can be divided into eight steps, as listed below.

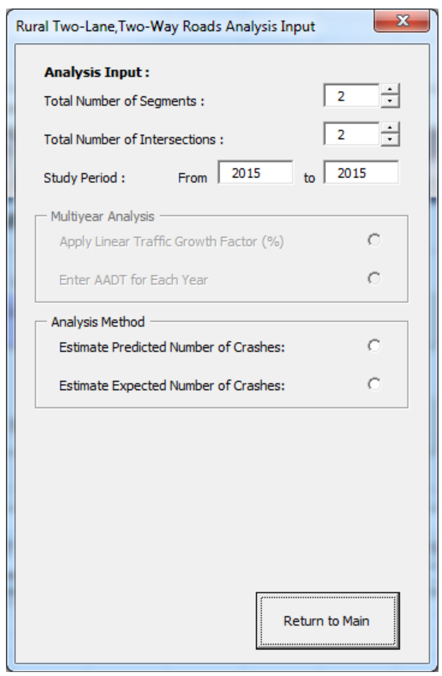
**Step 1**: Enter the following data in the **Getting Started** user form. The project is located in IDOT District 9, study period is 2015, and the facility is a rural two-lane, two-way roadway segment. Click the **Start Analysis** button.



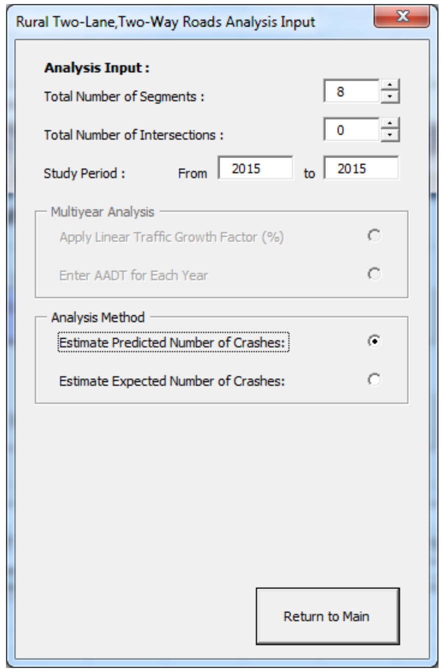
**Step 2**: The Main Menu user form will open up as shown below.



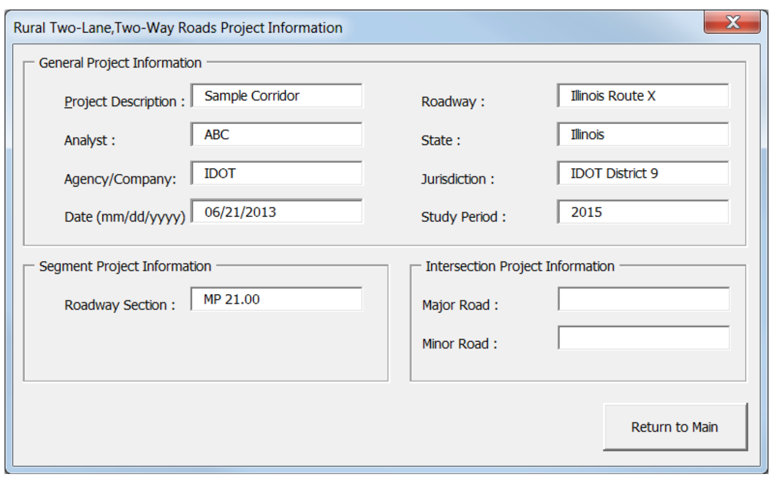

**Step 3:** Select the New Project button. The Rural Two-lane, Two-Way Roads Analysis Input user form will appear.



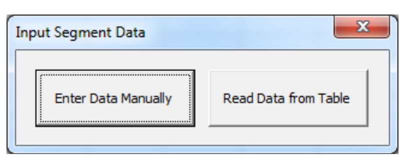
**Step 4**: Enter the required data. For this example, eight segments will be analyzed while no intersections will be included. The study period (2015 to 2015) will be prepopulated. The analysis method for this example is **Estimate Predicted Number of Crashes**. Once all the data are entered, click on **Return to Main** button.



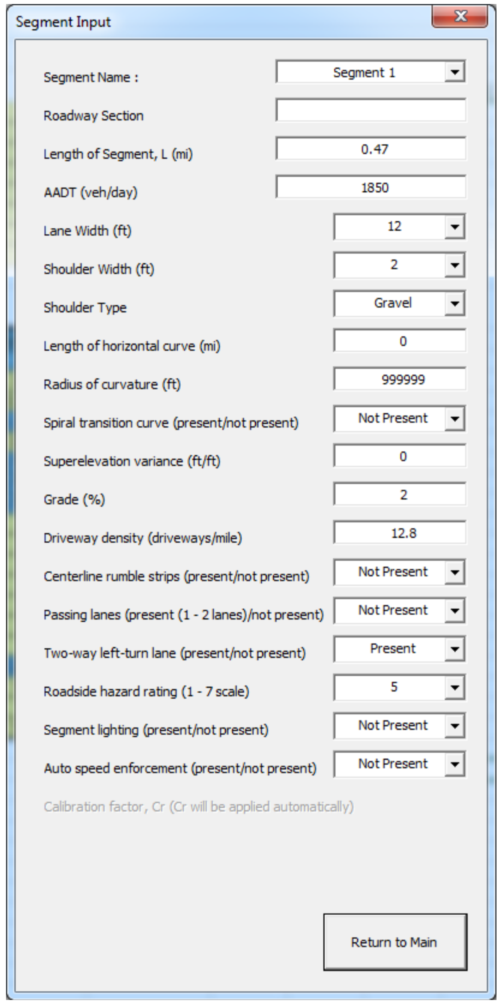

**Step 5**: Press the **Project Information** button, and enter details about the project. Once the form is filled out, press the **Return to Main** button to go back to the main menu.



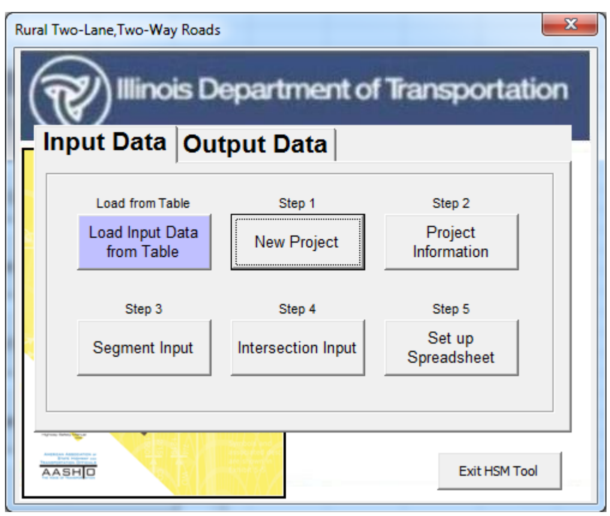

**Step 6**: Press the **Segment Input** button and enter the data. A new user form appears asking the user to choose the data input method. Data can be input either using user forms or in a table format.



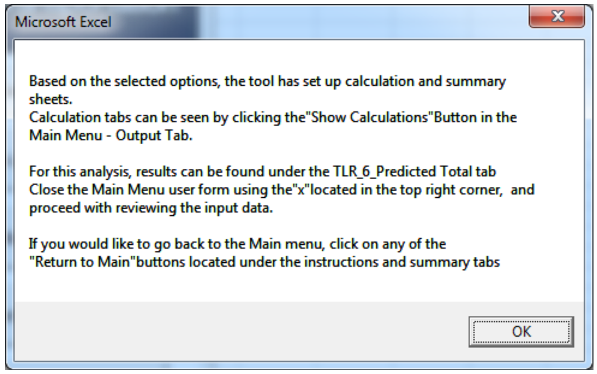

For this example, the **Enter Data Manually** option is selected. The **Segment Input** user form will pop up after clicking the **Enter Data Manually** button, and the roadway segment data can be input. For this example, the data for each roadway segment in Table 4-1 were input into the tool separately. Once the form is filled out, press the **Return to Main** button to go back to the main menu.




**Step 7**: Once all the data entry is completed, press the **Set up Spreadsheet** button. This button will run the entire set-up process for the application of the predictive method.



**Step 8**: Once the process is finished running, a pop-up window will appear, providing users with instructions on the next steps, and where to find results of the analysis. Click **OK** to continue, and close the main menu interface to go to the summary sheet.




Results can be found in Tab **TLR_6_Predicted_Total**.

## 4.1.4 Conclusions and Recommendations

The predicted crash frequencies for the corridor under different improvement alternatives (including the "no build" plan) were calculated using the Illinois SPF calibration factors and replaced default values, as summarized in Table 4-6.

TABLE 4-6
**Summary of Predicted Crash Frequency under Different Improvement Alternatives**

| Segment ID | Improvement Alternatives | | | |
|---|---|---|---|---|
| | "No Build" Plan | Alternative 1 | Alternative 2 | Alternative 3 |
| 1 | 0.489 | 0.402 | 0.442 | 0.363 |
| 2 | 0.335 | 0.315 | 0.303 | 0.285 |
| 3 | 0.233 | 0.219 | 0.211 | 0.198 |
| 4 | 0.375 | 0.352 | 0.338 | 0.318 |
| 5 | 1.447 | 1.360 | 1.315 | 1.236 |
| 6 | 0.309 | 0.290 | 0.281 | 0.264 |
| 7 | 0.427 | 0.328 | 0.388 | 0.298 |
| 8 | 0.204 | 0.192 | 0.186 | 0.174 |
| Total | 3.819 | 3.460 | 3.463 | 3.137 |

A cross-sectional comparison between the "no build" plan and different improvement alternatives indicated that Improvement Alternatives 1, 2, and 3 would decrease the predicted crash frequency by 0.359 (9.4 percent), 0.356 (9.3 percent), and 0.682 (17.9 percent), respectively. In other words, Improvement Alternatives 1 and 2 can reduce approximately one crash in every 1017 and 1025 days respectively, and Improvement Alternative 3 can reduce approximately one crash in every 535 days. For a design life period of 20 years, Improvement Alternatives 1, 2, and 3 can reduce approximately 7, 7, and 14 crashes, respectively. The crash frequency reduction can be further converted into monetary benefit with the application of appropriate unit crash cost. A final decision on the improvement alternatives can be made based on the reduction on crash frequency as well as other factors such as costs, right-of-way, traffic operations, and environmental assessment.

# 4.2 Calculation of Predicted Crash Frequency for Segments on Urban and Suburban Arterials

## 4.2.1 Introduction

The corridor of Illinois Route Y from M Street to N Avenue, as shown in Figure 4-2, is a 0.9-mile undivided two-lane segment on an urban and suburban arterial located in IDOT District 8. Based on the historical crash data and the adopted network screening process, the FHWA Five Percent Report identified this corridor as a Five Percent location under the peer group “urban two lane highway” and recommended it for further safety improvements.

IDOT is to apply the SHSP funding for safety improvements on the corridor. Based on the historical crash data, results from field visits, input from IDOT engineers, and IDOT policy, the corridor is proposed to be converted into a three-lane arterial. A comparison on predicted crash frequency between the “no build” plan and the proposed treatments is necessary to quantify the safety effects of the improvements. In addition to the safety concerns, other issues related to costs, right-of-way, traffic operations, environmental assessment, and others should be considered during the improvement selection process.

FIGURE 4-2
**Segmentation of the Selected Corridor**


This example illustrates how to calculate the predicted crash frequency for segments on urban and suburban arterials using the HSM Part C predictive method. The predicted crash frequencies for the “no build” plan and the proposed treatments are calculated manually first, followed by calculation using the **IDOT HSM Crash Prediction Tool**.

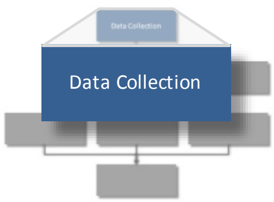
## 4.2.2 Manual Calculation of Predicted Crash Frequency

The predicted crash frequency for both the “no build” plan and the proposed treatments are calculated manually first. For this example, the facility type for all the segments in the corridor would change from “two-lane undivided arterial” (2U) under the “no build” plan to “three-lane arterial” (3T) under the proposed treatments. Correspondingly, the calculations of predicted crash frequency for the “no build” plan and the treatments are quite different. For clarification purposes, the calculations for both scenarios are described separately in the following sections. For the purpose of cross-sectional comparison, the AADTs for the planning year 2015 are used.

#### 4.2.2.1 Calculation of Predicted Crash Frequency for "No Build" Plan

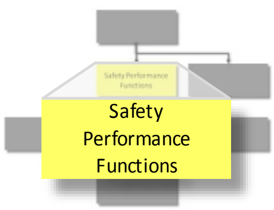
As discussed previously, the predicted crash frequency calculation can be divided into data collection, selection of SPFs, selection of CMFs, selection of calibration factors, calculation of predicted crash frequency under base conditions, calculation of CMFs, and calculation of predicted crash frequency under site prevailing conditions, respectively. The predicted crash frequency for the "no build" plan can be determined with the following steps.

**Step 1: Data Collection**




To achieve homogeneous segments, the corridor was divided into three parts, as illustrated in Figure 4-2. All the data required for the predicted crash frequency calculation were collected for different segments separately, as presented in Table 4-7. For this corridor, both the IDOT database and Google Earth Pro were used for the data collection efforts. All data in Table 4-7 are only for illustration purposes and do not necessarily represent the real conditions of the selected sites.

**Step 2: Selection of Safety Performance Functions**




To calculate the predicted crash frequency under base conditions, the SPFs were selected in this step based on the facility type, which is "two-lane undivided arterial (2U) on urban and suburban arterials" for all the segments in the corridor. The predicted crash frequency under base conditions for single-vehicle crashes, multiple-vehicle non-driveway collisions, and multiple-vehicle driveway-related collisions needs to be calculated in this example. Therefore, Equation (12-10) on HSM page 12-18, Equation (12-13) on HSM page 12-20, and Equation (12-16) on HSM page 12-22 were selected, as shown below. This SPF can be used to calculate the predicted total crash frequency under base conditions.

$$N_{brmv} = \exp(-15.22 + 1.68 \times \ln(AADT) + \ln(L)) \qquad (4\text{-}19)$$

$$N_{brsv} = \exp(-5.47 + 0.56 \times \ln(AADT) + \ln(L)) \qquad (4\text{-}20)$$

$$N_{brdwy} = \sum_{all\ driveway\ types} n_j \times N_j \times \left(\frac{AADT}{15{,}000}\right)^{(1.000)} \qquad (4\text{-}21)$$

where:

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

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

$N_{brdwy}$ = predicted average crash frequency of multiple-vehicle driveway-related collisions

$AADT$ = average annual daily traffic volume (vehicles)

$L$ = length of roadway segment (miles)

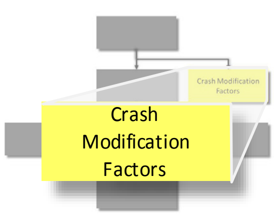
$n_j$ = number of driveways within roadway segment of driveway type j including all driveways on both sides of the road

$N_j$ = number of driveway-related collisions per driveway per year for driveway type j from HSM Table 12-7.

TABLE 4-7
**List of Data Collected for Predicted Crash Frequency Calculation**

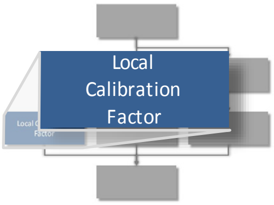
| Data Item | | Segment ID | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| **Data for Calculating Predicted Crash Frequency under Base Conditions** | | | | |
| Segment length (mile) | | 0.30 | 0.10 | 0.50 |
| AADT (vehicles/day) | | 10,300 | 8,700 | 9,400 |
| Number of driveways | Major commercial | 3 | 4 | 10 |
| | Minor commercial | 4 | 0 | 5 |
| | Major industrial/institutional | 0 | 0 | 0 |
| | Minor industrial/institutional | 0 | 0 | 0 |
| | Major residential | 5 | 0 | 8 |
| | Minor residential | 3 | 0 | 3 |
| | Other | 0 | 0 | 0 |
| Posted speed | | 35 mph | 35 mph | 40 mph |
| **Data for Calculating the Crash Modification Factors** | | | | |
| On-street parking | Type of parking | Parallel | Parallel | Parallel |
| | Land use | Commercial | Commercial | Commercial |
| | Proportion of curb length with on-street parking | 0.56 | 0.48 | 0.65 |
| Roadside fixed objects | Fixed object density (fixed objects per mile) | 100 | 140 | 230 |
| | Offset to fixed objects (feet) | 5 | 10 | 10 |
| Lighting | | Not present | Not present | Not present |
| Automated speed enforcement | | Not present | Not present | Not present |
| **Illinois Safety Performance Function Calibration Factor and Replaced Default Values** | | | | |
| Illinois calibration factor ($C_r$) | | 1.15 | | |
| Pedestrian crash adjustment factor ($f_{pedi}$) | | 0.004 | | |
| Bicycle crash adjustment factor ($f_{bikei}$) | | 0.002 | | |
| Nighttime crash proportions | $p_{nr}$ | 0.648 | | |
| | $p_{inr}$ | 0.210 | | |
| | $p_{pnr}$ | 0.790 | | |
| Note:<br>mph = miles per hour | | | | |

### Step 3: Selection of Crash Modification Factors




Altogether, there are four CMFs for two-lane undivided arterial (2U) on urban and suburban arterials; that is, the CMFs for on-street parking, roadside fixed objects, lighting, and automated speed enforcement, as listed from HSM pages 12-40 to 12-43. The CMF for median width in HSM Chapter 12, $CMF_{3r}$, does not apply to this facility type. All the CMFs applicable for the roadway segments in the corridor were selected.

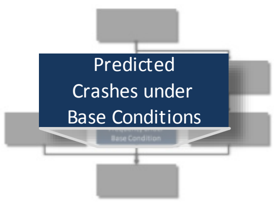
**Step 4: Selection of Illinois Safety Performance Function Calibration Factor**




The Illinois SPF calibration factor was selected in this step based on the facility type, IDOT jurisdiction of the site, and the time period for the analysis. For this example, Table A-4 in Appendix A of this document was used because the corridor is located within IDOT District 8 and the calendar year for the analysis is 2015. Based on Table A-4, the Illinois SPF calibration factor for two-lane undivided arterial on urban and suburban arterial is 1.15.

In addition to the Illinois SPF calibration factor, the replaced pedestrian crash adjustment factor, bicycle crash adjustment factor, and nighttime crash proportions were selected based on the facility type, IDOT jurisdiction of the site, and the time period for the analysis. Similarly, because the corridor is located within IDOT District 8 and the calendar year for the analysis is 2015, the pedestrian crash adjustment factor, bicycle crash adjustment factor, and nighttime crash proportions were selected from Appendix B Tables B-6-8, B-6-10, and B-6-20, respectively, as listed in Table 4-7.

**Step 5: Calculation of Predicted Crash Frequency under Base Conditions**




The predicted crash frequency under base conditions was calculated in this step. Based on the HSM methodology, the predicted crash frequency under base conditions for multiple-vehicle non-driveway collisions, multiple-vehicle driveway-related collisions and single-vehicle crashes can be determined with relevant SPFs. For illustration purposes, only the predicted crash frequency under base conditions for Segment 1 was calculated in the following section. The predicted crash frequency for the rest segments under base conditions can be calculated with similar procedures, as summarized in Table 4-8.

- Multiple-vehicle non-driveway collisions

For Segment 1, the predicted multiple-vehicle non-driveway collisions under base conditions can be determined with Equation (4-19). Based on data in Table 4-7, the AADT and segment length for Segment 1 were 10,300 vehicles per day and 0.30 miles, respectively; therefore, the predicted multiple-vehicle non-driveway collision under base conditions is:

$$\begin{aligned} N_{brmv} &= exp\big(-15.22 + 1.68 \times ln(AADT) + \ ln(L)\big) \\ &= exp\big(-15.22 + 1.68 \times ln(10300) + \ ln(0.30)\big) \\ &= 0.406\ crashes/year \end{aligned} \qquad (4\text{-}22)$$

- Single-vehicle crashes

For Segment 1, the predicted single-vehicle crashes under base conditions can be determined with Equation (4-20). Based on data in Table 4-7, the AADT and segment length for Segment 1 were 10,300 vehicles per day and 0.30 miles, respectively; therefore, the predicted single-vehicle crash under base conditions is:

$$\begin{aligned} N_{brmv} &= exp\big(-5.47 + 0.56 \times ln(AADT) + \ ln(L)\big) \\ &= exp\big(-5.47 + 0.56 \times ln(10300) + \ ln(0.30)\big) \\ &= 0.223\ crashes/year \end{aligned} \qquad (4\text{-}23)$$

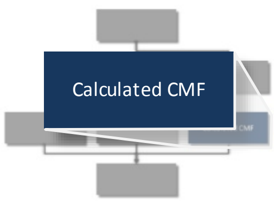
- Multiple-vehicle driveway-related collisions

For Segment 1, the predicted multiple-vehicle driveway-related collisions under base conditions can be determined with Equation (4-21). The AADT and number of driveways under different categories were listed in Table 4-7; therefore, the predicted multiple-vehicle driveway-related collision under base conditions is:

$$N_{brdwy} = \sum_{all\ driveway\ types} n_j \times N_j \times \left(\frac{AADT}{15{,}000}\right)^{(1.000)} \quad (4\text{-}24)$$
$$= 3 \times 0.158 \times \left(\frac{10300}{15000}\right)^{(1.000)} + 4 \times 0.050 \times \left(\frac{10300}{15000}\right)^{(1.000)} + 0 \times 0.172 \times \left(\frac{10300}{15000}\right)^{(1.000)}$$
$$+0 \times 0.023 \times \left(\frac{10300}{15000}\right)^{(1.000)} + 5 \times 0.083 \times \left(\frac{10300}{15000}\right)^{(1.000)} + 3 \times 0.016 \times \left(\frac{10300}{15000}\right)^{(1.000)}$$
$$+0 \times 0.025 \times \left(\frac{10300}{15000}\right)^{(1.000)}$$
$$= 0.781\ crashes/year$$

The relevant predicted crash frequencies under base conditions for the remaining two segments can be determined with similar procedures, as listed in Table 4-8.

**Step 6: Calculation of Crash Modification Factors**




The CMFs for different segments of the corridor can be determined based on the roadway characteristics on geometric and traffic control using the tables, equations, and figures included in the HSM. For illustration purposes, only the CMFs for Segment 1 are calculated here. The CMFs for the rest of the segments can be calculated with similar procedures, as summarized in Table 4-8.

1) CMF for on-street parking ($CMF_{1r}$)

The CMF for on-street parking can be determined with Equation (12-32) on page 12-40 of the HSM, as shown below.

$$CMF_{1r} = 1 + p_{pk} \times (f_{pk} - 1.0) \quad (4\text{-}25)$$

Based on data in Table 4-7, the $CMF_{1r}$ for Segment 1 is:

$$CMF_{1r} = 1 + p_{pk} \times (f_{pk} - 1.0) \quad (4\text{-}26)$$
$$= 1 + 0.56 \times (2.074 - 1)$$
$$= 1.60$$

2) CMF for roadside fixed objects ($CMF_{2r}$)

The CMF for roadside fixed objects can be determined with Equation (12-33) on page 12-40 of the HSM, as shown below:

$$CMF_{2r} = f_{offset} \times D_{fo} \times p_{fo} + (1.0 - p_{fo}) \quad (4\text{-}27)$$

Based on data in Table 4-7, the $CMF_{2r}$ for Segment 1 is:

$$CMF_{2r} = f_{offset} \times D_{fo} \times p_{fo} + (1.0 - p_{fo}) \quad (4\text{-}28)$$
$$= 0.133 \times 100 \times 0.059 + (1.0 - 0.059)$$
$$=1.73$$

3) CMF for lighting ($CMF_{4r}$)

The CMF for lighting can be determined based on Equation (12-34) on page 12-42 of the HSM, as shown below:

$$CMF_{4r} = 1.0 - \left(p_{nr} \times \left(1.0 - 0.72 \times p_{inr} - 0.83 \times p_{pnr}\right)\right) \tag{4-29}$$

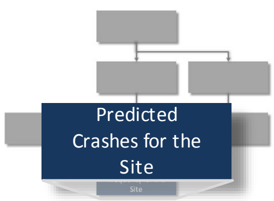
No street lighting was provided for the corridor; therefore, the $CMF_{4r}$ for the corridor was 1.00.

4) CMF for automated speed enforcement ($CMF_{5r}$)

The CMF for automated speed enforcement can be determined based on the description on page 12-43 of the HSM. No automated speed enforcement was provided for the corridor, therefore, the $CMF_{5r}$ for Segment 1 is 1.00.

The CMFs for the rest of the segments of the corridor can be determined with similar procedures, as summarized in Table 4-8.

**Step 7: Calculation of Predicted Crash Frequency under Site Prevailing Conditions**




The final step is to calculate the predicted crash frequency for the segments under site prevailing conditions, which is the sum of multiple-vehicle non-driveway collisions, multiple-vehicle driveway-related collisions, single-vehicle crashes, vehicle-pedestrian collisions, and vehicle-bicycle collisions. Based on Equations (12-2), (12-3), (12-4), (12-19), and (12-20), the total predicted crash frequency under site prevailing conditions for this facility type is:

$$\begin{aligned} N_{predicted\ rs} &= C_r \times (N_{br} + N_{pedr} + N_{biker}) \\ &= C_r \times (N_{br} + N_{br} \times f_{pedr} + N_{br} \times f_{biker}) \\ &= C_r \times (1 + f_{pedr} + f_{biker}) \times N_{br} \\ &= C_r \times (1 + f_{pedr} + f_{biker}) \times N_{spf\ rs} \times (CMF_{1r} \times CMF_{2r} \times CMF_{4r} \times CMF_{5r}) \\ &= C_r \times \left(1 + f_{pedr} + f_{biker}\right) \times (N_{brmv} + N_{brsv} + N_{brdwy}) \\ &\times (CMF_{1r} \times CMF_{2r} \times CMF_{4r} \times CMF_{5r}) \end{aligned} \tag{4-30}$$

where:

$C_r$ = calibration factor for the facility type
$f_{pedr}$ = pedestrian crash adjustment factor
$f_{biker}$ = bicycle crash adjustment factor
$N_{bimv}$ = predicted average number of multiple-vehicle non-driveway collisions for base conditions
$N_{bisv}$ = predicted average number of single-vehicle collisions for base conditions
$N_{brdwy}$ = predicted average number of multiple-vehicle driveway-related collisions for base conditions
$CMF_{nr}(n = 1,2,\cdots,6)$ = CMFs for vehicle-vehicle collisions for this facility type

All the CMFs, the Illinois SPF calibration factor, and predicted crash frequency under base conditions have been calculated or selected in the previous steps. For Segment 1, the predicted crash frequency under "no build" plan in 2015 is:

$$\begin{aligned} N_{predicted\ rs} &= C_r \times \left(1 + f_{pedr} + f_{biker}\right) \times (N_{brmv} + N_{brsv} + N_{brdwy}) \\ &\times (CMF_{1r} \times CMF_{2r} \times CMF_{4r} \times CMF_{5r}) \\ &= 4.509\ crashes/year \end{aligned} \tag{4-31}$$

The predicted crash frequencies for the rest segments under site prevailing conditions can be determined with similar procedures. To make the example concise, the calculation procedures are omitted and the final results are summarized in Table 4-8. In summary, the predicted crash frequency for the corridor under site prevailing conditions ("no build" plan) in 2015 would be 16.601, or approximately one crash every 22 days.

TABLE 4-8
**Summary of Crash Modification Factors and Predicted Crash Frequencies ("No Build" Plan)**

| Data Item | Segment ID | | |
|---|---|---|---|
| | Segment 1 | Segment 2 | Segment 3 |
| $N_{brmv}$ | 0.406 | 0.102 | 0.581 |
| $N_{brsv}$ | 0.223 | 0.068 | 0.353 |
| $N_{brdwy}$ | 0.781 | 0.367 | 1.593 |
| $CMF_{1r}$ | 1.60 | 1.52 | 1.70 |
| $CMF_{2r}$ | 1.73 | 1.66 | 2.12 |
| $CMF_{4r}$ | 1.00 | 1.00 | 1.00 |
| $CMF_{5r}$ | 1.00 | 1.00 | 1.00 |
| $N_{predicted\ rs}$ | 4.509 | 1.560 | 10.532 |

### 4.2.2.2 Proposed Improvements for the Corridor

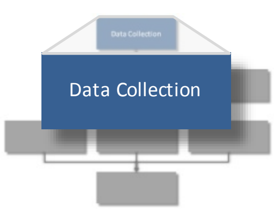
Based on the historical crash data, field visit results, and IDOT policy, the IDOT engineers proposed to convert the two-lane undivided arterial (2U) into a three-lane arterial (3T). In addition, all the street-parking facilities will be removed and street lighting poles will be installed along the corridor. All improvements proposed here are only for illustration purposes and do not necessarily represent the actual improvements developed in IDOT engineering practice.

### 4.2.2.3 Calculation of Predicted Crash Frequency for the Treatments

The facility type for all the segments in the corridor changed from "two-lane undivided arterial" in the period before the improvements to "three-lane arterial" in the after period. Correspondingly, the calculations of predicted crash frequency for the treatments are totally different than that for the "no build" plan. For clarification purposes, instead of summarizing the calculation results in tables, the predicted crash frequency for the treatments are calculated step by step.

Similarly, the predicted crash frequency calculation can be divided into data collection, selection of SPFs, selection of CMFs, selection of calibration factors, calculation of predicted crash frequency under base conditions, calculation of CMFs, and calculation of predicted crash frequency under site prevailing conditions, respectively. The predicted crash frequency for the treatments can be determined with the following steps.

**Step 1: Data Collection**

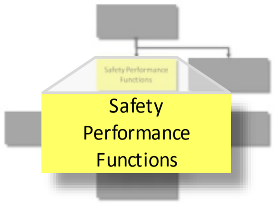



To achieve homogeneous segments, the corridor was also divided into three parts, as illustrated in Figure 4-2. All the data required for the predicted crash frequency calculation were collected separately for different segments, as presented in Table 4-9. For this corridor, both the IDOT database and Google Earth Pro were used for the data collection efforts. All the data in Table 4-9 are only for illustration purposes and do not necessarily represent the real conditions of the selected sites.

TABLE 4-9
**List of Data Collected for Predicted Crash Frequency Calculation (Proposed Treatments)**

| Data Item | | Segment ID 1 | Segment ID 2 | Segment ID 3 |
|---|---|---|---|---|
| **Data for Calculating Predicted Crash Frequency under Base Conditions** | | | | |
| Segment length (mile) | | 0.30 | 0.10 | 0.50 |
| AADT (vehicles/day) | | 10,300 | 8,700 | 9,400 |
| Number of driveways | Major commercial | 3 | 4 | 10 |
| | Minor commercial | 4 | 0 | 5 |
| | Major industrial/institutional | 0 | 0 | 0 |
| | Minor industrial/institutional | 0 | 0 | 0 |
| | Major residential | 5 | 0 | 8 |
| | Minor residential | 3 | 0 | 3 |
| | Other | 0 | 0 | 0 |
| Posted speed | | 35 mph | 35 mph | 40 mph |
| **Data for Calculating the Crash Modification Factors** | | | | |
| On-street parking | Type of parking | N/A | N/A | N/A |
| | Land use | N/A | N/A | N/A |
| | Proportion of curb length with on-street parking | 0.00 | 0.00 | 0.00 |
| Roadside fixed objects | Fixed object density (fixed objects per mile) | 100 | 140 | 230 |
| | Offset to fixed objects (feet) | 5 | 10 | 10 |
| Lighting | | Present | Present | Present |
| Automated speed enforcement | | Not present | Not present | Not present |
| **Illinois Safety Performance Function Calibration Factor and Replaced Default Values** | | | | |
| Illinois calibration factor ($C_r$) | | 1.22 | | |
| Pedestrian crash adjustment factor ($f_{pedi}$) | | 0.013 | | |
| Bicycle crash adjustment factor ($f_{bikei}$) | | 0.007 | | |
| Nighttime crash proportions | $p_{nr}$ | 0.304 | | |
| | $p_{inr}$ | 0.429 | | |
| | $p_{pnr}$ | 0.571 | | |

### Step 2: Selection of Safety Performance Functions




To calculate the predicted crash frequency under base conditions, the SPFs were selected in this step based on the facility type, which is “three-lane arterial (3T) on urban and suburban arterials” for all the segments in the corridor. The predicted crash frequency under base conditions for single-vehicle crashes, multiple-vehicle non-driveway collisions, and multiple-vehicle driveway-related collisions needs to be calculated in this example. Therefore, Equation (12-10) on HSM page 12-18, Equation (12-13) on HSM page 12-20, and Equation (12-16) on HSM page 12-22 were selected, as shown below. This SPF can be used to calculate the predicted total crash frequency under base conditions.

$$N_{brmv} = \exp(-12.40 + 1.41 \times \ln(AADT) + \ln(L)) \quad (4\text{-}32)$$

$$N_{brsv} = \exp(-5.74 + 0.54 \times \ln(AADT) + \ln(L)) \quad (4\text{-}33)$$

$$N_{brdwy} = \sum\nolimits_{all\ driveway\ types} n_j \times N_j \times \left(\frac{AADT}{15{,}000}\right)^{(1.000)} \quad (4\text{-}34)$$

where:

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

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

$N_{brdwy}$ = predicted average crash frequency of multiple-vehicle driveway-related collisions

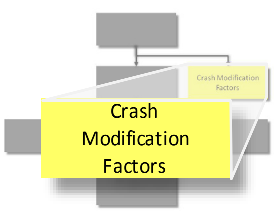
$AADT$ = average annual daily traffic volume (vehicles)

$L$ = length of roadway segment (miles)

$n_j$ = number of driveways within roadway segment of driveway type j including all driveways on both sides of the road

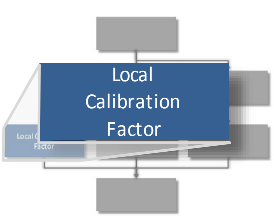
$N_j$ = number of driveway-related collisions per driveway per year for driveway type j from Table 12-7 in HSM

### Step 3: Selection of Crash Modification Factors




Altogether, there are four CMFs for three-lane arterial (3T) on urban and suburban arterials; that is, the CMFs for on-street parking, roadside fixed objects, lighting, and automated speed enforcement, as listed in HSM pages 12-40 to 12-43. The CMF for median width in HSM Chapter 12, $CMF_{3r}$, does not apply to this facility type. All the CMFs applicable for the roadway segments in the corridor were selected.

### Step 4: Selection of Illinois Safety Performance Function Calibration Factor




The Illinois SPF calibration factor was selected in this step based on the facility type, IDOT jurisdiction of the site, and the time period for the analysis. For this example, Table A-4 in Appendix A of this document was used, because the corridor is located within IDOT District 8 and the calendar year for the analysis is 2015. Based on Table A-4, the Illinois SPF calibration factor for “three-lane arterial on urban and suburban arterial” is 1.22.

In addition to the Illinois SPF calibration factor, the replaced pedestrian crash adjustment factor, bicycle crash adjustment factor, and nighttime crash proportions were selected based on the facility type, IDOT jurisdiction of the site, and the time period for the analysis. Similarly, because the corridor is located within IDOT District 8 and the calendar year for the analysis is 2015, the pedestrian crash adjustment factor, bicycle crash adjustment factor, and nighttime crash proportions were selected from Appendix B Tables B-6-8, B-6-10, and B-6-20, respectively, as listed in Table 4-9.

**Step 5: Calculation of Predicted Crash Frequency under Base Conditions**


The predicted crash frequency for "three-lane arterial" (3T) under base conditions was calculated in this step. Based on the HSM methodology, the predicted crash frequency under base conditions for multiple-vehicle non-driveway collisions, multiple-vehicle driveway-related collisions and single-vehicle crashes can be determined with relevant SPFs. For illustration purposes, only the predicted crash frequency under base conditions for Segment 1 was calculated in the following section. The predicted crash frequency for the rest of the segments under base conditions can be calculated with similar procedures, as summarized in Table 4-10.

- Multiple-vehicle non-driveway collisions

For Segment 1, the predicted multiple-vehicle non-driveway collisions under base conditions can be determined with Equation (4-32). Based on data in Table 4-9, the AADT and segment length for Segment 1 were 10,300 vehicles per day and 0.30 miles respectively; therefore, the predicted multiple-vehicle non-driveway collision for Segment 1 under base conditions is:

$$\begin{aligned} N_{brmv} &= exp\big(-12.40 + 1.41 \times ln(AADT) + \ ln(L)\big) \\ &= exp\big(-12.40 + 1.41 \times ln(10300) + \ ln(0.30)\big) \\ &= 0.562\ crashes/year \end{aligned} \tag{4-35}$$

- Single-vehicle crashes

For Segment 1, the predicted single-vehicle crashes under base conditions can be determined with Equation (4-33). Based on data in Table 4-9, the AADT and segment length for Segment 1 were 10,300 vehicles per day and 0.30 miles respectively; therefore, the predicted single-vehicle crash for Segment 1 under base conditions is:

$$\begin{aligned} N_{brmv} &= exp\big(-5.74 + 0.54 \times ln(AADT) + \ ln(L)\big) \\ &= exp\big(-5.74 + 0.54 \times ln(10300) + \ ln(0.30)\big) \\ &= 0.142\ crashes/year \end{aligned} \tag{4-36}$$

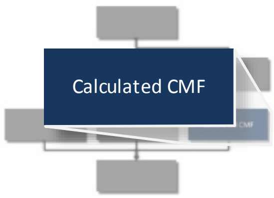
- Multiple-vehicle driveway-related collisions

For Segment 1, the predicted multiple-vehicle driveway-related collisions under base conditions can be determined with Equation (4-34). The AADT and number of driveways under different categories were listed in Table 4-9; therefore, the predicted multiple-vehicle driveway-related collision for Segment 1 under base conditions is:

$$\begin{aligned} N_{brdwy} &= \textstyle\sum_{all\ driveway\ types} n_j \times N_j \times \left(\frac{AADT}{15{,}000}\right)^{(1.000)} \\ &= 3 \times 0.102 \times \left(\frac{10300}{15000}\right)^{(1.000)} + 4 \times 0.032 \times \left(\frac{10300}{15000}\right)^{(1.000)} + 0 \times 0.110 \times \left(\frac{10300}{15000}\right)^{(1.000)} \\ &+ 0 \times 0.015 \times \left(\frac{10300}{15000}\right)^{(1.000)} + 5 \times 0.053 \times \left(\frac{10300}{15000}\right)^{(1.000)} + 3 \times 0.010 \times \left(\frac{10300}{15000}\right)^{(1.000)} \\ &+ 0 \times 0.016 \times \left(\frac{10300}{15000}\right)^{(1.000)} \\ &= \ 0.501\ crashes/year \end{aligned} \tag{4-37}$$

The predicted crash frequency for the remaining two segments under base conditions can be determined with similar procedures, as listed in Table 4-10.

### Step 6: Calculation of Crash Modification Factors




The CMFs for different segments in the corridor can be determined based on the roadway characteristics on geometric and traffic control using the tables, equations, and figures included in HSM. For illustration purposes, only the CMFs for Segment 1 are calculated here. The CMFs for the rest segments can be calculated with similar procedures, as summarized in Table 4-10.

1) CMF for on-street parking ($CMF_{1r}$)

The CMF for on-street parking can be determined with Equation (12-32) on page 12-40 of the HSM, as shown below.

$$CMF_{1r} = 1 + p_{pk} \times \left(f_{pk} - 1.0\right) \tag{4-38}$$

Based on data in Table 4-9, the on-street parking facilities would be removed from the corridor, and the proportion of curb length with on-street parking would be 0. Therefore, the CMF for on-street parking, $CMF_{1r}$ is 1.00 for Segment 1.

2) CMF for roadside fixed objects ($CMF_{2r}$)

The CMF for roadside fixed objects can be determined with Equation (12-33) on page 12-40 of the HSM, as shown below:

$$CMF_{2r} = f_{offset} \times D_{fo} \times p_{fo} + (1.0 - p_{fo}) \tag{4-39}$$

Based on data in Table 4-9, the $CMF_{2r}$ for Segment 1 is:

$$\begin{aligned} CMF_{2r} &= f_{offset} \times D_{fo} \times p_{fo} + \left(1 - p_{fo}\right) \\ &= 0.133 \times 100 \times 0.034 + (1 - 0.034) \\ &= 1.42 \end{aligned} \tag{4-40}$$

3) CMF for lighting ($CMF_{4r}$)

The CMF for lighting can be determined based on Equation (12-34) on page 12-42 of the HSM, as shown below:

$$CMF_{4r} = 1.0 - \left(p_{nr} \times \left(1.0 - 0.72 \times p_{inr} - 0.83 \times p_{pnr}\right)\right) \tag{4-41}$$

Based on data in Table 4-9, the CMF for lighting is:

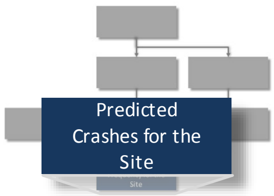
$$\begin{aligned} CMF_{4r} &= 1.0 - \left(p_{nr} \times \left(1.0 - 0.72 \times p_{inr} - 0.83 \times p_{pnr}\right)\right) \\ &= 1.0 - 0.304 \times (1.0 - 0.72 \times 0.429 - 0.83 \times 0.571) \\ &= 0.93 \end{aligned} \tag{4-42}$$

4) CMF for automated speed enforcement ($CMF_{5r}$)

The CMF for automated speed enforcement can be determined based on the description on page 12-43 of the HSM. No automated speed enforcement was provided for the corridor, therefore, the $CMF_{5r}$ for Segment 1 is 1.00.

The CMFs for the remaining two segments can be determined with similar procedures, as summarized in Table 4-10.

### Step 7: Calculation of Predicted Crash Frequency under Site Prevailing Conditions




The final step is to calculate the predicted crash frequency for the segments under site prevailing conditions, which is the sum of multiple-vehicle non-driveway collisions, multiple-vehicle driveway-related collisions, single-vehicle crashes, vehicle-pedestrian collisions, and vehicle-bicycle collisions. Based on Equations (12-2), (12-3), (12-4), (12-19), and (12-20), the total predicted crash frequency under site prevailing conditions for this facility type is:

$$\begin{aligned} N_{predicted\ rs} &= C_r \times (N_{br} + N_{pedr} + N_{biker}) \qquad (4\text{-}43) \\ &= C_r \times (N_{br} + N_{br} \times f_{pedr} + N_{br} \times f_{biker}) \\ &= C_r \times (1 + f_{pedr} + f_{biker}) \times N_{br} \\ &= C_r \times (1 + f_{pedr} + f_{biker}) \times N_{spf\ rs} \times (CMF_{1r} \times CMF_{2r} \times CMF_{4r} \times CMF_{5r}) \\ &= C_r \times \left(1 + f_{pedr} + f_{biker}\right) \times (N_{brmv} + N_{brsv} + N_{brdwy}) \\ &\times (CMF_{1r} \times CMF_{2r} \times CMF_{4r} \times CMF_{5r}) \end{aligned}$$

where:

$C_r$ = calibration factor for the facility type
$f_{pedr}$ = pedestrian crash adjustment factor
$f_{biker}$ = bicycle crash adjustment factor
$N_{bimv}$ = predicted average number of multiple-vehicle non-driveway collisions for base conditions
$N_{bisv}$ = predicted average number of single-vehicle collisions for base conditions
$N_{brdwy}$ = predicted average number of multiple-vehicle driveway-related collisions for base conditions
$CMF_{nr}(n = 1{,}2, \cdots ,6)$ = CMFs for vehicle-vehicle collisions for this facility type

All the CMFs, the Illinois SPF calibration factor, and predicted crash frequency under base conditions have been calculated or selected in the previous steps. The final predicted crash frequency for Segment 1 under site prevailing conditions in 2015 is:

$$\begin{aligned} N_{predicted\ rs} &= C_r \times \left(1 + f_{pedr} + f_{biker}\right) \times (N_{brmv} + N_{brsv} + N_{brdwy} \\ &\times (CMF_{1r} \times CMF_{2r} \times CMF_{4r} \times CMF_{5r})\ ) \qquad (4\text{-}44) \\ &= 1.22 \times (1 + 0.013 + 0.007) \times (0.562 + 0.142 + 0.501) \times 1.00 \times 1.42 \times 0.93 \times 1.00 \\ &= 1.985\ crashes/year \end{aligned}$$

The predicted crash frequencies for the rest segments under site prevailing conditions can be determined with similar procedures. To make the example concise, the calculation procedures are omitted and the final results are summarized in Table 4-10. The total predicted crash frequency for the corridor under the treatments in 2015 is 6.637, or approximately one crash every 55 days.

TABLE 4-10

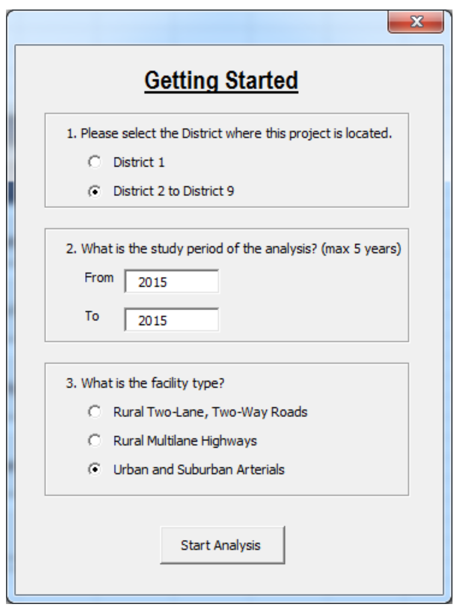
**Summary of Crash Modification Factors and Predicted Crash Frequencies (Proposed Treatments)**

| Data Item | Segment ID | | |
|---|---|---|---|
| | Segment 1 | Segment 2 | Segment 3 |
| $N_{brmv}$ | 0.562 | 0.148 | 0.824 |
| $N_{brsv}$ | 0.142 | 0.043 | 0.225 |
| $N_{brdwy}$ | 0.501 | 0.237 | 1.024 |
| $CMF_{1r}$ | 1.00 | 1.00 | 1.00 |
| $CMF_{2r}$ | 1.42 | 1.38 | 1.65 |
| $CMF_{4r}$ | 0.93 | 0.93 | 0.93 |
| $CMF_{5r}$ | 1.00 | 1.00 | 1.00 |
| $N_{predicted\ rs}$ | 1.985 | 0.686 | 3.966 |

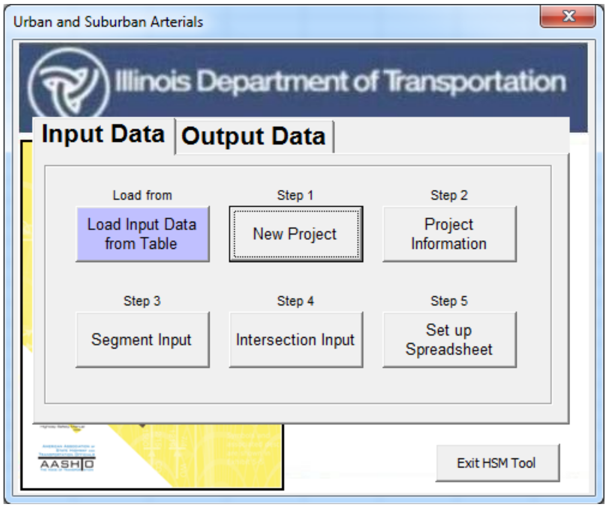
### 4.2.3 Calculation of Predicted Crash Frequency Using the IDOT HSM Crash Prediction Tool

The predicted crash frequency for this corridor was calculated using the **IDOT HSM Crash Prediction Tool**. For illustration purposes, only the procedures for the "no build" plan are described, while the predicted crash frequency for the improvements can be calculated with similar procedures. The predicted crash frequency calculation can be divided into eight steps, as listed below.

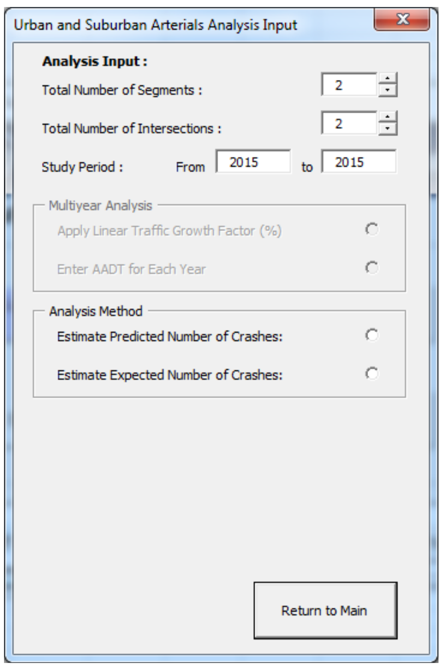
**Step 1**: Enter the following data in the **Getting Started** user form. The project is located in IDOT District 8, the study period is 2015, and the facility is an urban and suburban arterial. Click the **Start Analysis** button.



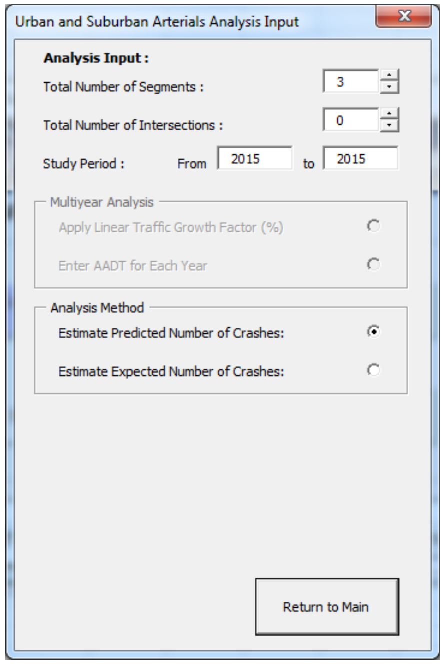
**Step 2**: The **Main Menu** user form will open up as shown below.



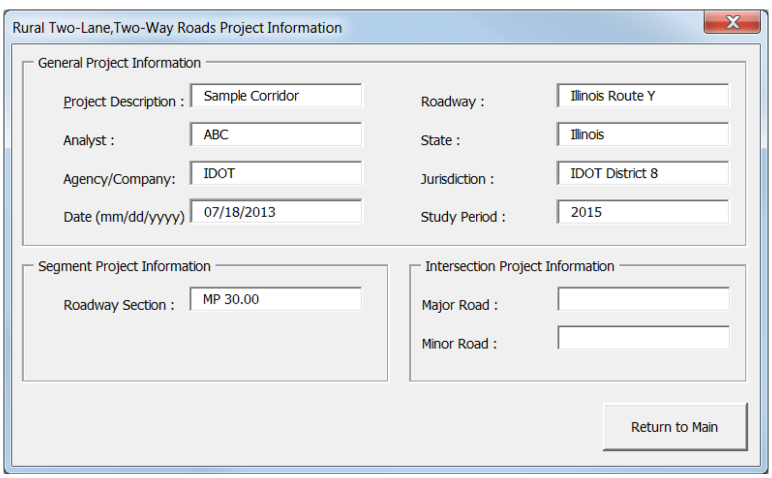

**Step 3**: Select the **New Project** button. **The Urban and Suburban Arterials Analysis Input** user form will appear.



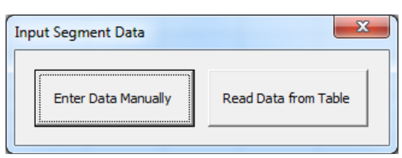
**Step 4**: Enter the required data. For this example, three segments will be analyzed while no intersections will be included. The study period (2015 to 2015) will be prepopulated. The analysis method for this example is the **Estimate Predicted Number of Crashes**. Once all the data are entered, click the **Return to Main** button.



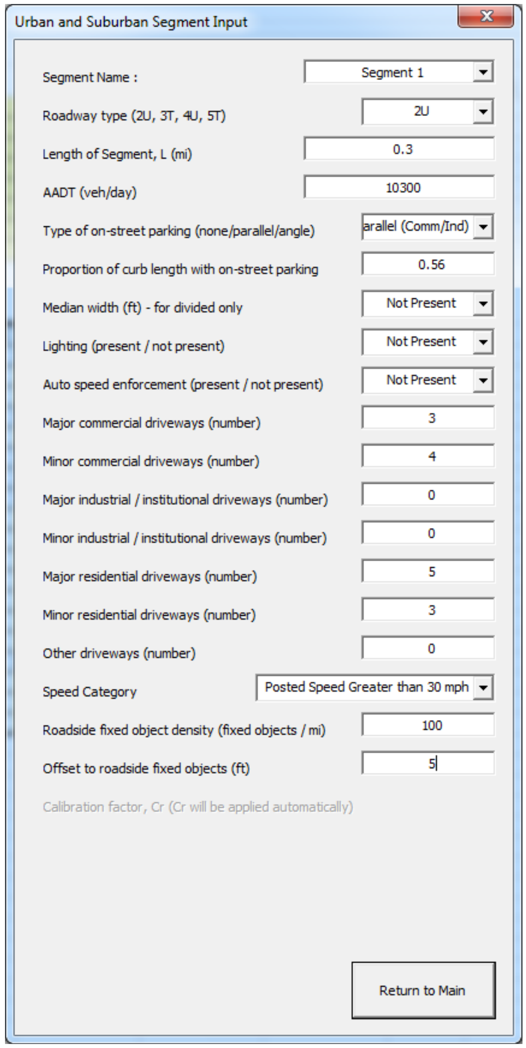

**Step 5**: Press the **Project Information** button, and enter details about the project. Once the form is filled out, press the **Return to Main** button to go back to the main menu.



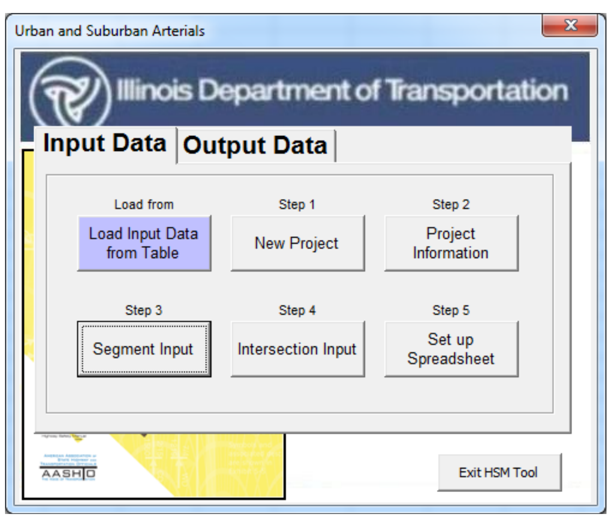

**Step 6**: Press the **Segment Input** button and enter the data. A new user form will appear, asking the user to choose the data input method. Data can be input either using user forms or in a table format.



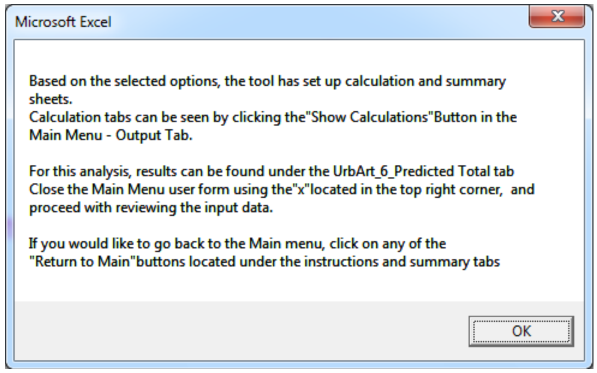

For this example, the **Enter Data Manually** option is selected. The **Urban and Suburban Segment Input** user form will pop up after clicking the **Enter Data Manually** button, and the roadway segment data can be input. For this example, the data for each roadway segment in Table 4-7 were input into the tool separately. Once the form is filled out, press the **Return to Main** button to go back to the main menu.




**Step 7**: Once all the data entry is completed, press the **Set up Spreadsheet** button. This button will run the entire set-up process for the application of the predictive method.



**Step 8**: Once the process is finished running, a pop-up window will appear, providing users with instructions on the next steps, and where to find results of the analysis. Click **OK** to continue, and close the main menu interface to go to the summary sheet.




Results can be found in Tab **TLR_6_Predicted_Total**.

## 4.2.4 Conclusions and Recommendations

The predicted crash frequencies for the corridor under the “no build” plan and the proposed treatments were calculated using the Illinois SPF calibration factors and replaced default values, as summarized in Table 4-11.

TABLE 4-11
**Summary of Predicted Crash Frequency under Different Improvement Alternatives**

| Segment ID | Improvement Alternatives | |
|---|---|---|
| | “No Build” Plan | Proposed Improvements |
| 1 | 4.509 | 1.985 |
| 2 | 1.560 | 0.686 |
| 3 | 10.532 | 3.966 |
| Total | 16.601 | 6.637 |

A cross-sectional comparison between the “no build” plan and proposed improvements indicated that the improvements would decrease the predicted crash frequency by 9.964, or 60 percent. In other words, the improvements can reduce approximately one crash in every 36 days. For a design life period of 20 years, the improvements alternative can reduce approximately 100 crashes. The crash frequency reduction can be further converted into monetary benefit with the application of appropriate unit crash cost. A final decision on the improvement alternatives can be made based on the reduction in crash frequency as well as other factors such as costs, right-of-way, traffic operations, and environmental assessment.

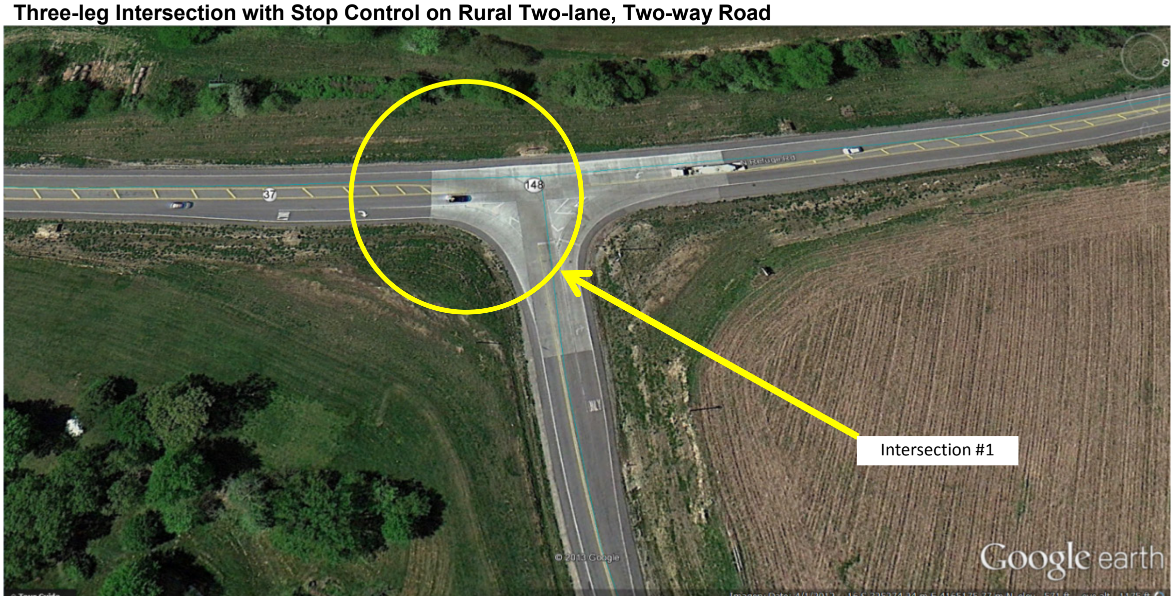
# 4.3 Calculation of Expected Crash Frequency for Three-leg Intersection with Stop Control on Rural Two-lane, Two-way Roads

## 4.3.1 Introduction

The intersection between Illinois Route K and Illinois Route J, as shown in Figure 4-3, is a three-leg intersection with stop control on rural two-lane, two-way road located in IDOT District 9. Based on the historical crash data and the adopted network screening process, the FHWA Five Percent Report identified this intersection as a Five Percent location under the peer group “rural minor leg stop control” and recommended it for further safety improvements.

IDOT is to apply the SHSP funding for safety improvements at this intersection. For decision- making purposes, the expected average crash frequency for the intersection from 2009 to 2011 is required. This example illustrates how to calculate the expected crash frequency for three-leg intersection with stop control on rural two-lane, two-way roads using the HSM Part C predictive method. The expected crash frequency for the intersection are calculated manually first, followed by calculation using the **IDOT HSM Crash Prediction Tool**.

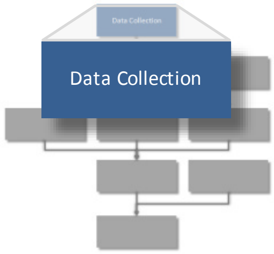
FIGURE 4-3
**Three-leg Intersection with Stop Control on Rural Two-lane, Two-way Road**




## 4.3.2 Manual Calculation of Expected Crash Frequency

The expected crash frequency for the intersection from 2009 to 2011 is calculated manually first. As discussed previously, the expected crash frequency calculation can be divided into data collection, the selection of SPFs, the selection of CMFs, the selection of calibration factors, calculation of predicted crash frequency under base conditions, calculation of CMFs, calculation of predicted crash frequency under site prevailing conditions, observed crash data, and finally, expected crash frequency for the site, as described below.

### Step 1: Data Collection

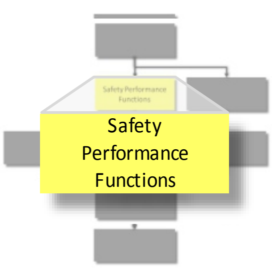



Numerous data on AADT, roadway geometry, and traffic control for the intersection were collected for the predicted crash frequency calculation, as presented in Table 4-12. The skew angle for an intersection was defined as the absolute value of the deviation from an intersection angle of 90 degrees. For this intersection, both the IDOT database and Google Earth Pro were used for the data collection efforts. All the data in Table 4-12 are only for illustration purposes and do not necessarily represent the real conditions of the intersection.

TABLE 4-12
**List of Data Collected for Predicted Crash Frequency Calculation**

| Data Item | Data Collected | |
|---|---|---|
| **Data for Calculating Predicted Crash Frequency under Base Conditions** | | |
| AADT for major road (vehicles/day) | 2009 | 6,000 |
| | 2010 | 6,100 |
| | 2011 | 6,200 |
| AADT for minor road (vehicles/day) | 2009 | 4800 |
| | 2010 | 4,900 |
| | 2011 | 5,000 |
| **Data for Calculating the Crash Modification Factors** | | |
| Intersection skew angle | 0 | |
| Number of uncontrolled approaches with left-turn lanes | 1 | |
| Number of uncontrolled approaches with right-turn lanes | 1 | |
| lighting | Yes | |
| **Illinois Safety Performance Function Calibration Factor and Replaced Default Values** | | |
| Illinois calibration factor, $C_i$ | 0.24 | |
| $p_{ni}$ | 0.600 | |

### Step 2: Selection of Safety Performance Functions




To calculate the predicted crash frequency for the intersection under base conditions, the SPF was selected in this step based on the facility type, which is "three-leg intersection with stop control (3ST) on rural two-lane, two-way roads. Therefore, Equation (10-8) on page 10-18 of the HSM was selected, as shown below. This SPF can be used to calculate the predicted total crash frequency under base conditions.

$$N_{spf\ 3ST} = \exp(-9.86 + 0.79 \times \ln(AADT_{maj}) + 0.49 \times \ln(AADT_{min})) \quad (4\text{-}45)$$

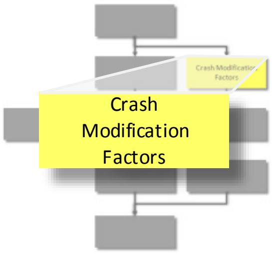
where:

$N_{spf\ rs}$ = estimate of intersection-related predicted average crash frequency for base conditions for three-leg stop-controlled intersections

$AADT_{maj}$ = AADT (vehicles per day) on the major road

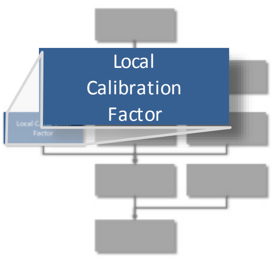
$AADT_{min}$ = AADT (vehicles per day) on the minor road

### Step 3: Selection of Crash Modification Factors



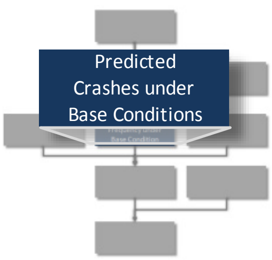

Altogether, there are four CMFs for three-leg intersection with stop control (3ST) on rural two-lane, two-way roads, that is, the CMFs for intersection skew angle, intersection left-turn lanes, intersection right-turn lanes, and lighting, as listed on HSM pages 10-31 to 10-33. All the CMFs applicable for the intersection were selected.

### Step 4: Selection of Illinois Safety Performance Function Calibration Factor




The Illinois SPF calibration factor was selected in this step based on the facility type, IDOT jurisdiction of the site, and the time period for the analysis. For this example, Table A-4 in Appendix A of this document was used because the intersection is located within IDOT District 9 and the calendar year for the analysis is from 2009 to 2011. Based on Table A-4, the Illinois SPF calibration factor for three-leg intersection with stop control (3ST) on rural two-lane, two-way roads is 0.24.

### Step 5: Calculation of Predicted Crash Frequency under Base Conditions




The predicted crash frequency for the intersection under base conditions was calculated in this step. To be concise, only the predicted crash frequency under base conditions for 2009 was calculated with detailed steps in the following section, and the results for the remaining years were summarized in Table 4-13.

Based on data in Table 4-12, the AADTs for major and minor roads in 2009 were 6,000 vehicles per day and 4,800 vehicles per day, respectively. Therefore, for this intersection, the predicted crash frequency under base conditions in 2009 is:

$$\begin{aligned} N_{spf\ 3ST} &= exp\left(a + b \times ln(AADT_{maj}) + c \times ln(AADT_{min})\right) \\ &= exp\left(-9.86 + 0.79 \times ln(6000) + 0.49 \times ln(4800)\right) \\ &= 3.209\ crashes/year \end{aligned} \tag{4-46}$$

### Step 6: Calculation of Crash Modification Factors


The CMFs for the intersection can be determined based on its geometric and traffic control characteristics using the tables, equations, and figures included in the HSM. For illustration purposes, only the CMFs for the intersection in 2009 are calculated in the following section. The CMFs for the intersection in the remaining years can be calculated with similar procedures, as summarized in Table 4-13.

1) CMF for intersection skew angle ($CMF_{1i}$)

The CMF for intersection skew angle can be estimated with Equation (10-22) on page 10-31 of the HSM. For this intersection, the skew angle is 0; therefore, the CMF for intersection skew angle is:

$$\begin{aligned} CMF_{1i} &= e^{(0.004 \times skew)} \\ &= e^{(0.004 \times 0)} \end{aligned} \tag{4-47}$$

$= 1.00$

2) CMF for intersection left-turn lanes ($CMF_{2i}$)

The CMF for intersection left-turn lanes can be determined with Table 10-13 on page 10-32 of the HSM. Based on Table 4-12, the number of left-turn lanes on uncontrolled approach is 1; therefore, the CMF for intersection left-turn lanes is 0.56.

3) CMF for intersection right-turn lanes ($CMF_{3i}$)

The CMF for intersection right-turn lanes can be determined with Table 10-14 on page 10-33 of the HSM. Based on Table 4-12, the number of right-turn lanes on uncontrolled approach is 1; therefore, the CMF for intersection right turn lanes is 0.86.

4) CMF for lighting ($CMF_{4i}$)

The CMF for lighting can be determined with Equation (10-24) on page 10-33 of the HSM, as shown below:

$$CMF_{4i} = 1 - 0.38 \times p_{ni} \qquad (4\text{-}48)$$

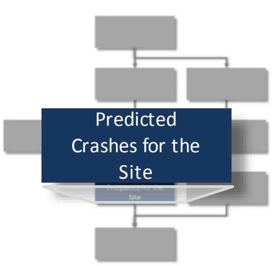
where:
$p_{ni}$ = the proportion of total crashes for unlighted intersections that occur at night

A default value of 0.260 was provided for the $p_{ni}$ in Table 10-15 in page 10-33 of the HSM; however, the HSM recommended that the value be replaced with local data when available. For this example, Table B-4-12 in Appendix B of this document was selected based on the jurisdiction of the intersection (IDOT District 9) and the targeted time period for analysis (2009). Based on Table B-4-12, the $p_{ni}$ is 0.600.

Lighting is present at the intersection; therefore, the CMF for lighting is:

$$\begin{aligned} CMF_{4i} &= 1 - 0.38 \times p_{ni} \qquad (4\text{-}49) \\ &= 1 - 0.38 \times 0.600 \\ &= 0.77 \end{aligned}$$

**Step 7: Calculation of Predicted Crash Frequency under Site Prevailing Conditions**




The next step is to calculate the predicted crash frequency for the intersection under site prevailing conditions, which can be determined with Equation (10-3) on page 10-4 of the HSM based on the predicted crash frequency under base conditions, the Illinois SPF calibration factor, and all the CMFs calculated in previous steps, as shown below:

$$N_{predicted\ int} = N_{spf\ int} \times C_i \times (CMF_{1i} \times CMF_{2i} \times \cdots \times CMF_{4i}) \qquad (4\text{-}50)$$

where:
$N_{spf\ int}$ = the predicted crash frequency for an individual intersection under base conditions
$C_i$ = the calibration factor developed for a particular jurisdiction or geographical area
$CMF_{1i}, CMF_{2i}, \cdots, CMF_{4i}$ = the CMFs for the intersection, respectively.

All the CMFs, the Illinois SPF calibration factor, and the predicted crash frequency under base conditions have been calculated or selected in the previous steps. For the intersection, the final predicted crash frequency under site prevailing conditions in 2009 is:

$$N_{predicted\ int} = N_{spf\ int} \times C_i \times C_{1i} \times C_{2i} \times C_{3i} \times C_{4i} \tag{4-51}$$
$$= 3.209 \times 0.24 \times 1.00 \times 0.56 \times 0.86 \times 0.77$$
$$= 0.286\ crashes/year$$

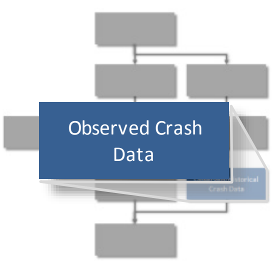
The predicted crash frequency for the intersection in the remaining years can be determined with similar procedures. To be concise, the calculation procedures are omitted and the final calculated results are summarized in Table 4-13.

TABLE 4-13

**Summary of Calculated Crash Modification Factors and Predicted Crash Frequencies for Different Years**

| Year | $N_{spf\ int}$ | $CMF_{1i}$ | $CMF_{2i}$ | $CMF_{3i}$ | $CMF_{4i}$ | $C_i$ | $N_{predicted\ int}$ |
|---|---|---|---|---|---|---|---|
| 2009 | 3.209 | 1.00 | 0.56 | 0.86 | 0.77 | 0.24 | 0.286 |
| 2010 | 3.284 | 1.00 | 0.56 | 0.86 | 0.77 | 0.24 | 0.293 |
| 2011 | 3.360 | 1.00 | 0.56 | 0.86 | 0.77 | 0.24 | 0.300 |

### Step 8: Observed Crash Data




The observed crash for the intersection in different years was identified in this step. Based on the IDOT crash database, the observed crash frequencies for the intersection in 2009, 2010, and 2011 were 2, 1, and 1, respectively. Therefore, the total observed crash frequency is 4, among which 2 are PDO crashes and the remaining 2 are fatal and injury crashes. The identified intersection crashes include all the crashes within the curbline limits of the intersection as well as all the intersection-related crashes.

### Step 9: Calculation of Expected Average Crash Frequency for the Site


The weighted adjustment, $w$, was calculated with Equation (3-3) first. Based on Table 4-13, the predicted crash frequencies for the intersection in 2009, 2010, and 2011 were 0.286, 0.293, and 0.300, respectively. Therefore, the total predicted crash frequency from 2009 to 2011 was 0.879. The overdispersion parameter, $k$, for this facility type is 0.54 based on the description on page 10-18 of the HSM. Therefore, the weighted adjustment $w$ is:

$$w = \frac{1}{1+k\times\sum_{all\ study\ years} N_{predicted}} \tag{4-52}$$
$$= \frac{1}{1+0.54\times0.879}$$
$$= 0.678$$

The average predicted crash frequency for the intersection is 0.293, and the average observed crash frequency for the intersection is 1.333. Based on Equation (3-2), the expected average crash frequency for the intersection is:

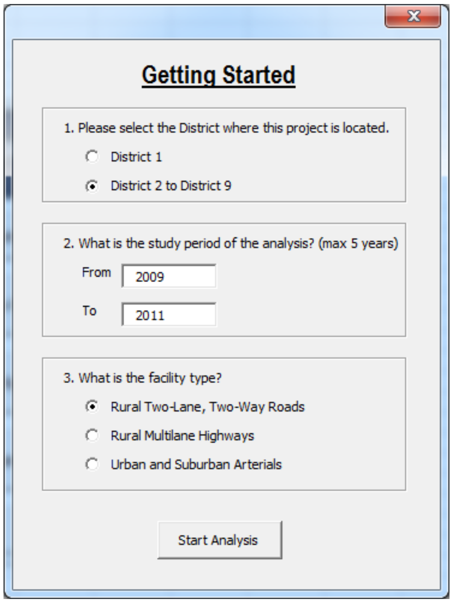
$$N_{expected} = w \times N_{predicted} + (1-w) \times N_{observed} \tag{4-53}$$
$$= 0.678 \times 0.0.293 + (1-0.678) \times 1.333$$
$$= 0.628\ crashes/year$$

Therefore, the expected average crash frequency for the intersection is 0.628 crashes per year, or approximately one crash every 581 days.

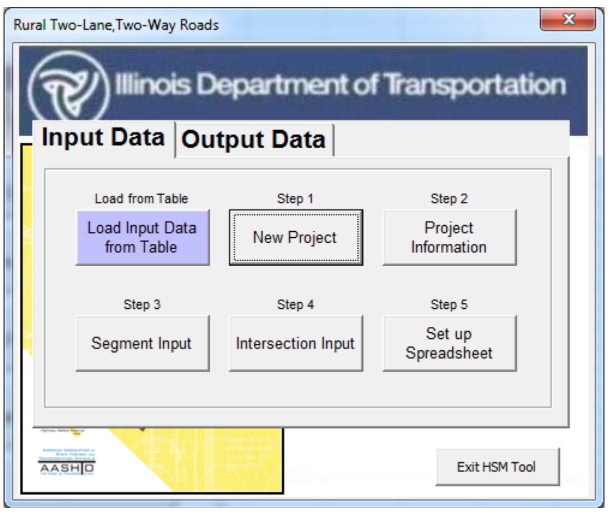
### 4.3.3 Calculation of Expected Crash Frequency Using the IDOT HSM Crash Prediction Tool

The expected average crash frequency for this intersection from 2009 to 2011 was calculated using the **IDOT HSM Crash Prediction Tool**. The whole process can be divided into eight steps, as listed below.

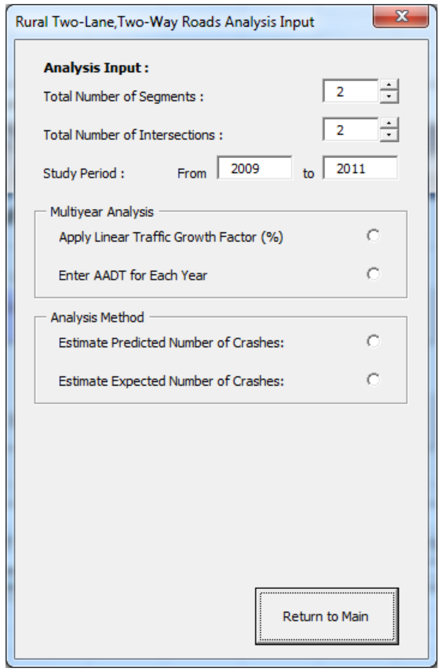
**Step 1**: Enter the following data in the **Getting Started** user form. The project is located in IDOT District 9, the study period is 2009 to 2011, and the facility is rural two-lane, two-way roads. Click the **Start Analysis** button.



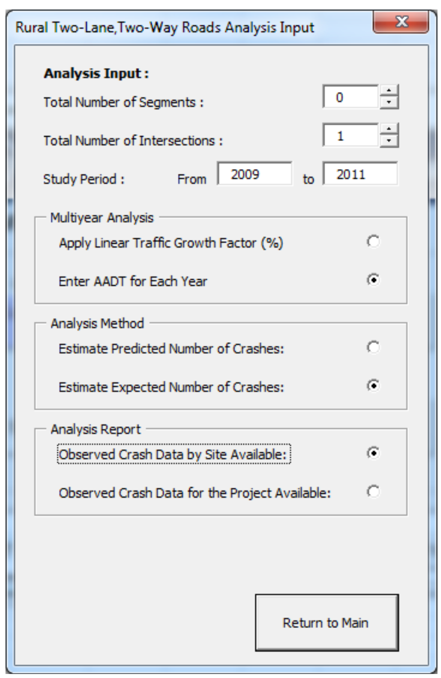

**Step 2**: The Main Menu user form will open up as shown below.



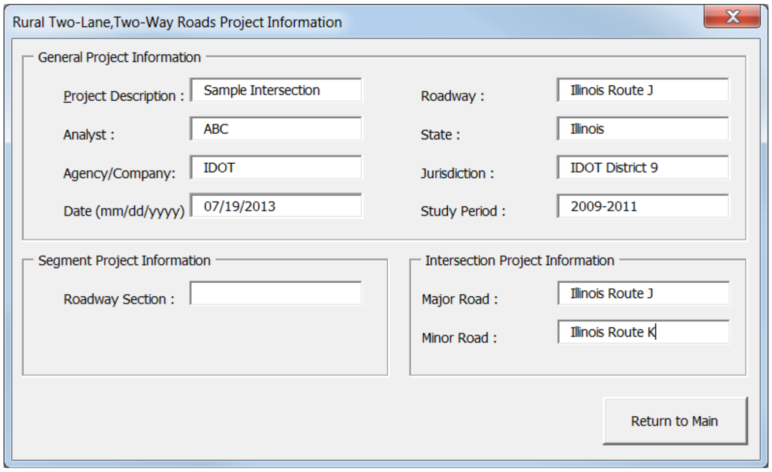
**Step 3:** Select the **New Project** button. **The Rural Two-lane, Two-Way Roads Analysis** Input user form will appear.



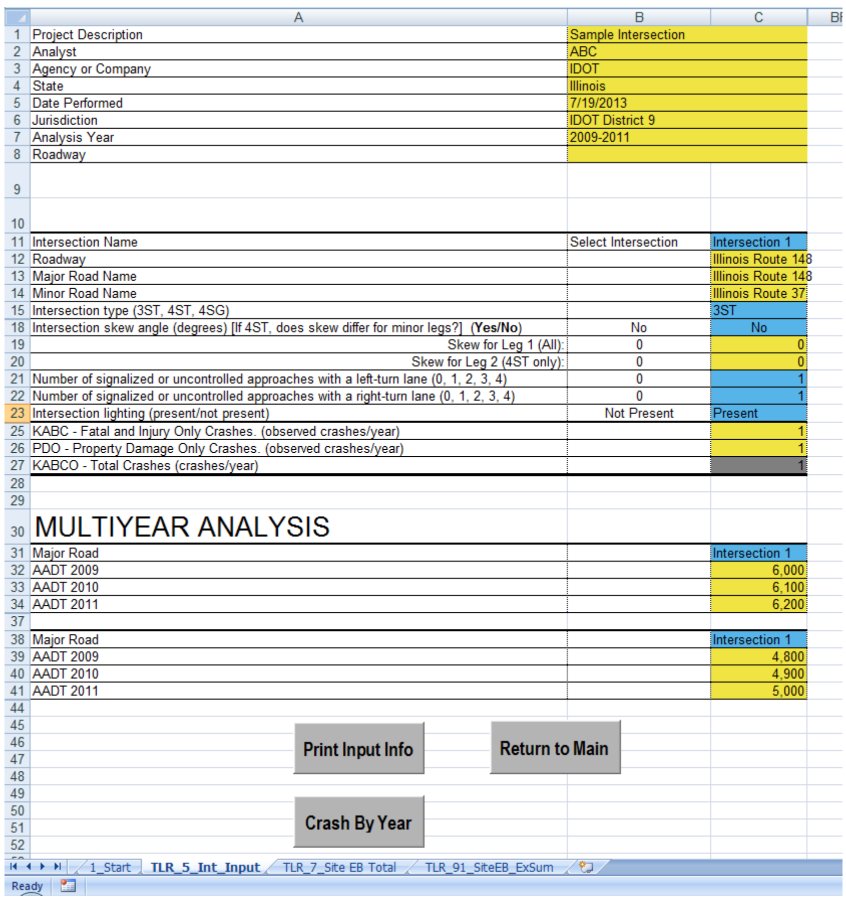

**Step 4**: Enter the required data. For this example, one intersection will be analyzed while no segments will be included. The study period (2009 to 2011) will be prepopulated. Table 4-12 provides the AADTs for different years, all of which will be input into the tool later manually. The analysis method for this example is the **Estimate Expected Number of Crashes**, and all the observed crash data were available by site. Once all the data are entered, click the **Return to Main** button.



**Step 5**: Press the **Project Information** button, and enter details about the project. Once the form is filled out, press the **Return to Main** button to go back to the main menu.

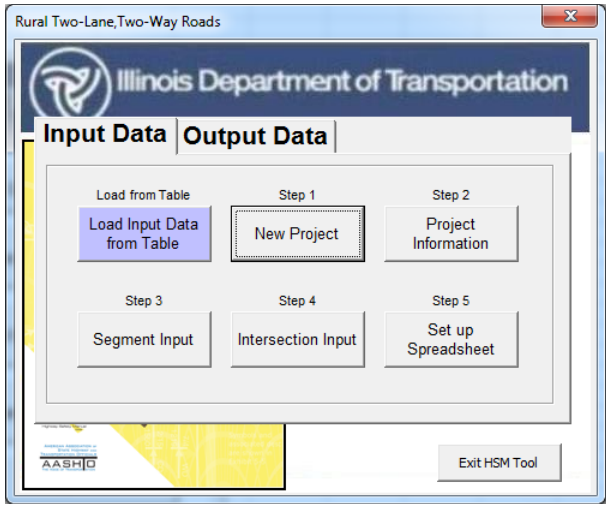



**Step 6**: Press the **Intersection Input** button and enter the data. For this example, the data for the intersection in Table 4-12 were input into the tool. Once the form is filled out, press the **Return to Main** button to go back to the main menu.

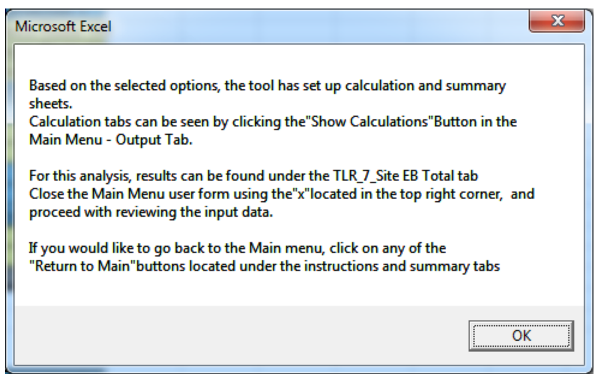


| | A | B | C |
|---|---|---|---|
| 1 | Project Description | Sample Intersection | |
| 2 | Analyst | ABC | |
| 3 | Agency or Company | IDOT | |
| 4 | State | Illinois | |
| 5 | Date Performed | 7/19/2013 | |
| 6 | Jurisdiction | IDOT District 9 | |
| 7 | Analysis Year | 2009-2011 | |
| 8 | Roadway | | |
| 9 | | | |
| 10 | | | |
| 11 | Intersection Name | Select Intersection | Intersection 1 |
| 12 | Roadway | | Illinois Route 148 |
| 13 | Major Road Name | | Illinois Route 148 |
| 14 | Minor Road Name | | Illinois Route 37 |
| 15 | Intersection type (3ST, 4ST, 4SG) | | 3ST |
| 18 | Intersection skew angle (degrees) [If 4ST, does skew differ for minor legs?] **(Yes/No)** | No | No |
| 19 | Skew for Leg 1 (All): | 0 | 0 |
| 20 | Skew for Leg 2 (4ST only): | 0 | 0 |
| 21 | Number of signalized or uncontrolled approaches with a left-turn lane (0, 1, 2, 3, 4) | 0 | 1 |
| 22 | Number of signalized or uncontrolled approaches with a right-turn lane (0, 1, 2, 3, 4) | 0 | 1 |
| 23 | Intersection lighting (present/not present) | Not Present | Present |
| 25 | KABC - Fatal and Injury Only Crashes. (observed crashes/year) | | 1 |
| 26 | PDO - Property Damage Only Crashes. (observed crashes/year) | | 1 |
| 27 | KABCO - Total Crashes (crashes/year) | | 1 |
| 28 | | | |
| 29 | | | |
| 30 | MULTIYEAR ANALYSIS | | |
| 31 | Major Road | | Intersection 1 |
| 32 | AADT 2009 | | 6,000 |
| 33 | AADT 2010 | | 6,100 |
| 34 | AADT 2011 | | 6,200 |
| 37 | | | |
| 38 | Major Road | | Intersection 1 |
| 39 | AADT 2009 | | 4,800 |
| 40 | AADT 2010 | | 4,900 |
| 41 | AADT 2011 | | 5,000 |

**Step 7**: Once all the data entry is completed, press the **Set up Spreadsheet** button. This button will run the entire set-up process for the application of the predictive method.




**Step 8**: Once the process is finished running, a pop-up window will appear, providing users with instructions on the next steps, and where to find results of the analysis. Click **OK** to continue, and close the main menu interface to go to the summary sheet.




Results can be found in Tab **TLR_7_Site EB Total.**

## 4.3.4 Conclusions and Recommendations

The process of calculating the expected crash frequency for three-leg intersection with stop control on rural two-lane, two-way road was discussed. The predicted crash frequency for the intersection in different years was calculated using the HSM Part C predictive method. Furthermore, the expected average crash frequency for the intersection was determined by combining the average predicted and observed crash frequency with the EB method. The expected average crash frequency for the intersection was also calculated using the **IDOT HSM Crash Prediction Tool**, and identical results were obtained. The expected average crash frequency can be further converted into monetary benefit with the application of appropriate unit crash cost, and the information can be used by the IDOT engineers for decision-making purposes.

# 4.4 Calculation of Expected Crash Frequency for Four-leg Signalized Intersection on Urban and Suburban Arterials

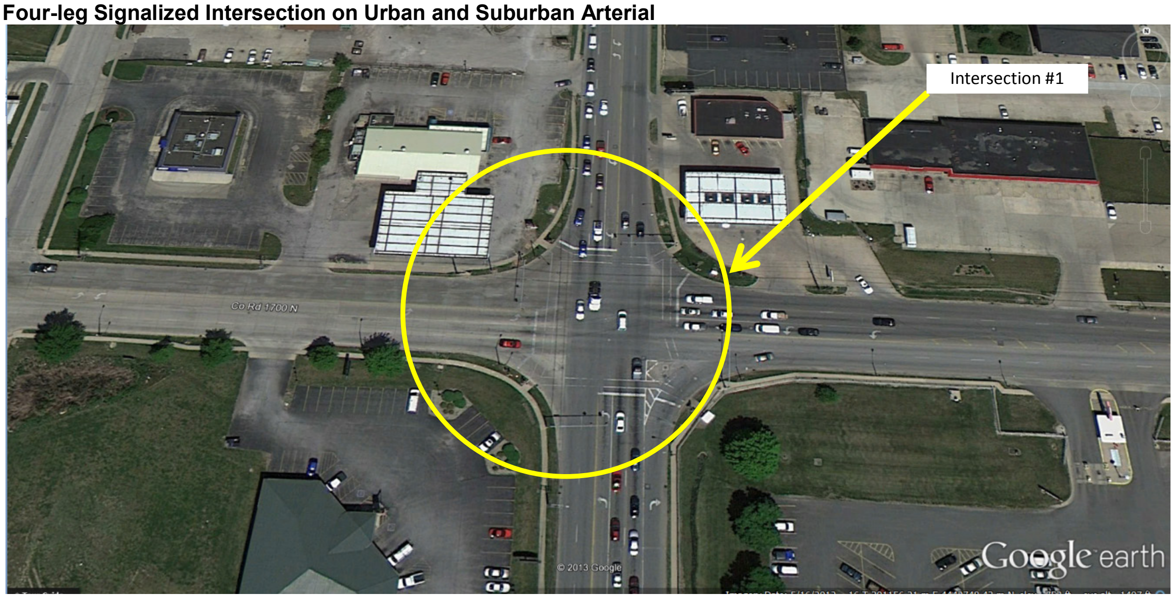
## 4.4.1 Introduction

The intersection of Unknown Avenue and Anonymous Road, as shown in Figure 4-4, is a four-leg signalized intersection on urban and suburban arterial located in IDOT District 6. Based on the historical crash data and the adopted network screening process, the FHWA Five Percent Report identified this intersection as a Five Percent location under the peer group "urban signalized intersection" and recommended it for further safety improvements.

IDOT is to apply the SHSP funding for safety improvements at the intersection. Multiple improvement alternatives are proposed based on the historical crash data, results from field visits, inputs from IDOT engineers, and IDOT policy. A comparison of expected crash frequency among different alternatives (including "no build") in the future time period is necessary to quantify the safety effects of different alternatives and finalize the safety improvements. The safety concerns will be considered together with other issues on costs, right-of-way, traffic operations, and environmental assessment during the project selection process.

This example illustrates how to calculate the expected crash frequency for a four-leg signalized intersection on urban and suburban arterials in a future year using the HSM Part C predictive method. The expected crash frequencies for different improvement alternatives in a future year are calculated manually first, followed by the calculation using the **IDOT HSM Crash Prediction Tool**.

FIGURE 4-4
**Four-leg Signalized Intersection on Urban and Suburban Arterial**




## 4.4.2 Manual Calculation of Expected Crash Frequency in a Future Year

The expected crash frequencies for different improvement alternatives (including the "no build" plan) in a future year are calculated manually first. To make the example concise, the calculation mainly focuses on the "no build" plan, while the procedures for different improvement alternatives are described briefly later with the results summarized in tables. For the purpose of cross-sectional comparison, the years 2009 and 2015 are used as the past and future time periods, respectively.

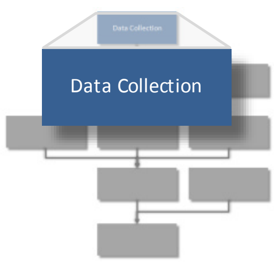
#### 4.4.2.1 Calculation of Expected Crash Frequency for "No Build" Plan

The calculation of expected crash frequency in a future year for the "No Build" plan can be divided into three parts; that is, the calculation of expected crash frequency for the past time period, the calculation of predicted crash frequencies under base conditions for past and future time periods, and the calculation of CMFs for past and future time periods, as listed below.

**Calculation of Expected Crash Frequency for Past Time Period**

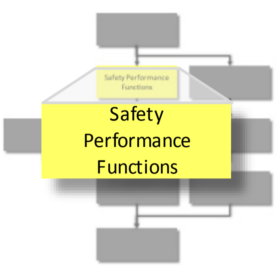
As discussed previously in Chapter 3, the calculation of expected crash frequency for the past time period can be divided into data collection, selection of SPFs, selection of CMFs, selection of calibration factors, calculation of predicted crash frequency under base conditions, calculation of CMFs, calculation of predicted crash frequency under site prevailing conditions, observed crash data, and finally, expected average crash frequency for the site. The expected crash frequency for the past time period can be determined with the following steps.

**Step 1: Data Collection**




All the data required for calculating the expected crash frequency for the past time period are collected, as presented in Table 4-14. For this intersection, both the IDOT database and Google Earth Pro are used for the data collection efforts. All the data in Table 4-14 are for illustration purposes only and do not necessarily represent the real conditions of the selected sites.

**Step 2: Selection of Safety Performance Functions**




To calculate the predicted crash frequency under base conditions, the SPFs are selected in this step based on the facility type, which is "four-leg signalized intersection (4SG) on urban and suburban arterial." The predicted crash frequencies under base conditions for multiple-vehicle collisions, single-vehicle crashes, and vehicle-pedestrian collisions need to be calculated in this example. Therefore, Equations (12-21) on page 12-29, (12-24) on page 12-32, and (12-29) on page 12-36 of the HSM are selected, as shown below.

$$N_{bimv} = \exp(-10.99 + 1.07 \times \ln(AADT_{maj}) + 0.23 \times \ln(AADT_{min})) \quad (4\text{-}54)$$

$$N_{bisv} = \exp(-10.21 + 0.68 \times \ln(AADT_{maj}) + 0.27 \times \ln(AADT_{min})) \quad (4\text{-}55)$$

$$N_{pedbase} = \exp(-9.53 + 0.40 \times \ln(AADT_{maj} + AADT_{min}) + 0.26 \times \ln\left(\frac{AADT_{min}}{AADT_{maj}}\right)$$
$$+0.45 \times \ln(PedVol) + 0.04 \times n_{lanesx}) \quad (4\text{-}56)$$

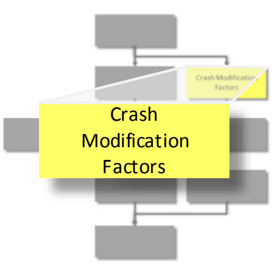
where:

$N_{bimv}$ = predicted average number of multiple-vehicle collisions for base conditions
$N_{bisv}$ = predicted average number of single-vehicle crashes for base conditions
$N_{pedbase}$ = predicted average number of vehicle-pedestrian collisions for base conditions
$AADT_{maj}$ = AADT for major road
$AADT_{min}$ = AADT for minor road
$PedVol$ = sum of daily pedestrian volumes crossing all intersection legs
$n_{lanesx}$ = maximum number of traffic lanes crossed by a pedestrian

TABLE 4-14
**List of Data Collected for Calculating the Expected Crash Frequency for Past Time Period**

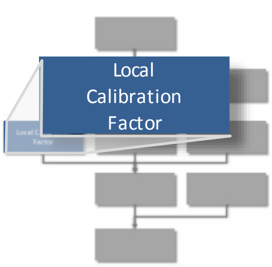
| Data Item | Data Collected | |
|---|---|---|
| **Data for Calculating Predicted Crash Frequency under Base Conditions** | | |
| AADT for major road (vehicles/day) | 20,900 | |
| AADT for minor road (vehicles/day) | 18,800 | |
| Sum of daily pedestrian volume (pedestrians/day) | 1,500 | |
| Maximum number of lanes crossed by a pedestrian | 6 | |
| **Data for Calculating the Crash Modification Factors** | | |
| Number of approaches with left-turn lanes | 4 | |
| Type of left-turn signal phasing | Approach 1 | Permissive |
| | Approach 2 | Permissive |
| | Approach 3 | Permissive |
| | Approach 4 | Permissive |
| Number of approaches with right-turn lanes | 1 | |
| Number of approaches with right-turn-on-red prohibited | 0 | |
| Lighting | Not present | |
| Red-light camera | Not present | |
| Number of bus stops within 1,000 feet of the intersection | 11 | |
| Presence of schools within 1,000 feet of the intersection | Not present | |
| Number of alcohol sales establishments within 1,000 feet of the intersection | 1 | |
| **Illinois Safety Performance Function Calibration Factor and Replaced Default Values** | | |
| Illinois calibration factor ($C_i$) | 2.32 | |
| Bicycle crash adjustment factor ($f_{bikei}$) | 0.010 | |
| Proportion of total crashes for unlighted intersections that occur at night ($p_{ni}$) | 0.235 | |

### Step 3: Selection of Crash Modification Factors




For signalized intersections on urban and suburban arterials, there are six CMFs for vehicle-vehicle collisions; that is, the CMFs for intersection left-turn lanes, intersection left-turn signal phasing, intersection right-turn lanes, right-turn-on-red, lighting, and red-light cameras. Besides that, there are also three CMFs for vehicle-pedestrian collisions; that is, CMFs for bus stops, schools, and alcohol sales establishments, as listed from HSM pages 12-43 to page 12-47. All the CMFs applicable for the intersection are selected.

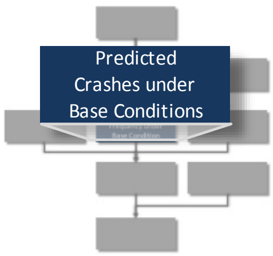
### Step 4: Selection of Illinois Safety Performance Function Calibration Factor




The Illinois SPF calibration factor is selected in this step based on the facility type, IDOT jurisdiction for the site, and the time period for the analysis. For this example, Table A-4 in Appendix A of this document is used because the corridor is located within IDOT District 6, and the calendar year for the analysis is 2009. Based on Table A-4, the Illinois SPF calibration factor for a four-leg signalized intersection (4SG) on urban and suburban arterial is 2.32.

In addition to the Illinois SPF calibration factor, the replaced bicycle crash adjustment factor and nighttime crash proportions are selected based on the facility type, IDOT jurisdiction for the site, and the time period for the analysis. Similarly, because the corridor is located within IDOT District 6 and the calendar year for the analysis is 2009, the bicycle crash adjustment factor and nighttime crash proportions are selected from Table B-6-18 and Table B-6-22 in Appendix B respectively, as listed in Table 4-14.

**Step 5: Calculation of Predicted Crash Frequency under Base Conditions**




The predicted crash frequency under base conditions is calculated in this step. Based on the HSM methodology, the predicted crash frequency under base conditions for multiple-vehicle collisions, single-vehicle crashes, and vehicle-pedestrian collisions can be determined separately with relevant SPFs, as listed below.

- Multiple-vehicle collisions

The predicted multiple-vehicle collisions under base conditions for the intersection can be estimated with Equation (4-54). Based on data in Table 4-14, the AADTs for major and minor roads are 20,900 vehicles per day and 18,800 vehicles per day, respectively. Therefore, for this intersection, the predicted number of multiple-vehicle collisions under base conditions is:

$$N_{bimv} = exp\left(-10.99 + 1.07 \times ln(AADT_{maj}) + 0.23 \times ln(AADT_{min})\right) \quad (4\text{-}57)$$
$$= exp(-10.99 + 1.07 \times ln(20900) + 0.23 \times ln(18800))$$
$$= 6.803\ crashes/year$$

- Single-vehicle crashes

The predicted single-vehicle crashes under base conditions can be estimated with Equation (4-55). Based on data in Table 4-14, the AADTs for major and minor road are 20,900 vehicles per day and 18,800 vehicles per day, respectively. Therefore, for this intersection, the predicted number of single-vehicle crashes under base conditions is:

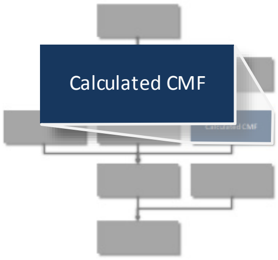
$$N_{bisv} = exp\left(-10.21 + 0.68 \times ln(AADT_{maj}) + 0.27 \times ln(AADT_{min})\right) \quad (4\text{-}58)$$
$$= exp(-10.21 + 0.68 \times ln(20900) + 0.27 \times ln(18800))$$
$$= 0.455\ crashes/year$$

- Vehicle-pedestrian collisions

The vehicle-pedestrian collisions under base conditions can be determined with Equation (4-56). Based on Table 4-14, the maximum number of traffic lanes crossed by a pedestrian at this intersection is six lanes. The pedestrian crossing volume for this intersection is not available. However, the HSM provides a recommended pedestrian crossing volume based on the general level of pedestrian activity, as listed in Table 12-15 on page 12-37 of the HSM. The general level of pedestrian activity for the intersection is determined to be “medium high”; therefore, a pedestrian crossing volume of 1,500 pedestrians per day is used, as listed in Table 4-14. The predicted number of vehicle-pedestrian collisions under base conditions is:

$$N_{pedbase} = exp\left(-9.53 + 0.40 \times ln(AADT_{total}) + 0.26 \times ln\left(\frac{AADT_{min}}{AADT_{maj}}\right) + 0.45 \times ln(PedVol)\right.$$
$$\left. + 0.04 \times n_{lanesx}\right) \quad (4\text{-}59)$$
$$= exp\left(-9.53 + 0.40 \times ln(39700) + 0.26 \times ln\left(\frac{18800}{20900}\right) + 0.45 \times ln(1500) + 0.04 \times 6\right)$$
$$= 0.167\ crashes/year$$

**Step 6: Calculation of Crash Modification Factors**




The CMFs for the intersection can be determined based on the geometric and traffic control characteristics using the tables, equations, and figures included in HSM. Altogether, the HSM provides nine CMFs for this facility type, including six CMFs for vehicle-vehicle collisions and three CMFs for pedestrian-vehicle collisions. The CMFs for vehicle-vehicle collisions and vehicle-pedestrian collisions can be determined separately, as described below.

- CMFs for vehicle-vehicle collisions

1) CMF for intersection left-turn lanes ($CMF_{1i}$)

The $CMF_{1i}$ can be determined with Table 12-24 on page 12-43 of the HSM. Based on Table 4-14, the number of approaches with left-turn lanes is four; therefore, the $CMF_{1i}$ for this intersection is 0.66.

2) CMF for intersection left-turn phasing ($CMF_{2i}$)

Based on the HSM methodology, the CMF for different types of left-turn signal phasing can be determined based on Table 12-25 on page 12-44 of the HSM. The $CMF_{2i}$ for the intersection is the product of $CMF_{2i}$ for different approaches.

For this intersection, the left-turn signal phasing for all four approaches is “permissive”; therefore, the $CMF_{2i}$ for the intersection is:

$$CMF_{2i} = 1.00 \times 1.00 \times 1.00 \times 1.00 \\ = 1.00 \qquad \text{4-60)}$$

3) CMF for intersection right-turn lanes ($CMF_{3i}$)

The $CMF_{3i}$ can be determined with Table 12-26 on page 12-44 of the HSM. The number of approaches with right-turn lanes is 1; therefore, the $CMF_{3i}$ for this intersection is 0.96.

4) CMF for right-turn-on-red ($CMF_{4i}$)

The $CMF_{4i}$ can be determined with Equation (12-35) on page 12-44 of the HSM, as shown below:

$$CMF_{4i} = 0.98^{(n_{prohib})} \qquad (4\text{-}61)$$

where:
$n_{prohib}$ = the number of signalized intersection approaches for which right-turn-on-red is prohibited

Based on Table 4-14, right-turn-on-red was prohibited on none of the approaches at the intersection; therefore, the $CMF_{4i}$ for this intersection is:

$$CMF_{4i} = 0.98^{(n_{prohib})} \\ = 0.98^{0} \\ = 1.00 \qquad (4\text{-}62)$$

5) CMF for lighting ($CMF_{5i}$)

The $CMF_{5i}$ for this intersection can be determined with Equation (12-36) on page 12-45 of the HSM, as shown below:

$$CMF_{5i} = 1 - 0.38 \times p_{ni} \qquad (4\text{-}63)$$

where:
$p_{ni}$ = proportion of total crashes for unlighted intersections that occur at night

Lighting is not provided for this intersection; therefore, the $CMF_{5i}$ is 1.00 for this intersection.

6) CMF for red-light cameras ($CMF_{6i}$)

The $CMF_{6i}$ for this intersection can be determined with Equation (12-37) on page 12-45 of the HSM. The reader can refer to the relevant sections for more details.

Based on Table 4-14, no red-light cameras were installed at this intersection; therefore, the $CMF_{6i}$ is 1.00for this intersection.

- CMFs for pedestrian-vehicle collisions

1) CMF for bus stops ($CMF_{1p}$)

The $CMF_{1p}$ for this intersection can be determined with Table 12-28 on page 12-46 of the HSM. Based on Table 4-14, 11 bus stops are within 1,000 feet of the intersection; therefore, the $CMF_{1p}$ for this intersection is 4.15.

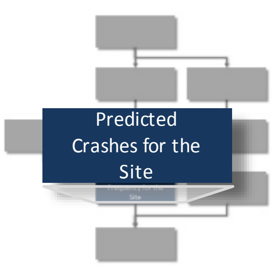
2) CMF for schools ($CMF_{2p}$)

The $CMF_{2p}$ for this intersection can be determined with Table 12-29 on page 12-46 of the HSM. No schools are located within 1,000 feet of the intersection; therefore, the $CMF_{1p}$ for this intersection is 1.00.

3) CMF for alcohol sales establishments ($CMF_{3p}$)

The $CMF_{3p}$ can be determined with Table 12-30 on page 12-47 of the HSM. Based on Table 4-14, there is one alcohol sales establishment within 1,000 feet of the intersection; therefore, the $CMF_{3p}$ for this intersection is 1.12.

**Step 7: Calculation of Predicted Crash Frequency under Site Prevailing Conditions**




The next step is to calculate the predicted crash frequency for the intersection under site prevailing conditions. For a four-leg signalized intersection on urban and suburban arterial, the HSM developed SPFs for different collision types separately. Therefore, in Step 5, the predicted crash frequency under base conditions is calculated separately for different collision types. To facilitate the calculation of expected crash frequency in the following steps, the predicted crash frequency for site prevailing conditions is calculated separately for different collision types as well, as listed below.

- Multiple-vehicle collisions

The predicted crash frequency for multiple-vehicle collisions under site prevailing conditions can be calculated with the following equation:

$$N_{predicted\ mv} = C_i \times N_{bimv} \times (CMF_{1i} \times CMF_{2i} \times \cdots \times CMF_{6i}) \quad (4\text{-}64)$$

where:
$C_i$ = calibration factor for the facility type
$N_{bimv}$ = predicted average number of multiple-vehicle collisions for base conditions

$CMF_{ni}(n = 1,2,\cdots,6)$ = CMFs for vehicle-vehicle collisions at signalized intersections

Based on the calculated results in previous steps, the predicted number of multiple-vehicle collisions for the intersection is:

$$N_{predicted\ mv} = 2.32 \times 6.803 \times 0.66 \times 1.00 \times 0.96 \times 1.00 \times 1.00 \times 1.00$$
$$= 10.000\ crashes/year$$

- Single-vehicle crashes

The predicted crash frequency for single-vehicle crashes under site prevailing conditions can be calculated with the following equation:

$$N_{predicted\ sv} = C_i \times N_{bisv} \times (CMF_{1i} \times CMF_{2i} \times \cdots \times CMF_{6i}) \quad (4\text{-}65)$$

where:

$C_i$ = calibration factor for the facility type
$N_{bisv}$ = predicted average number of single-vehicle crashes for base conditions
$CMF_{ni}(n = 1,2,\cdots,6)$ = CMFs for vehicle-vehicle collisions at signalized intersections

Based on the calculated results in previous steps, the predicted number of single-vehicle crashes for the intersection is:

$$N_{predicted\ sv} = 2.32 \times 0.455 \times 0.66 \times 1.00 \times 0.96 \times 1.00 \times 1.00 \times 1.00$$
$$= 0.669\ crashes/year$$

- Vehicle-pedestrian collisions

The predicted crash frequency for vehicle-pedestrian collisions under site prevailing conditions can be calculated with the following equation:

$$N_{predicted\ vp} = C_i \times N_{pedbase} \times \left(CMF_{1p} \times CMF_{2p} \times CMF_{3p}\right) \quad (4\text{-}66)$$

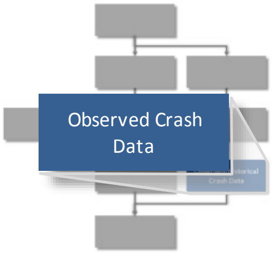
where:

$C_i$ = calibration factor for the facility type
$N_{pedbase}$ = predicted number of vehicle-pedestrian collisions per year for base conditions at signalized intersections
$CMF_{np}(n = 1,2,3)$ = CMFs for vehicle-pedestrian collisions at signalized intersections

Based on the calculated results in previous steps, the predicted number of vehicle-pedestrian collisions for the intersection is:

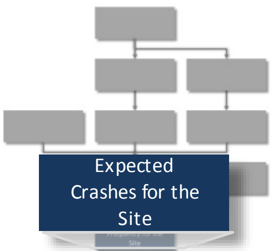
$$N_{predicted\ vp} = 2.32 \times 0.167 \times 4.15 \times 1.00 \times 1.12$$
$$= 1.801\ crashes/year$$

### Step 8: Observed Crash Data




The observed crashes for the intersection in 2009 are identified in this step. For this facility type, the crash frequency for different collision types needs to be identified separately. Based on the IDOT crash database, the observed crash frequencies for multiple-vehicle collisions, single-vehicle crashes, and vehicle-pedestrian collisions are 7, 2, and 1, respectively. The identified intersection crashes include all the crashes within the curb line limits of the intersection as well as all the intersection-related crashes.

### Step 9: Calculation of Expected Average Crash Frequency for the Site




The expected crash frequency for the past time period can be determined with two steps. First, the weighted adjustment, $w$, is calculated with Equation (3-3) based on the SPF overdispersion parameter ($k$) and the predicted crash frequency for the time period. After that, the expected crash frequency is determined by combining the predicted and observed crash frequencies using Equation (3-2). For this facility type, the expected crash frequency is calculated separately for multiple-vehicle collisions, single-vehicle crashes, and vehicle-pedestrian collisions.

- Multiple-vehicle collisions

The overdispersion parameter ($k$) for total multiple-vehicle collisions is 0.39, and the predicted crash frequency for total multiple-vehicle collisions is 10.000. Therefore, the weighted adjustment, $w$, is:

$$w = \frac{1}{1+k\times\sum_{all\ study\ years} N_{predicted}} \quad (4\text{-}67)$$
$$= \frac{1}{1+0.39\times10.000}$$
$$= 0.204$$

Based on the calculated results in Steps 7 and 8, the predicted and observed crash frequencies for the intersection are 10.000 and 7, respectively. Based on Equation (3-2), the expected average crash frequency for the intersection is:

$$N_{expected} = w \times N_{predicted} + (1 - w) \times N_{observed} \quad (4\text{-}68)$$
$$= 0.204 \times 10.000 + (1 - 0.204) \times 7$$
$$= 7.612\ crashes/year$$

Therefore, the expected total of multiple-vehicle collisions for the intersection is 7.612 crashes per year, or approximately one crash every 2 months.

- Single-vehicle crashes

The overdispersion parameter ($k$) and the predicted crash frequency for total single-vehicle crashes are 0.36 and 0.669, respectively. Therefore, the weighted adjustment, $w$, is:

$$w = \frac{1}{1+k\times\sum_{all\ study\ years} N_{predicted}} \quad (4\text{-}69)$$
$$= \frac{1}{1+0.36\times0.669}$$
$$= 0.806$$

Based on the calculated results in Steps 7 and 8, the predicted and observed crash frequencies for the intersection are 0.669 and 2, respectively. Based on Equation (3-2), the expected average crash frequency for the intersection is:

$$N_{expected} = w \times N_{predicted} + (1 - w) \times N_{observed} \tag{4-70}$$
$$= 0.806 \times 0.669 + (1 - 0.806) \times 2$$
$$= 0.927\ crashes/year$$

Therefore, the expected total of single-vehicle crashes for the intersection is 0.927 crashes per year, or approximately one crash every year.

- Vehicle-pedestrian collisions

The overdispersion parameter ($k$) and predicted crash frequency for total vehicle-pedestrian collisions are 0.24 and 1.801, respectively. Therefore, the weighted adjustment, $w$, is:

$$w = \frac{1}{1 + k \times \sum_{all\ study\ years} N_{predicted}} \tag{4-71}$$
$$= \frac{1}{1 + 0.24 \times 1.801}$$
$$= 0.698$$

Based on the calculated results in Steps 7 and 8, the predicted and observed crash frequencies for the intersection are 1.801 and 1, respectively. Based on Equation (3-2), the expected average crash frequency for the intersection is:

$$N_{expected} = w \times N_{predicted} + (1 - w) \times N_{observed} \tag{4-72}$$
$$= 0.698 \times 1.801 + (1 - 0.698) \times 1$$
$$= 1.559\ crashes/year$$

Therefore, the expected total of vehicle-pedestrian collisions for the intersection is 1.559 crashes per year, or approximately one crash every 234 days.

**Calculation of Predicted Crash Frequencies under Base Conditions for Past and Future Time Periods**

The predicted crash frequencies for the past and future time periods under base conditions are required for the calculation. The predicted crash frequencies for the past time period under base conditions were calculated in Step 5 in Section 4.4.2.1 and will not be reiterated here. The following section will focus only on the calculation of predicted crash frequency under base conditions in a future time period. Similarly, the predicted crash frequency will be calculated separately for different collision types. The predicted AADTs for major and minor roads at the intersection in 2015 are 23,000 and 20,700, respectively.

- Multiple-vehicle collisions

The predicted multiple-vehicle collisions under base conditions can be estimated with Equation (4-54). The predicted crash frequency under base conditions for multiple-vehicle collisions in 2009 is 6.803 crashes. The AADTs for major and minor roads in 2015 are 23,000 and 20,700 vehicles per day, respectively. Therefore, for this intersection, the predicted number of multiple-vehicle collisions under base conditions in 2015 is:

$$N_{bimv} = exp\left(-10.99 + 1.07 \times ln\left(AADT_{maj}\right) + 0.23 \times ln(AADT_{min})\right) \tag{4-73}$$
$$=(-10.99+1.07\times ln23000+0.23\times ln20700)$$
$$= 7.706\ crashes/year$$

- Single-vehicle crashes

The predicted single-vehicle crashes under base conditions can be estimated with Equation (4-55). The predicted crash frequency under base conditions for single-vehicle crashes in 2009 is 0.455 crashes. The AADTs for major and minor roads in 2015 are 23,000 and 20,700 vehicles per day, respectively.

Therefore, for this intersection, the predicted number of single-vehicle crashes under base conditions in 2015 is:

$$N_{bisv} = exp\left(-10.21 + 0.68 \times ln\left(AADT_{maj}\right) + 0.27 \times ln(AADT_{min})\right) \quad (4\text{-}74)$$
$$=(-10.21+0.68\times ln23000+0.27\times ln20700)$$
$$= 0.498\ crashes/year$$

- Vehicle-pedestrian collisions

The crash frequency for vehicle-pedestrian collisions under base conditions can be determined with Equation (4-56). The predicted crash frequency under base conditions for vehicle-pedestrian collisions in 2009 is 0.167 crashes. The AADTs for major and minor roads in 2015 are 23,000 and 20,700 vehicles per day, respectively. The pedestrian crossing volume for this intersection in 2015 is not available. However, the HSM provides a recommended pedestrian crossing volume based on the general level of pedestrian activity, as listed in Table 12-15 on page 12-37 of the HSM. The general level of pedestrian activity for the intersection in 2015 is determined to be “medium high”; therefore, a pedestrian crossing volume of 1,500 pedestrians per day is used. The maximum number of traffic lanes crossed by a pedestrian at this intersection in 2015 is still six lanes. The predicted number of vehicle-pedestrian collisions under base conditions in 2015 is:

$$N_{pedbase} = exp\left(-9.53 + 0.40 \times ln(AADT_{total}) + 0.26 \times ln\left(\frac{AADT_{min}}{AADT_{maj}}\right) + 0.45 \times ln(PedVol)\right.$$
$$\left. +0.04 \times n_{lanesx}\right) \quad (4\text{-}75)$$
$$= exp\left(-9.53 + 0.40 \times ln(43700) + 0.26 \times ln\left(\frac{20700}{23000}\right) + 0.45 \times ln(1500) + 0.04 \times 6\right)$$
$$= 0.173\ crashes/year$$

The predicted crash frequencies under base conditions for past and future time periods are summarized in Table 4-15.

TABLE 4-15
**Predicted Crash Frequencies under Base Conditions for Past and Future Time Periods**

| Collision Type | Past Time Period | Future Time Period |
|---|---|---|
| Multiple-vehicle collisions | 6.803 | 7.706 |
| Single-vehicle crashes | 0.455 | 0.498 |
| Vehicle-pedestrian collisions | 0.167 | 0.173 |

### Calculation of Crash Modification Factors for Past and Future Time Periods

The third part of the calculation is to calculate the CMFs for past and future time periods. The CMFs for the past time period have been calculated in Step 6 in Section 4.4.2.1 and will not be reiterated here. For the “no build” plan, the CMFs for a future time period will remain the same because no changes will be made to the roadway geometric characteristics or traffic control of the intersection. All the CMFs for “no build” plan in the past and future time periods are summarized in Table 4-16.

TABLE 4-16
**Crash Modification Factors for Past and Future Time Periods**

| CMF | Past Time Period | Future Time Period |
|---|---|---|
| $CMF_{1i}$ | 0.66 | 0.66 |
| $CMF_{2i}$ | 1.00 | 1.00 |
| $CMF_{3i}$ | 0.96 | 0.96 |
| $CMF_{4i}$ | 1.00 | 1.00 |
| $CMF_{5i}$ | 1.00 | 1.00 |
| $CMF_{6i}$ | 1.00 | 1.00 |
| $CMF_{1p}$ | 4.15 | 4.15 |
| $CMF_{2p}$ | 1.00 | 1.00 |
| $CMF_{3p}$ | 1.12 | 1.12 |

**Calculation of Expected Crash Frequency for Future Time Period**

The expected crash frequency for a future time period can be calculated based on Equation (3-4). Similarly, the expected crash frequency is calculated separately for different collision types.

- Multiple-vehicle collisions

$$N_{f\ mv} = N_{p\ mv}\left(\frac{N_{bf\ mv}}{N_{bp\ mv}}\right)\left(\frac{CMF_{1f}}{CMF_{1p}}\right)\left(\frac{CMF_{2f}}{CMF_{2p}}\right)\cdots\left(\frac{CMF_{nf}}{CMF_{np}}\right) \quad (4\text{-}76)$$
$$=7.612 \times \frac{7.706}{6.803} \times \frac{0.66}{0.66} \times \frac{1.00}{1.00} \times \frac{0.96}{0.96} \times \frac{1.00}{1.00} \times \frac{1.00}{1.00} \times \frac{1.00}{1.00}$$
$$= 8.622\ crashes/year$$

- Single-vehicle crashes

$$N_{f\ sv} = N_{p\ sv}\left(\frac{N_{bf\ sv}}{N_{bp\ sv}}\right)\left(\frac{CMF_{1f}}{CMF_{1p}}\right)\left(\frac{CMF_{2f}}{CMF_{2p}}\right)\cdots\left(\frac{CMF_{nf}}{CMF_{np}}\right) \quad (4\text{-}77)$$
$$=0.927 \times \frac{0.498}{0.455} \times \frac{0.66}{0.66} \times \frac{1.00}{1.00} \times \frac{0.96}{0.96} \times \frac{1.00}{1.00} \times \frac{1.00}{1.00} \times \frac{1.00}{1.00}$$
$$= 1.015\ crashes/year$$

- Vehicle-pedestrian collisions

$$N_{f\ vp} = N_{p\ vp}\left(\frac{N_{bf\ vp}}{N_{bp\ vp}}\right)\left(\frac{CMF_{1f}}{CMF_{1p}}\right)\left(\frac{CMF_{2f}}{CMF_{2p}}\right)\cdots\left(\frac{CMF_{nf}}{CMF_{np}}\right) \quad (4\text{-}78)$$
$$= 1.559 \times \frac{0.173}{0.167} \times \frac{0.66}{0.66} \times \frac{1.00}{1.00} \times \frac{0.96}{0.96} \times \frac{1.00}{1.00} \times \frac{1.00}{1.00} \times \frac{1.00}{1.00}$$
$$= 1.615\ crashes/year$$

- Vehicle-bicycle collisions

The expected total vehicle-bicycle collisions can be determined by multiplying the expected total vehicle collisions with the bicycle crash adjustment factor. The intersection is located within IDOT District 6, and the analysis time period is 2015. The facility type for the intersection is a four-leg signalized intersection on urban and suburban arterials. Therefore, the bicycle crash adjustment factor for 4SG in Table B-6-18 in Appendix B, 0.010, is used. The expected number of vehicle-bicycle collisions in 2015 is:

$$N_{f\ vb} = (N_{f\ mv} + N_{f\ sv}) \times f_{bikei} \quad (4\text{-}79)$$
$$= (8.622 + 1.015) \times 0.010$$
$$= 0.096\ crashes/year$$

Therefore, the expected total crash frequency for the intersection in 2015 is 11.348, or approximately one crash every 32 days, including 8.622 multiple-vehicle collisions, 1.015 single-vehicle crashes, 1.615 vehicle-pedestrian collisions, and 0.096 vehicle-bicycle collisions.

#### 4.4.2.2 Proposed Improvement Alternatives for the Intersection

To improve the safety performance of the intersection, multiple improvement alternatives are developed based on the historical crash data, field visit results, input from IDOT engineers, and IDOT policy, as listed below:

- Improvement Alternative 1: Convert the left-turn signal phasing from “permissive” to “protected” for all approaches
- Improvement Alternative 2: Install lighting pole at the intersection and prohibit right-turn-on-red on all approaches
- Improvement Alternative 3: Apply all the treatments in Improvement Alternatives 1 and 2 to the intersection.

These improvement alternatives are for illustration purposes only and do not necessarily represent the actual improvement alternatives developed in IDOT engineering practice.

#### 4.4.2.3 Calculation of Expected Crash Frequency under Different Improvement Alternatives in Future Time Period

The expected crash frequencies for the intersection under different improvement alternatives in a future time period are calculated with similar procedures. For the purpose of cross-sectional comparison, years 2009 and 2015 were selected for the past and future time periods, respectively. As shown in Equation (3-4), the calculation of expected crash frequency for the past time period and the calculation of predicted crash frequency under base conditions for past and future time period will be the same for different improvement alternatives. The only differences for different improvement alternatives lie in the calculation of CMFs for the past and future time periods. To make the example concise, only CMFs related to different improvement alternatives are discussed, while all duplicate calculation procedures are omitted, as listed below.

- CMFs for Improvement Alternative 1

Improvement Alternative 1 would convert the left-turn signal phasing from “permissive” to “protected” for all four approaches. Correspondingly, for each approach, the CMF would change from 1.00 to 0.94. Since the left-turn signal phasing is to be converted for all four approaches, the $CMF_{2i}$ for the intersection should be determined by multiplying the CMFs for all approaches together. Therefore, the $CMF_{2i}$ for this intersection in 2015 is 0.78.

- CMFs for Improvement Alternative 2

Improvement Alternative 2 would install lighting poles at the intersection and prohibit right-turn-on-red on all approaches. The CMFs for the improvements can be calculated as follows.

1) CMF for right-turn-on-red

The CMF for right-turn-on-red, $CMF_{4i}$, can be determined based on Equation (12-35) on page 12-44 of the HSM, as shown below:

$$CMF_{4i} = 0.98^{(n_{prohib})} \tag{4-80}$$

where:
$n_{prohib}$ = the number of signalized intersection approaches for which right-turn-on-red is prohibited.

The $n_{prohib}$ for the intersection is 4; therefore, the CMF for right-turn-on-red is:

$$CMF_{4i} = 0.98^{(4)} \\ = 0.92 \quad (4\text{-}81)$$

2) CMF for lighting

The CMF for lighting, $CMF_{5i}$, can be determined based on Equation (12-36) on page 12-45 of the HSM, as shown below.

$$CMF_{5i} = 1 - 0.38 \times p_{ni} \quad (4\text{-}82)$$

where:

$p_{ni}$ = the proportion of total crashes for unlighted intersections that occur at night

Based on Table B-6-22 in Appendix B of this document, the value of $p_{ni}$ is 0.235. The default value table should be selected based on the jurisdiction where the intersection is located and the time period for the analysis. The intersection is located in IDOT District 6, and the time period for the analysis is 2015; therefore, Table B-6-22 is selected. The CMF for lighting is:

$$CMF_{5i} = 1 - 0.38 \times p_{ni} \\ = 1 - 0.38 \times 0.235 \\ = 0.91 \quad (4\text{-}83)$$

- CMFs for Improvement Alternative 3

Improvement Alternative 3 would apply all the treatments in Improvement Alternatives 1 and 2 to the intersection. Therefore, all the CMFs calculated for Improvement Alternatives 1 and 2 can be applied to Improvement Alternative 3. To make the example concise, the calculation of CMFs for Improvement Alternative 3 is not reiterated here. Table 4-17 lists the CMFs for different improvement alternatives (including the “no build” plan).

TABLE 4-17

**Summary of Crash Modification Factors under Different Improvement Alternatives**

| CMF | Improvement Alternative | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | “No Build” Plan | | Improvement Alternative 1 | | Improvement Alternative 2 | | Improvement Alternative 3 | |
| | Past | Future | Past | Future | Past | Future | Past | Future |
| $CMF_{1i}$ | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 |
| $CMF_{2i}$ | 1.00 | 1.00 | 1.00 | 0.78 | 1.00 | 1.00 | 1.00 | 0.78 |
| $CMF_{3i}$ | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| $CMF_{4i}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.92 | 1.00 | 0.92 |
| $CMF_{5i}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.91 | 1.00 | 0.91 |
| $CMF_{6i}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{1p}$ | 4.15 | 4.15 | 4.15 | 4.15 | 4.15 | 4.15 | 4.15 | 4.15 |
| $CMF_{2p}$ | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $CMF_{3p}$ | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 |

The expected crash frequencies for different improvement alternatives in a future time period are calculated with Equation (3-4). Similarly, the expected crash frequencies are calculated separately for different collision types, as listed in Table 4-18.

TABLE 4-18
**Expected Crash Frequency under Different Improvement Alternatives in Future Year**

| Collision Type | Improvement Alternative | | | |
|---|---|---|---|---|
| | "No Build" Plan | Improvement Alternative 1 | Improvement Alternative 2 | Improvement Alternative 3 |
| Multiple-vehicle Collisions | 8.622 | 6.725 | 7.219 | 5.631 |
| Single-vehicle Crashes | 1.015 | 0.791 | 0.849 | 0.663 |
| Vehicle-pedestrian collisions | 1.615 | 1.615 | 1.615 | 1.615 |
| Vehicle-bicycle Collisions | 0.096 | 0.075 | 0.081 | 0.063 |
| Total | 11.348 | 9.207 | 9.764 | 7.971 |

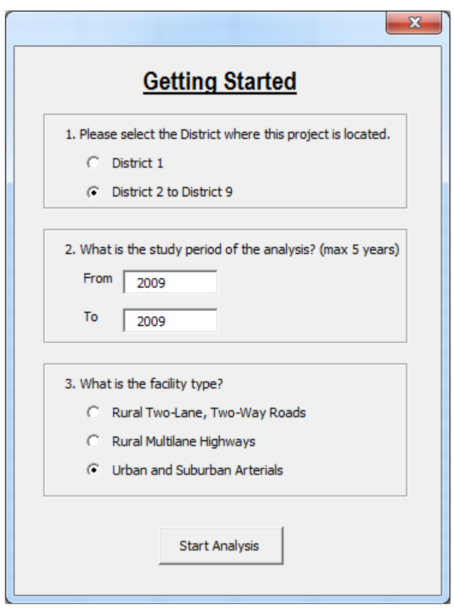
## 4.4.3 Calculation of Predicted Crash Frequency Using the IDOT HSM Crash Prediction Tool

The current edition of the **IDOT HSM Crash Prediction Tool** does not incorporate the module for calculating the expected crash frequency for a future time period. However, the tool provides users the ability to calculate the predicted crash frequency for the past and future time periods, and expected crash frequency for the past period. This provides enough information to calculate the expected crash frequency for a future time period using equations 4-76 to 4-79.

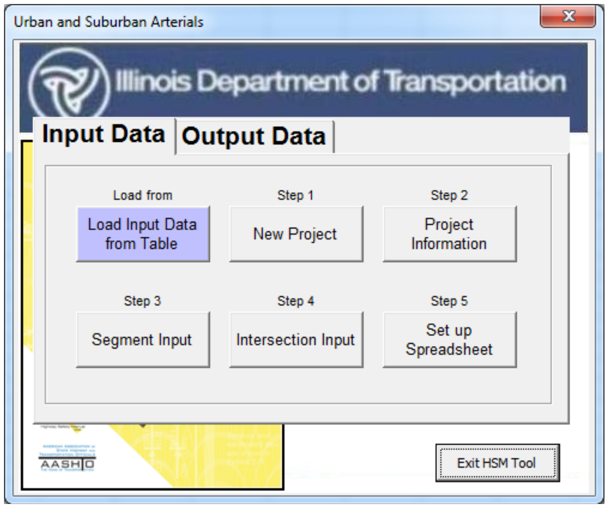
Only the expected crash frequency for the past time period is calculated with the tool in this section.

The expected crash frequency calculation can be divided into eight steps, as listed below.

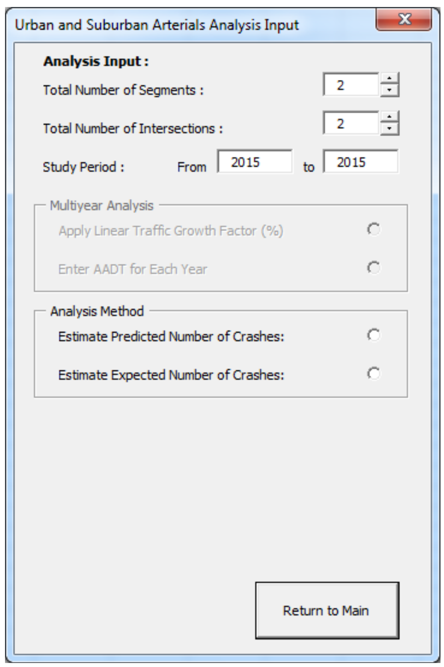
**Step 1**: Enter the following data in the **Getting Started** user form. The project is located in IDOT District 6, the study period is 2009, and the facility is a four-leg signalized intersection (4SG) on urban and suburban arterial. Click the **Start Analysis** button.



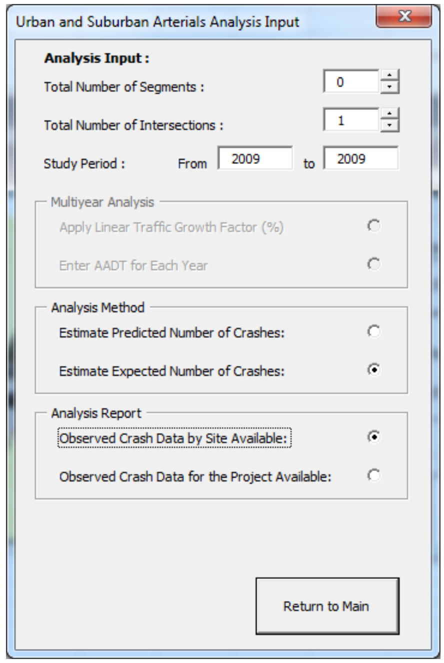
**Step 2**: The Main Menu user form will open up as shown below.



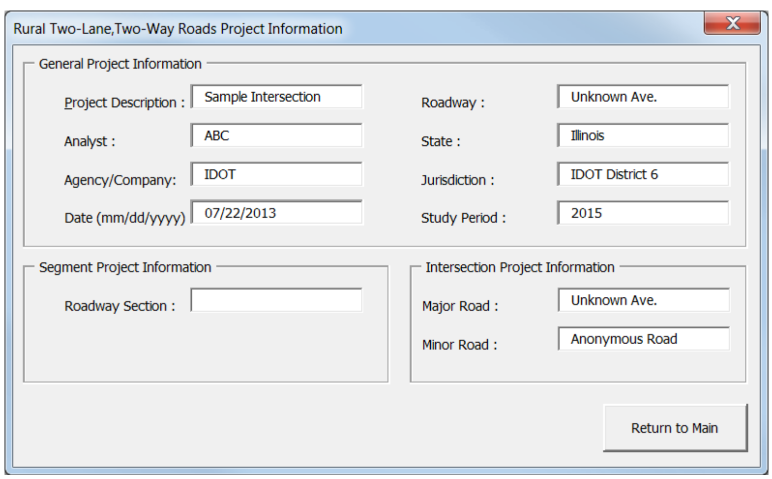

**Step 3:** Select the **New Project** button. **The Urban and Suburban Arterials Analysis Input** user form will appear.



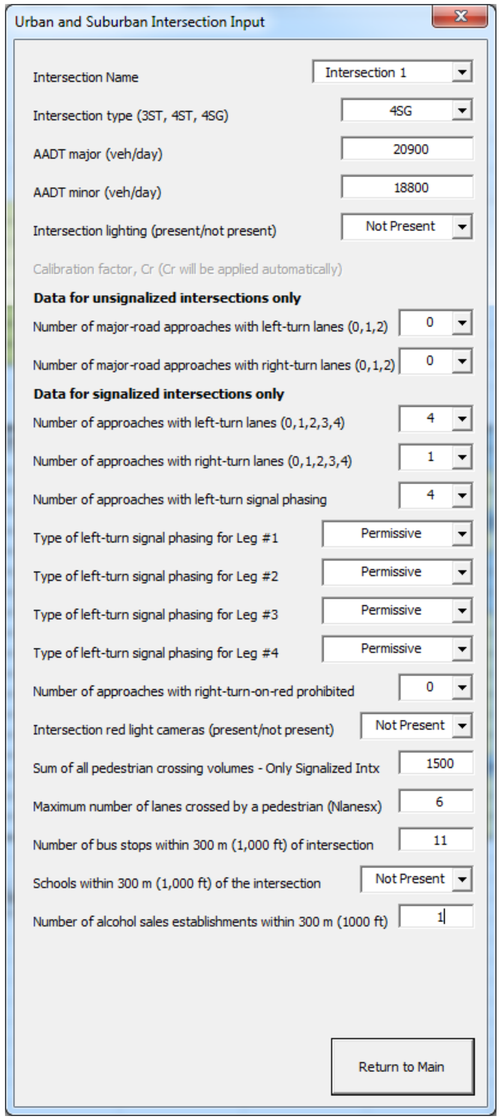
**Step 4**: Enter the required data. For this example, one intersection will be analyzed while no segments will be included. The study period (2009 to 2009) will be prepopulated. The analysis method for this example is the **Estimate Expected Number of Crashes**. Once all the data are entered, click the **Return to Main** button.



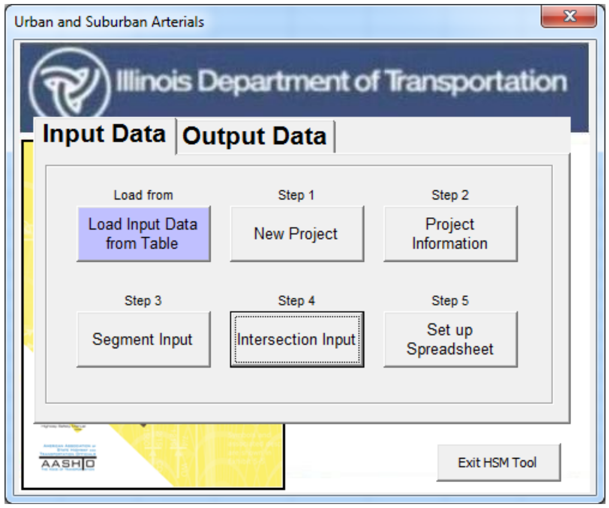

**Step 5**: Press the **Project Information** button, and enter details about the project. Once the form is filled out, press the **Return to Main** button to go back to the main menu.



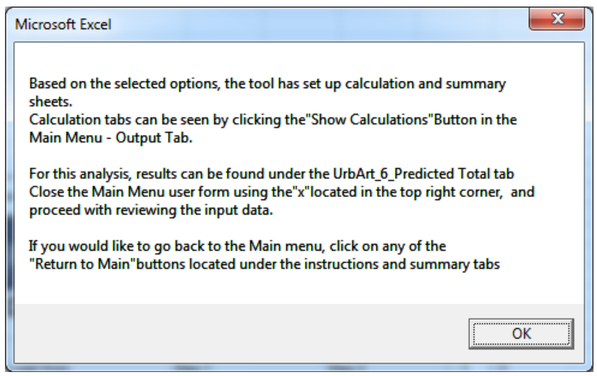
**Step 6**: Press the **Intersection Input** button and enter the data. The **Urban and Suburban Intersection Input** user form will pop up, and the intersection data can be input. For this example, the data for the intersection in Table 4-14 were input into the tool separately. Once the form is filled out, press the **Return to Main** button to go back to the main menu.




**Step 7**: Once all the data entry is completed, press the **Set up Spreadsheet** button. This button will run the entire set-up process for the application of the predictive method.




**Step 8**: Once the process is finished running, a pop-up window will appear, providing users with instructions on the next steps, and where to find results of the analysis. Click **OK** to continue, and close the main menu interface to go to the summary sheet.




Results can be found in Tab **UrbArt_4_Int 1**.

## 4.4.4 Conclusions and Recommendations

The expected crash frequencies for the intersection under different improvement alternatives (including the "no build" plan) in a future year were calculated using the HSM Part C predictive method, as summarized in Table 4-18. A cross-sectional comparison between the "no build" plan and different improvement alternatives indicated that Improvement Alternatives 1, 2, and 3 would decrease the expected crash frequency by 2.141 (18.9 percent), 1.584 (14.0 percent), and 3.377 (29.8 percent), respectively. In other words, compared to the "no build" plan, Improvement Alternative 1 can reduce approximately one crash in every 170 days, and Improvement Alternative 2 can reduce approximately one crash every 230 days. Improvement Alternative 3, however, can reduce approximately one crash in every 108 days. For a design life period of 20 years, Improvement Alternatives 1, 2, and 3 can reduce approximately 43, 32, and 68 crashes, respectively. The crash frequency reduction can be further converted into monetary benefit with the application of appropriate unit crash cost. Further decisions about the treatment to the intersection can be made by IDOT engineers when combining the above calculation results with other factors such as right of way, costs, and environmental assessment.

# Appendix A
# Tables for HSM Part C Illinois Safety Performance Function Calibration Factors

IDOT BSE calibrated the HSM Part C SPFS based on the crash, roadway geometric, and traffic control data from Illinois. The calibration process focused on crash data from 2006 to 2011. The crash reporting threshold increased in 2009 from $500 to $1,500 for property-damage-only (PDO) crashes so calibration factors were developed separately for years 2006 to 2008 and 2009 to 2011. The HSM recommends that for large jurisdictions with a variety of topographical and climate conditions, it may be desirable to develop separate calibration factors for each specific terrain type or geographical region. The crash frequency level and collision pattern for IDOT District 1 (the Chicago metropolitan area) and all other IDOT districts (IDOT District 2 to District 9, which are less urbanized districts) were observed to be significantly different. For accuracy purposes, the Illinois SPF calibration factors were also developed separately for these distinct areas—one set for IDOT District 1 and another set for IDOT District 2 to District 9. Altogether, the Illinois SPF calibration factors were developed for the following four different scenarios and are shown in respective tables in Appendix A of this document:

- IDOT District 1 for Years 2006 to 2008 (Table A-1)
- IDOT District 1 for Years 2009 to 2011 (Table A-2)
- IDOT District 2 to District 9 for Years 2006 to 2008 (Table A-3)
- IDOT District 2 to District 9 for Years 2009 to 2011 (Table A-4)

When selecting the Illinois SPF calibration factor for a roadway site, the reader should select the values from appropriate tables based on the IDOT jurisdiction for the site and the time period analyzed. For example, when calculating the predicted crash frequency in 2006 for a two-lane, two-way roadway segment, if the segment is within IDOT District 1, the Illinois SPF calibration factor for that facility type in Table A-1, 1.72, should be applied; however, if the segment is within IDOT District 5, the Illinois SPF calibration factor for that facility type in Table A-3, 1.78, should be used. The **IDOT HSM Crash Prediction Tool** (Version 3.0) has incorporated the Illinois SPF calibration factors into the crash frequency calculation procedures already.

TABLE A-1:
**HSM Safety Performance Function Illinois Calibration Factors for IDOT District 1 for Years 2006 to 2008**

| Roadway Type (HSM Chapter) | Facility Type | | | Posted Speed (mph) | Local Calibration Factor $C_r$ | $C_r$ Used in Equation (page number) |
|---|---|---|---|---|---|---|
| Rural Two-lane Two-way Road (HSM Chapter 10) | Roadway Segment | Undivided roadway segment | R2_2U | - | **1.72** | Eq. 10-2 (p. 10-3) |
| | Intersection | Three-leg intersection with stop control | R2_3ST | - | **0.35** | Eq. 10-3 (p. 10-4) |
| | | Four-leg intersection with stop control | R2_4ST | - | **0.99** | |
| | | Four-leg signalized intersection | R2_4SG | - | **1.00**[a] | |
| Rural Multilane Highway (HSM Chapter 11) | Roadway Segment | Undivided four-lane roadway segment | R4_4U | - | **1.00**[a] | Eq. 11-2 (p. 11-4) |
| | | Divided four-lane roadway segment | R4_4D | - | **1.00**[a] | Eq. 11-3 (p. 11-4) |
| | Intersection | Three-leg intersection with stop control | R4_3ST | - | **1.00**[a] | Eq. 11-4 (p. 11-4) |
| | | Four-leg intersection with stop control | R4_4ST | - | **1.00**[a] | |
| | | Four-leg signalized intersection | R4_4SG | - | **1.00**[a] | |
| Urban and Suburban Arterial (HSM Chapter 12) | Roadway Segment | Two-lane undivided arterial | USA_2U | ≤30 | **1.94** | Eq. 12-2 (p. 12-4) |
| | | | | >30 | **3.65** | |
| | | Three-lane arterial | USA_3T | ≤30 | **2.13** | |
| | | | | >30 | **1.47** | |
| | | Four-lane undivided arterial | USA_4U | ≤30 | **1.18** | |
| | | | | >30 | **1.30** | |
| | | Four-lane divided arterial | USA_4D | ≤30 | **2.27** | |
| | | | | >30 | **2.63** | |
| | | Five-lane arterial | USA_5T | ≤30 | **1.48** | |
| | | | | >30 | **0.95** | |
| | Intersection | Three-leg intersection with stop control | USA_3ST | - | **0.87** | Eq. 12-5 (p. 12-5) |
| | | Three-leg signalized intersection | USA_3SG | - | **2.01** | |
| | | Four-leg intersection with stop control | USA_4ST | - | **0.99** | |
| | | Four-leg signalized intersection | USA_4SG | - | **3.11** | |

[a] No adequate sites available for the facility type to develop the local calibration factor. Recommend using $C_r$=1.00.

Notes:

>: greater than

≤: less than or equal to

TABLE A-2:

**HSM Safety Performance Function Illinois Calibration Factors for IDOT District 1 for Years 2009 to 2011**

| Roadway Type (HSM Chapter) | Facility Type | | | Posted Speed (mph) | Local Calibration Factor $C_r$ | $C_r$ Used in Equation (page number) |
|---|---|---|---|---|---|---|
| Rural Two-lane Two-way Road (HSM Chapter 10) | Roadway Segment | Undivided roadway segment | R2_2U | - | **1.20** | Eq. 10-2 (p. 10-3) |
| | Intersection | Three-leg intersection with stop control | R2_3ST | - | **0.23** | Eq. 10-3 (p. 10-4) |
| | | Four-leg intersection with stop control | R2_4ST | - | **0.83** | |
| | | Four-leg signalized intersection | R2_4SG | - | **1.00**[a] | |
| Rural Multilane Highway (HSM Chapter 11) | Roadway Segment | Undivided four-lane roadway segment | R4_4U | - | **1.00**[a] | Eq. 11-2 (p. 11-4) |
| | | Divided four-lane roadway segment | R4_4D | - | **1.00**[a] | Eq. 11-3 (p. 11-4) |
| | Intersection | Three-leg intersection with stop control | R4_3ST | - | **1.00**[a] | Eq. 11-4 (p. 11-4) |
| | | Four-leg intersection with stop control | R4_4ST | - | **1.00**[a] | |
| | | Four-leg signalized intersection | R4_4SG | - | **1.00**[a] | |
| Urban and Suburban Arterial (HSM Chapter 12) | Roadway Segment | Two-lane undivided arterial | USA_2U | ≤30 | **1.36** | Eq. 12-2 (p. 12-4) |
| | | | | >30 | **2.89** | |
| | | Three-lane arterial | USA_3T | ≤30 | **1.56** | |
| | | | | >30 | **1.15** | |
| | | Four-lane undivided arterial | USA_4U | ≤30 | **0.91** | |
| | | | | >30 | **0.85** | |
| | | Four-lane divided arterial | USA_4D | ≤30 | **1.76** | |
| | | | | >30 | **1.69** | |
| | | Five-lane arterial | USA_5T | ≤30 | **1.29** | |
| | | | | >30 | **0.75** | |
| | Intersection | Three-leg intersection with stop control | USA_3ST | - | **0.54** | Eq. 12-5 (p. 12-5) |
| | | Three-leg signalized intersection | USA_3SG | - | **1.37** | |
| | | Four-leg intersection with stop control | USA_4ST | - | **0.66** | |
| | | Four-leg signalized intersection | USA_4SG | - | **2.26** | |

[a] No adequate sites available for the facility type to develop the local calibration factor. Recommend using $C_r$=1.00.

Notes:

>: greater than

≤: less than or equal to

TABLE A-3:

**HSM Safety Performance Function Illinois Calibration Factors for IDOT District 2 to District 9 for Years 2006 to 2008**

| Roadway Type (HSM Chapter) | Facility Type | | | Posted Speed (mph) | Local Calibration Factor $C_r$ | $C_r$ Used in Equation (page number) |
|---|---|---|---|---|---|---|
| Rural Two-lane Two-way Road (HSM Chapter 10) | Roadway Segment | Undivided roadway segment | R2_2U | - | **1.78** | Eq. 10-2 (p. 10-3) |
| | Intersection | Three-leg intersection with stop control | R2_3ST | - | **0.24** | Eq. 10-3 (p. 10-4) |
| | | Four-leg intersection with stop control | R2_4ST | - | **0.28** | |
| | | Four-leg signalized intersection | R2_4SG | - | **1.00**[a] | |
| Rural Multilane Highway (HSM Chapter 11) | Roadway Segment | Undivided four-lane roadway segment | R4_4U | - | **1.00**[a] | Eq. 11-2 (p. 11-4) |
| | | Divided four-lane roadway segment | R4_4D | - | **1.72** | Eq. 11-3 (p. 11-4) |
| | Intersection | Three-leg intersection with stop control | R4_3ST | - | **0.55** | Eq. 11-4 (p. 11-4) |
| | | Four-leg intersection with stop control | R4_4ST | - | **0.66** | |
| | | Four-leg signalized intersection | R4_4SG | - | **1.00**[a] | |
| Urban and Suburban Arterial (HSM Chapter 12) | Roadway Segment | Two-lane undivided arterial | USA_2U | ≤30 | **1.22** | Eq. 12-2 (p. 12-4) |
| | | | | >30 | **1.54** | |
| | | Three-lane arterial | USA_3T | ≤30 | **1.62** | |
| | | | | >30 | **1.42** | |
| | | Four-lane undivided arterial | USA_4U | ≤30 | **1.57** | |
| | | | | >30 | **1.33** | |
| | | Four-lane divided arterial | USA_4D | ≤30 | **1.99** | |
| | | | | >30 | **2.55** | |
| | | Five-lane arterial | USA_5T | ≤30 | **1.18** | |
| | | | | >30 | **1.09** | |
| | Intersection | Three-leg intersection with stop control | USA_3ST | - | **0.59** | Eq. 12-5 (p. 12-5) |
| | | Three-leg signalized intersection | USA_3SG | - | **2.21** | |
| | | Four-leg intersection with stop control | USA_4ST | - | **0.68** | |
| | | Four-leg signalized intersection | USA_4SG | - | **3.22** | |

[a] No adequate sites available for the facility type to develop the local calibration factor. Recommend using $C_r$=1.00.

Notes:

>: greater than

≤: less than or equal to

TABLE A-4:
**HSM Safety Performance Function Illinois Calibration Factors for IDOT District 2 to District 9 for Years 2009 to 2011**

| Roadway Type (HSM Chapter) | Facility Type | | | Posted Speed (mph) | Local Calibration Factor $C_r$ | $C_r$ Used in Equation (page number) |
|---|---|---|---|---|---|---|
| Rural Two-lane Two-way Road (HSM Chapter 10) | Roadway Segment | Undivided roadway segment | R2_2U | - | **1.47** | Eq. 10-2 (p. 10-3) |
| | Intersection | Three-leg intersection with stop control | R2_3ST | - | **0.24** | Eq. 10-3 (p. 10-4) |
| | | Four-leg intersection with stop control | R2_4ST | - | **0.31** | |
| | | Four-leg signalized intersection | R2_4SG | - | **1.00**[a] | |
| Rural Multilane Highway (HSM Chapter 11) | Roadway Segment | Undivided four-lane roadway segment | R4_4U | - | **1.00**[a] | Eq. 11-2 (p. 11-4) |
| | | Divided four-lane roadway segment | R4_4D | - | **1.30** | Eq. 11-3 (p. 11-4) |
| | Intersection | Three-leg intersection with stop control | R4_3ST | - | **0.37** | Eq. 11-4 (p. 11-4) |
| | | Four-leg intersection with stop control | R4_4ST | - | **0.60** | |
| | | Four-leg signalized intersection | R4_4SG | - | **1.00**[a] | |
| Urban and Suburban Arterial (HSM Chapter 12) | Roadway Segment | Two-lane undivided arterial | USA_2U | ≤30 | **0.92** | Eq. 12-2 (p. 12-4) |
| | | | | >30 | **1.15** | |
| | | Three-lane arterial | USA_3T | ≤30 | **1.35** | |
| | | | | >30 | **1.22** | |
| | | Four-lane undivided arterial | USA_4U | ≤30 | **1.17** | |
| | | | | >30 | **1.13** | |
| | | Four-lane divided arterial | USA_4D | ≤30 | **1.36** | |
| | | | | >30 | **2.04** | |
| | | Five-lane arterial | USA_5T | ≤30 | **0.97** | |
| | | | | >30 | **0.88** | |
| | Intersection | Three-leg intersection with stop control | USA_3ST | - | **0.32** | Eq. 12-5 (p. 12-5) |
| | | Three-leg signalized intersection | USA_3SG | - | **1.68** | |
| | | Four-leg intersection with stop control | USA_4ST | - | **0.63** | |
| | | Four-leg signalized intersection | USA_4SG | - | **2.32** | |

[a] No adequate sites available for the facility type to develop the local calibration factor. Recommend using $C_r$=1.00.

Notes:

>: greater than

≤: less than or equal to

# Appendix B: Tables for HSM Part C Default Values Replaced by Illinois Data

The Illinois Department of Transportation (IDOT) Bureau of Safety Engineering (BSE) replaced the HSM Part C default values based on the crash, roadway geometric, and traffic control data from Illinois. The default value replacement process focused on crash data from 2006 to 2011. The crash reporting threshold increased in 2009 from $500 to $1,500 for property-damage-only (PDO) crashes so default values were replaced separately for years 2006 to 2008 and 2009 to 2011. The HSM recommends that for large jurisdictions with a variety of topographical and climate conditions, it may be desirable to develop separate default values for each specific terrain type or geographical region. The crash frequency level and collision pattern for IDOT District 1 (the Chicago metropolitan area) and all other IDOT districts (IDOT Districts 2 to 9, which are less urbanized districts) were observed to be significantly different. For accuracy purposes, default values were also developed separately for these distinct areas—one set for IDOT District 1 and another set for IDOT Districts 2 to 9. Altogether, default values were developed for the following four different scenarios:

- IDOT District 1 for Years 2006 to 2008
- IDOT District 1 for Years 2009 to 2011
- IDOT District 2 to District 9 for Years 2006 to 2008
- IDOT District 2 to District 9 for Years 2009 to 2011

Altogether the default values were replaced for three roadway types; that is, rural two-lane, two-way roads, rural multilane highways, and urban and suburban arterials. For each of the three roadway types, the default values were replaced for the four different scenarios. For convenience, the replaced default values for different time periods were put together, while values for different roadway types and jurisdictions were prepared separately. The final replaced default values were organized into different chapters, as described below:

- Appendix B.1: Rural Two-lane, Two-way Roads for IDOT District 1
- Appendix B.2: Rural Multilane Highways for IDOT District 1
- Appendix B.3: Urban and Suburban Arterials for IDOT District 1
- Appendix B.4: Rural Two-lane, Two-way Roads for IDOT District 2 to District 9
- Appendix B.5: Rural Multilane Highways for IDOT District 2 to District 9
- Appendix B.6: Urban and Suburban Arterials for IDOT District 2 to District 9

When selecting the default values for a roadway site, the reader should select the values from appropriate tables based on the IDOT jurisdiction for the site and the time period analyzed. For example, when calculating the predicted vehicle-pedestrian crash frequency in 2006 for a four-leg stop-controlled intersection on urban and suburban arterial, if it is within IDOT District 1, the pedestrian crash adjustment factor for that facility type in Table 3-15 in Appendix B.3 of this document, 0.033, should be applied; however, if it is within IDOT District 5, the pedestrian crash adjustment factor for that facility type in Table 6-15 of this document, 0.009, should be used. The **IDOT HSM Crash Prediction Tool** (Version 3.0) has incorporated the replaced default values into the crash frequency calculation procedures already.

# Appendix B-1:
# HSM Part C for Rural Two-Lane, Two-Way Roads (HSM Chapter 10) Default Tables for IDOT District 1

**Table B-1-1: Illinois District 1 for years 2006 to 2008 for HSM Table 10-3**

**HSM Table 10-3.** Default Distribution for Crash Severity Level on Rural Two-Lane, Two-Way Roadway Segments

| Crash Severity Level | Percentage of Total Roadway Segment Crashes* |
|---|---|
| Fatal | 1.3 |
| Incapacitating Injury | 6.8 |
| Nonincapacitating injury | 14.4 |
| Possible Injury | 5.1 |
| Total fatal plus injury | 27.6 |
| Property damage only | 72.4 |
| **Total** | **100.0** |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-17**

**Table B-1-2: Illinois District 1 for years 2009 to 2011 for HSM Table 10-3**

**HSM Table 10-3.** Default Distribution for Crash Severity Level on Rural Two-Lane, Two-Way Roadway Segments

| Crash Severity Level | Percentage of Total Roadway Segment Crashes* |
|---|---|
| Fatal | 1.0 |
| Incapacitating Injury | 8.4 |
| Nonincapacitating injury | 18.4 |
| Possible Injury | 3.8 |
| Total fatal plus injury | 31.6 |
| Property damage only | 68.4 |
| **Total** | **100.0** |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-17**

**Table B-1-3: Illinois District 1 for years 2006 to 2008 for HSM Table 10-4**

**HSM Table 10-4.** Default Distribution by Collision Type for Specific Crash Severity Levels on Rural Two-Lane, Two-Way Roadway Segments

| Collision Type | Percentage of Total Roadway Segment Crashes by Crash Severity Level | | |
|---|---|---|---|
| | Total Fatal and Injury | Property Damage Only | Total |
| **SINGLE-VEHICLE CRASHES** | | | |
| Collision with animal | 1.9 | 30.4 | 22.5 |
| Collision with bicycle | 0.7 | 0.0 | 0.2 |
| Collision with pedestrian | 0.0 | 0.0 | 0.0 |
| Overturned | 24.3 | 8.8 | 13.1 |
| Ran off road | 42.7 | 34.7 | 36.9 |
| Other single-vehicle crashes | 1.3 | 6.2 | 4.8 |
| Total single-vehicle crashes | 70.9 | 80.1 | 77.5 |
| **MULTIPLE-VEHICLE CRASHES** | | | |
| Angle collision | 2.9 | 1.3 | 1.8 |
| Head-on collision | 8.1 | 0.1 | 2.3 |
| Rear-end collision | 7.1 | 7.2 | 7.2 |
| Sideswipe collision | 6.8 | 4.6 | 5.2 |
| Other multiple-vehicle collision | 4.2 | 6.7 | 6 |
| Total multiple-vehicle crashes | 29.1 | 19.9 | 22.5 |
| **Total Crashes** | **100.0** | **100.0** | **100.0** |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-17**

**Table B-1-4: Illinois District 1 for years 2009 to 2011 for HSM Table 10-4**

**HSM Table 10-4.** Default Distribution by Collision Type for Specific Crash Severity Levels on Rural Two-Lane, Two-Way Roadway Segments

| Collision Type | Percentage of Total Roadway Segment Crashes by Crash Severity Level | | |
|---|---|---|---|
| | Total Fatal and Injury | Property Damage Only | Total |
| **SINGLE-VEHICLE CRASHES** | | | |
| Collision with animal | 1.9 | 30.7 | 21.6 |
| Collision with bicycle | 1.9 | 0.0 | 0.6 |
| Collision with pedestrian | 1.3 | 0.0 | 0.4 |
| Overturned | 20.9 | 7.9 | 12 |
| Ran off road | 45.6 | 33.9 | 37.6 |
| Other single-vehicle crashes | 3.8 | 5.8 | 5.2 |
| Total single-vehicle crashes | 75.3 | 78.4 | 77.4 |
| **MULTIPLE-VEHICLE CRASHES** | | | |
| Angle collision | 2.5 | 0.6 | 1.2 |
| Head-on collision | 3.2 | 0.9 | 1.6 |
| Rear-end collision | 8.9 | 8.5 | 8.6 |
| Sideswipe collision | 5.7 | 5.2 | 5.4 |
| Other multiple-vehicle collision | 4.4 | 6.4 | 5.8 |
| Total multiple-vehicle crashes | 24.7 | 21.6 | 22.6 |
| **Total Crashes** | **100.0** | **100.0** | **100.0** |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-17**

**Table B-1-5: Illinois District 1 for years 2006 to 2008 for HSM Table 10-5**

**HSM Table 10-5.** Default Distribution for Crash Severity Level at Rural Two-Lane, Two-Way Intersections

| | Percentage of Total Crashes | | |
|---|---|---|---|
| **Crash Severity Level** | **Three-Leg Stop-Controlled Intersections** | **Four-Leg Stop-Controlled Intersections** | **Four-Leg Signalized Intersections*** |
| Fatal | 0.0 | 1.4 | 0.9 |
| Incapacitating injury | 6.4 | 8.4 | 2.1 |
| Nonincapacitating injury | 17.2 | 25.7 | 10.5 |
| Possible injury | 8.2 | 6.4 | 20.5 |
| Total fatal plus injury | 31.8 | 41.9 | 34.0 |
| Property damage only | 68.2 | 58.1 | 66.0 |
| **Total** | **100.0** | **100.0** | **100.0** |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-21**

**Table B-1-6: Illinois District 1 for years 2009 to 2011 for HSM Table 10-5**

**HSM Table 10-5.** Default Distribution for Crash Severity Level at Rural Two-Lane, Two-Way Intersections

| | Percentage of Total Crashes | | |
|---|---|---|---|
| **Crash Severity Level** | **Three-Leg Stop-Controlled Intersections** | **Four Leg Stop-Controlled Intersections** | **Four-Leg Signalized Intersections*** |
| Fatal | 0.0 | 0.8 | 0.9 |
| Incapacitating injury | 4.5 | 10.9 | 2.1 |
| Nonincapacitating injury | 18.8 | 23.5 | 10.5 |
| Possible injury | 9.0 | 11.3 | 20.5 |
| Total fatal plus injury | 32.3 | 46.5 | 34.0 |
| Property damage only | 67.7 | 53.5 | 66.0 |
| **Total** | **100.0** | **100.0** | **100.0** |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-21**

**Table B-1-7: Illinois District 1 for years 2006 to 2008 for HSM Table 10-6**

**Table 10-6.** Default Distribution for Collision Type and Manner of Collision at Rural Two-Lane, Two-Way Intersections

| | Percentage of Total Crashes by Collision Type | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Three-Leg Stop-Controlled Intersections | | | Four-Leg Stop Controlled Intersections | | | Four-Leg Signalized Intersections* | | |
| **Collision Type** | **Fatal and Injury** | **Property Damage Only** | **Total** | **Fatal and Injury** | **Property Damage Only** | **Total** | **Fatal and Injury** | **Property Damage Only** | **Total** |
| **SINGLE-VEHICLE CRASHES** | | | | | | | | | |
| Collision with animal | 0.0 | 2.2 | 1.5 | 0.0 | 2.3 | 1.3 | 0.0 | 0.3 | 0.2 |
| Collision with bicycle | 0.0 | 0.0 | 0.0 | 1.6 | 0.0 | 0.7 | 0.1 | 0.1 | 0.1 |
| Collision with pedestrian | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 |
| Overturned | 9.7 | 2.2 | 4.5 | 0.8 | 0.6 | 0.7 | 0.3 | 0.3 | 0.3 |
| Ran off road | 17.7 | 30.7 | 26.7 | 4.9 | 13.4 | 9.8 | 3.2 | 8.1 | 6.4 |
| Other single-vehicle crash | 0.0 | 0.7 | 0.5 | 0.8 | 1.7 | 1.4 | 0.3 | 1.8 | 0.5 |
| Total single-vehicle crashes | 27.4 | 35.8 | 33.2 | 8.1 | 18.0 | 13.9 | 4.0 | 10.7 | 7.6 |
| **MULTIPLE-VEHICLE CRASHES** | | | | | | | | | |
| Angle collision | 6.5 | 2.9 | 4.0 | 55.6 | 34.9 | 43.6 | 33.6 | 24.2 | 27.4 |
| Head-on collision | 0.0 | 0.7 | 0.5 | 0.8 | 0.0 | 0.3 | 8.0 | 4.0 | 5.4 |
| Rear-end collision | 30.6 | 20.5 | 23.6 | 13.7 | 19.8 | 17.2 | 40.3 | 43.8 | 42.6 |
| Sideswipe collision | 3.2 | 8.0 | 6.5 | 4.0 | 2.9 | 3.4 | 5.1 | 15.3 | 11.8 |
| Other multiple-vehicle collision | 32.3 | 32.1 | 32.2 | 17.7 | 24.4 | 21.6 | 9.0 | 2.0 | 5.2 |
| Total multiple-vehicle collision | 72.6 | 64.2 | 66.8 | 91.9 | 82.0 | 86.1 | 96.0 | 89.3 | 92.4 |
| **Total Crashes** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-22**

**Table B-1-8: Illinois District 1 for years 2009 to 2011 for HSM Table 10-6**

**Table 10-6.** Default Distribution for Collision Type and Manner of Collision at Rural Two-Lane, Two-Way Intersections

| | Percentage of Total Crashes by Collision Type | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Three-Leg Stop-Controlled Intersections | | | Four-Leg Stop Controlled Intersections | | | Four-Leg Signalized Intersections* | | |
| **Collision Type** | **Fatal and Injury** | **Property Damage Only** | **Total** | **Fatal and Injury** | **Property Damage Only** | **Total** | **Fatal and Injury** | **Property Damage Only** | **Total** |
| **SINGLE-VEHICLE CRASHES** | | | | | | | | | |
| Collision with animal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.2 |
| Collision with bicycle | 2.3 | 0.0 | 0.7 | 1.9 | 0.0 | 0.9 | 0.1 | 0.1 | 0.1 |
| Collision with pedestrian | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 |
| Overturned | 4.7 | 1.1 | 2.3 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.3 |
| Ran off road | 18.6 | 28.9 | 25.6 | 3.7 | 6.5 | 5.2 | 3.2 | 8.1 | 6.4 |
| Other single-vehicle crash | 0.0 | 1.1 | 0.7 | 0.9 | 0.0 | 0.4 | 0.3 | 1.8 | 0.5 |
| Total single-vehicle crashes | 25.6 | 31.1 | 29.3 | 6.5 | 6.5 | 6.5 | 4.0 | 10.7 | 7.6 |
| **MULTIPLE-VEHICLE CRASHES** | | | | | | | | | |
| Angle collision | 11.6 | 11.1 | 11.3 | 56.1 | 41.5 | 48.3 | 33.6 | 24.2 | 27.4 |
| Head-on collision | 7.0 | 0.0 | 2.2 | 1.9 | 0.0 | 0.9 | 8.0 | 4.0 | 5.4 |
| Rear-end collision | 23.3 | 24.5 | 24.1 | 14.0 | 23.6 | 19.1 | 40.3 | 43.8 | 42.6 |
| Sideswipe collision | 2.3 | 3.3 | 3 | 0.9 | 3.2 | 2.2 | 5.1 | 15.3 | 11.8 |
| Other multiple-vehicle collision | 30.2 | 30.0 | 30.1 | 20.6 | 25.2 | 23.0 | 9.0 | 2.0 | 5.2 |
| Total multiple-vehicle collision | 74.4 | 68.9 | 70.7 | 93.5 | 93.5 | 93.5 | 96 | 89.3 | 92.4 |
| **Total Crashes** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-22**

**Table B-1-9: Illinois District 1 for years 2006 to 2008 for HSM Table 10-12**

**Table 10-12.** Nighttime Crash Proportions for Unlighted Roadway Segments

| | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| **Roadway Type** | **Fatal and Injury $p_{nr}$** | **PDO $p_{pnr}$** | **$p_{nr}$** |
| 2U | 0.228 | 0.772 | 0.679 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-31**

**Table B-1-10: Illinois District 1 for years 2009 to 2011 for HSM Table 10-12**

**Table 10-12.** Nighttime Crash Proportions for Unlighted Roadway Segments

| | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| **Roadway Type** | **Fatal and Injury $p_{nr}$** | **PDO $p_{pnr}$** | **$p_{nr}$** |
| 2U | 0.272 | 0.728 | 0.625 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-31**

**Table B-1-11: Illinois District 1 for years 2006 to 2008 for HSM Table 10-15**

**Table 10-15.** Nighttime Crash Proportions for Unlighted Intersections*

| | Proportion of Crashes that Occur at Night |
|---|---|
| **Intersection Type** | **$p_{ni}$** |
| 3ST | 0.260 |
| 4ST | 0.244 |
| 4SG | 0.286 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-33**

**Table B-1-12: Illinois District 1 for years 2009 to 2011 for HSM Table 10-15**

**Table 10-15.** Nighttime Crash Proportions for Unlighted Intersections*

| | Proportion of Crashes that Occur at Night |
|---|---|
| **Intersection Type** | **$p_{ni}$** |
| 3ST | 0.260 |
| 4ST | 0.244 |
| 4SG | 0.286 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-33**

# Appendix B-2:
# HSM Part C for Rural Multilane Highways
# (HSM Chapter 11) Default Tables for IDOT District 1

**Table B-2-1: Illinois District 1 for years 2006 to 2008 for HSM Table 11-4**

**HSM Table 11-4.** Default Distribution of Crashes by Collision Type and Crash Severity Level for Undivided Roadway Segments*

| | Proportion of Crashes by Collision Type and Crash Severity Level | | | |
|---|---|---|---|---|
| | Severity Level | | | |
| **Collision Type** | **Total** | **Fatal and Injury** | **Fatal and Injury[a]** | **PDO** |
| Head-on | 0.009 | 0.029 | 0.043 | 0.001 |
| Sideswipe | 0.098 | 0.048 | 0.044 | 0.120 |
| Rear-end | 0.246 | 0.305 | 0.217 | 0.220 |
| Angle | 0.356 | 0.352 | 0.348 | 0.358 |
| Single | 0.238 | 0.238 | 0.304 | 0.237 |
| Other | 0.053 | 0.028 | 0.044 | 0.064 |

**[a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.**

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-17**

**Table B-2-2: Illinois District 1 for years 2009 to 2011 for HSM Table 11-4**

**HSM Table 11-4.** Default Distribution of Crashes by Collision Type and Crash Severity Level for Undivided Roadway Segments*

| | Proportion of Crashes by Collision Type and Crash Severity Level | | | |
|---|---|---|---|---|
| | Severity Level | | | |
| **Collision Type** | **Total** | **Fatal and Injury** | **Fatal and Injury[a]** | **PDO** |
| Head-on | 0.009 | 0.029 | 0.043 | 0.001 |
| Sideswipe | 0.098 | 0.048 | 0.048 | 0.120 |
| Rear-end | 0.246 | 0.305 | 0.217 | 0.220 |
| Angle | 0.356 | 0.352 | 0.348 | 0.358 |
| Single | 0.238 | 0.238 | 0.304 | 0.237 |
| Other | 0.053 | 0.028 | 0.044 | 0.064 |

**[a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.**

***Data take from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-17**

**Table B-2-3: Illinois District 1 for years 2006 to 2008 for HSM Table 11-6**

**HSM Table 11-6.** Default Distribution of Crashes by Collision Type and Crash Severity Level for Divided Roadway Segments*

| | Proportion of Crashes by Collision Type and Crash Severity Level | | | |
|---|---|---|---|---|
| | Severity Level | | | |
| Collision Type | Total | Fatal and Injury | Fatal and Injury [a] | PDO |
| Head-on | 0.006 | 0.013 | 0.018 | 0.002 |
| Sideswipe | 0.043 | 0.027 | 0.022 | 0.053 |
| Rear-end | 0.116 | 0.163 | 0.114 | 0.088 |
| Angle | 0.043 | 0.048 | 0.045 | 0.041 |
| Single | 0.768 | 0.727 | 0.778 | 0.792 |
| Other | 0.024 | 0.022 | 0.023 | 0.024 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-20**

**Table B-2-4: Illinois District 1 for years 2009 to 2011 for HSM Table 11-6**

**HSM Table 11-6.** Default Distribution of Crashes by Collision Type and Crash Severity Level Divided Roadway Segments*

| | Proportion of Crashes by Collision Type and Crash Severity Level | | | |
|---|---|---|---|---|
| | Severity Level | | | |
| Collision Type | Total | Fatal and Injury | Fatal and Injury [a] | PDO |
| Head-on | 0.006 | 0.013 | 0.018 | 0.002 |
| Sideswipe | 0.043 | 0.027 | 0.022 | 0.053 |
| Rear-end | 0.116 | 0.163 | 0.114 | 0.088 |
| Angle | 0.043 | 0.048 | 0.045 | 0.041 |
| Single | 0.768 | 0.727 | 0.778 | 0.792 |
| Other | 0.024 | 0.022 | 0.023 | 0.024 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010 Page 11-20**

**Table B-2-5: Illinois District 1 for years 2006 to 2008 for HSM Table 11-9.**

**HSM Table 11-9.** Default Distribution of Intersection Crashes by Collision Type and Crash Severity*

| | Proportion of Crashes by Severity Level | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Three-Leg Intersection with Minor-Road Stop Control | | | | Four-Leg Intersection with Minor-Road Stop Control | | | |
| **Collision Type** | **Total** | **Fatal and Injury** | **Fatal and AB-Injury** | **PDO** | **Total** | **Fatal and Injury** | **Fatal and AB-Injury** | **PDO** |
| Head-on | 0.029 | 0.043 | 0.052 | 0.020 | 0.016 | 0.018 | 0.023 | 0.015 |
| Sideswipe | 0.133 | 0.058 | 0.057 | 0.179 | 0.107 | 0.042 | 0.040 | 0.156 |
| Rear-end | 0.289 | 0.247 | 0.142 | 0.315 | 0.228 | 0.213 | 0.108 | 0.240 |
| Angle | 0.263 | 0.369 | 0.381 | 0.198 | 0.395 | 0.534 | 0.571 | 0.292 |
| Single | 0.234 | 0.219 | 0.284 | 0.244 | 0.202 | 0.148 | 0.199 | 0.243 |
| Other | 0.052 | 0.064 | 0.084 | 0.044 | 0.051 | 0.046 | 0.059 | 0.055 |
| | **Three-Leg Signalized Intersection** | | | | **Four-Leg Signalized Intersection*** | | | |
| **Collision Type** | **Total** | **Fatal and Injury** | **Fatal and AB-Injury** | **PDO** | **Total** | **Fatal and Injury** | **Fatal and AB-Injury** | **PDO** |
| Head-on | -- | -- | -- | -- | 0.054 | 0.083 | 0.093 | 0.034 |
| Sideswipe | -- | -- | -- | -- | 0.106 | 0.047 | 0.039 | 0.147 |
| Rear-end | -- | -- | -- | -- | 0.492 | 0.472 | 0.314 | 0.505 |
| Angle | -- | -- | -- | -- | 0.256 | 0.315 | 0.407 | 0.215 |
| Single | -- | -- | -- | -- | 0.062 | 0.041 | 0.078 | 0.077 |
| Other | -- | -- | -- | -- | 0.030 | 0.041 | 0.069 | 0.023 |

**Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.**

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-24.**

**Table B-2-6: Illinois District 1 for years 2009 to 2011 for HSM Table 11-9**

**HSM Table 11-9.** Default Distribution of Intersection Crashes by Collision Type and Crash Severity*

| Collision Type | Proportion of Crashes by Severity Level | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Three-Leg Intersection with Minor-Road Stop Control | | | | Four-Leg Intersection with Minor-Road Stop Control | | | |
| | Total | Fatal and Injury | Fatal and AB-Injury | PDO | Total | Fatal and Injury | Fatal and AB-Injury | PDO |
| Head-on | 0.029 | 0.043 | 0.052 | 0.020 | 0.016 | 0.018 | 0.023 | 0.015 |
| Sideswipe | 0.133 | 0.058 | 0.057 | 0.179 | 0.107 | 0.042 | 0.04 | 0.156 |
| Rear-end | 0.289 | 0.247 | 0.142 | 0.315 | 0.228 | 0.213 | 0.108 | 0.240 |
| Angle | 0.263 | 0.369 | 0.381 | 0.198 | 0.395 | 0.534 | 0.571 | 0.292 |
| Single | 0.234 | 0.219 | 0.284 | 0.244 | 0.202 | 0.148 | 0.199 | 0.243 |
| Other | 0.052 | 0.064 | 0.084 | 0.044 | 0.051 | 0.046 | 0.059 | 0.055 |
| | Three-Leg Signalized Intersection | | | | Four-Leg Signalized Intersection | | | |
| Collision Type | Total | Fatal and Injury | Fatal and AB-Injury | PDO | Total | Fatal and Injury | Fatal and AB-Injury | PDO |
| Head-on | -- | -- | -- | -- | 0.054 | 0.083 | 0.093 | 0.034 |
| Sideswipe | -- | -- | -- | -- | 0.106 | 0.047 | 0.039 | 0.147 |
| Rear-end | -- | -- | -- | -- | 0.492 | 0.472 | 0.314 | 0.505 |
| Angle | -- | -- | -- | -- | 0.256 | 0.315 | 0.407 | 0.215 |
| Single | -- | -- | -- | -- | 0.062 | 0.041 | 0.078 | 0.077 |
| Other | -- | -- | -- | -- | 0.030 | 0.041 | 0.069 | 0.023 |

**Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.**

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-24**

**Table B-2-7: Illinois District 1 for years 2006 to 2008 for HSM Table 11-15**

**HSM Table 11-15.** Nighttime Crash Proportions for Unlighted Roadway Segments*

| | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| **Roadway Type** | **Fatal and Injury $p_{nr}$** | **PDO $p_{pnr}$** | **$p_{nr}$** |
| 4U | 0.361 | 0.639 | 0.255 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-29**

**Table B-2-8: Illinois District 1 for years 2009 to 2011 for HSM Table 11-15**

**HSM Table 11-15.** Nighttime Crash Proportions for Unlighted Roadway Segments*

| | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| **Roadway Type** | **Fatal and Injury $p_{nr}$** | **PDO $p_{pnr}$** | **$p_{nr}$** |
| 4U | 0.361 | 0.639 | 0.255 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-29**

**Table B-2-9: Illinois District 1 for years 2006 to 2008 for HSM Table 11-19**

**HSM Table 11-19.** Nighttime Crash Proportions for Unlighted Roadway Segments*

| | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| **Roadway Type** | **Fatal and Injury $p_{nr}$** | **PDO $p_{nr}$** | **$p_{nr}$** |
| 4D | 0.323 | 0.677 | 0.426 |

**This group has three crashes in total.**

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-32**

**Table B-2-10: Illinois District 1 for years 2009 to 2011 for HSM Table 11-19**

**HSM Table 11-19.** Nighttime Crash Proportions for Unlighted Roadway Segments*

| | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| **Roadway Type** | **Fatal and Injury $p_{nr}$** | **PDO $p_{nr}$** | **$p_{nr}$** |
| 4D | 0.323 | 0.677 | 0.426 |

**This group has three crashes in total.**

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-32**

**Table B-2-11: Illinois District 1 for years 2006 to 2008 for HSM Table 11-24**

**HSM Table 11-24.** Default Nighttime Crash Proportions for Unlighted Intersections*

| Intersection Type | Proportion of Crashes that Occur at Night, $p_{ni}$ |
|---|---|
| 3ST | 0.276 |
| 4ST | 0.273 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-35**

**Table B-2-12: Illinois District 1 for years 2009 to 2011 for HSM Table 11-24**

**HSM Table 11-24.** Default Nighttime Crash Proportions for Unlighted Intersections*

| Intersection Type | Proportion of Crashes that Occur at Night, $p_{ni}$ |
|---|---|
| 3ST | 0.276 |
| 4ST | 0.273 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-35**

# Appendix B-3:
# HSM Part C for Urban and Suburban Arterials
# (HSM Chapter 12) Default Tables for IDOT District 1

**Table B-3-1: Illinois District 1 for years 2006 to 2008 for HSM Table 12-4**

**HSM Table 12-4.** Distribution of Multiple-Vehicle Nondriveway Collisions for Roadway Segments by Manner of Collision Type

| Collision Type | Proportion of Crashes by Severity Level for Specific Road Types | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2U | | 3T | | 4U | | 4D | | 5T | |
| | FI | PDO | FI | PDO | FI | PDO | FI | PDO | FI | PDO |
| Rear-end collision | 0.527 | 0.512 | 0.714 | 0.621 | 0.536 | 0.437 | 0.558 | 0.487 | 0.459 | 0.455 |
| Head-on collision | 0.092 | 0.017 | 0.012 | 0.004 | 0.044 | 0.010 | 0.036 | 0.007 | 0.039 | 0.005 |
| Angle collision | 0.083 | 0.068 | 0.095 | 0.089 | 0.082 | 0.091 | 0.088 | 0.070 | 0.121 | 0.100 |
| Sideswipe, same direction | 0.058 | 0.161 | 0.048 | 0.102 | 0.088 | 0.230 | 0.082 | 0.220 | 0.058 | 0.169 |
| Sideswipe, opposite direction | 0.073 | 0.048 | 0.036 | 0.004 | 0.026 | 0.023 | 0.026 | 0.018 | 0.031 | 0.015 |
| Other multiple-vehicle collisions | 0.166 | 0.193 | 0.095 | 0.179 | 0.223 | 0.208 | 0.211 | 0.198 | 0.293 | 0.256 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-20**

**Table B-3-2: Illinois District 1 for years 2009 to 2011 for HSM Table 12-4**

**HSM Table 12-4.** Distribution of Multiple-Vehicle Nondriveway Collisions for Roadway Segments by Manner of Collision Type

| Collision Type | Proportion of Crashes by Severity Level for Specific Road Types | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2U | | 3T | | 4U | | 4D* | | 5T | |
| | FI | PDO | FI | PDO | FI | PDO | FI | PDO | FI | PDO |
| Rear-end collision | 0.557 | 0.498 | 0.600 | 0.643 | 0.551 | 0.450 | 0.832 | 0.662 | 0.493 | 0.452 |
| Head-on collision | 0.081 | 0.016 | 0.033 | 0.006 | 0.048 | 0.010 | 0.020 | 0.007 | 0.034 | 0.006 |
| Angle collision | 0.064 | 0.080 | 0.117 | 0.076 | 0.087 | 0.090 | 0.040 | 0.036 | 0.116 | 0.095 |
| Sideswipe, same direction | 0.050 | 0.186 | 0.017 | 0.070 | 0.091 | 0.236 | 0.050 | 0.223 | 0.061 | 0.154 |
| Sideswipe, opposite direction | 0.052 | 0.035 | 0.033 | 0.012 | 0.031 | 0.017 | 0.010 | 0.001 | 0.015 | 0.010 |
| Other multiple-vehicle collisions | 0.176 | 0.185 | 0.200 | 0.193 | 0.192 | 0.198 | 0.048 | 0.071 | 0.282 | 0.282 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-20**

**Table B-3-3: Illinois District 1 for years 2006 to 2008 for HSM Table 12-6**

**HSM Table 12-6.** Distribution of Single-Vehicle Crashes for Roadway Segments by Collision Type

| | Proportion of Crashes by Severity Level for Specific Road Types | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2U | | 3T | | 4U | | 4D | | 5T | |
| **Collision Type** | **FI** | **PDO** | **FI** | **PDO** | **FI** | **PDO** | **FI** | **PDO** | **FI** | **PDO** |
| Collision with animal | 0.046 | 0.266 | 0.050 | 0.078 | 0.035 | 0.169 | 0.046 | 0.167 | 0.018 | 0.120 |
| Collision with fixed object | 0.613 | 0.332 | 0.800 | 0.400 | 0.655 | 0.400 | 0.706 | 0.484 | 0.782 | 0.517 |
| Collision with other object | 0.029 | 0.032 | 0.050 | 0.056 | 0.029 | 0.045 | 0.031 | 0.054 | 0.018 | 0.086 |
| Other single-vehicle collision | 0.311 | 0.410 | 0.100 | 0.467 | 0.281 | 0.386 | 0.217 | 0.295 | 0.182 | 0.277 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-22**

**Table B-3-4: Illinois District 1 for years 2009 to 2011 for HSM Table 12-6**

**HSM Table 12-6.** Distribution of Single-Vehicle Crashes for Roadway Segments by Collision Type

| | Proportion of Crashes by Severity Level for Specific Road Types | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2U | | 3T | | 4U | | 4D* | | 5T | |
| **Collision Type** | **FI** | **PDO** | **FI** | **PDO** | **FI** | **PDO** | **FI** | **PDO** | **FI** | **PDO** |
| Collision with animal | 0.044 | 0.200 | 0.000 | 0.217 | 0.032 | 0.171 | 0.001 | 0.063 | 0.017 | 0.122 |
| Collision with fixed object | 0.631 | 0.303 | 0.300 | 0.696 | 0.639 | 0.348 | 0.500 | 0.813 | 0.793 | 0.590 |
| Collision with other object | 0.031 | 0.026 | 0.000 | 0.043 | 0.027 | 0.041 | 0.028 | 0.016 | 0.069 | 0.053 |
| Other single-vehicle collision | 0.295 | 0.472 | 0.700 | 0.043 | 0.302 | 0.440 | 0.471 | 0.108 | 0.121 | 0.234 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-22**

**Table B-3-5: Illinois District 1 for years 2006 to 2008 for HSM Table 12-7**

**HSM Table 12-7.** SPF Coefficients for Multiple-Vehicle Driveway Related Collisions

| | Coefficients for Specific Road Types | | | | |
|---|---|---|---|---|---|
| **Driveway Type (j)** | **2U** | **3T** | **4U** | **4D** | **5T** |
| **Proportion of Fatal-and-Injury Crashes** | | | | | |
| All driveways | 0.174 | 0.111 | 0.248 | 0.251 | 0.204 |
| **Proportion of Property-Damage-Only Crashes** | | | | | |
| All driveways | 0.826 | 0.889 | 0.752 | 0.749 | 0.796 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-24**

**Table B-3-6: Illinois District 1 for years 2009 to 2011 for HSM Table 12-7**

**HSM Table 12-7.** SPF Coefficients for Multiple-Vehicle Driveway Related Collisions

| | Coefficients for Specific Road Types | | | | |
|---|---|---|---|---|---|
| **Driveway Type (j)** | **2U*** | **3T** | **4U** | **4D*** | **5T** |
| **Proportion of Fatal-and-Injury Crashes** | | | | | |
| All driveways | 0.323 | 0.226 | 0.236 | 0.284 | 0.228 |
| **Proportion of Property-Damage-Only Crashes** | | | | | |
| All driveways | 0.677 | 0.774 | 0.764 | 0.716 | 0.772 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-24**

**Table B-3-7: Illinois District 1 for years 2006 to 2008 for HSM Table 12-8**

**HSM Table 12-8.** Pedestrian Crash Adjustment Factor for Roadway Segments

| Road Type | Pedestrian Crash Adjustment Factor | |
|---|---|---|
| | Posted Speed 30 mph or Less | Posted Speed Greater than 30 mph |
| 2U | 0.014 | 0.003 |
| 3T* | 0.041 | 0.013 |
| 4U | 0.019 | 0.006 |
| 4D | 0.010 | 0.007 |
| 5T | 0.004 | 0.013 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-27**

**Table B-3-8: Illinois District 1 for years 2009 to 2011 for HSM Table 12-8**

**HSM Table 12-8.** Pedestrian Crash Adjustment Factor for Roadway Segments

| Road Type | Pedestrian Crash Adjustment Factor | |
|---|---|---|
| | Posted Speed 30 mph or Less | Posted Speed Greater than 30 mph |
| 2U | 0.018 | 0.004 |
| 3T* | 0.041 | 0.013 |
| 4U | 0.017 | 0.006 |
| 4D* | 0.067 | 0.019 |
| 5T | 0.006 | 0.015 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-27**

**Table B-3-9: Illinois District 1 for years 2006 to 2008 for HSM Table 12-9**

**HSM Table 12-9.** Bicycle Crash Adjustment Factor for Roadway Segments

| Road Type | Bicycle Crash Adjustment Factor ($f_{biker}$) | |
|---|---|---|
| | Posted Speed 30 mph or Less | Posted Speed Greater than 30 mph |
| 2U | 0.006 | 0.002 |
| 3T* | 0.027 | 0.007 |
| 4U | 0.007 | 0.003 |
| 4D | 0.003 | 0.004 |
| 5T | 0.003 | 0.006 |

*** Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-28**

**Table B-3-10: Illinois District 1 for years 2009 to 2011 for HSM Table 12-9**

**HSM Table 12-9.** Bicycle Crash Adjustment Factor for Roadway Segments

| Road Type | Bicycle Crash Adjustment Factor ($f_{biker}$) | |
|---|---|---|
| | Posted Speed 30 mph or Less | Posted Speed Greater than 30 mph |
| 2U | 0.008 | 0.003 |
| 3T* | 0.027 | 0.007 |
| 4U | 0.005 | 0.005 |
| 4D* | 0.013 | 0.005 |
| 5T | 0.004 | 0.009 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-28**

**TABLE B-3-11: ILLINOIS DISTRICT 1 FOR YEARS 2006 TO 2008 FOR HSM TABLE 12-11**

**HSM Table 12-11**. Distribution of Multiple-Vehicle Collision for Intersections by Collision Type

| Manner of Collision | Proportion of Crashes by Severity Level for Specific Intersection Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3ST | | 3SG | | 4ST | | 4SG | |
| | FI | PDO | FI | PDO | FI | PDO | FI | PDO |
| Rear-end Collision | 0.380 | 0.411 | 0.487 | 0.542 | 0.273 | 0.338 | 0.392 | 0.475 |
| Head-on Collision | 0.014 | 0.004 | 0.008 | 0.004 | 0.010 | 0.004 | 0.009 | 0.004 |
| Angle Collision | 0.119 | 0.095 | 0.090 | 0.062 | 0.367 | 0.263 | 0.212 | 0.117 |
| Sideswipe | 0.029 | 0.073 | 0.021 | 0.072 | 0.019 | 0.071 | 0.023 | 0.090 |
| Other multiple-vehicle collisions | 0.458 | 0.417 | 0.393 | 0.32 | 0.331 | 0.323 | 0.364 | 0.314 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-32**

**TABLE B-3-12: ILLINOIS DISTRICT 1 FOR YEARS 2009 TO 2011 FOR HSM TABLE 12-11**

**HSM Table 12-11**. Distribution of Multiple-Vehicle Collision for Intersections by Collision Type

| Manner of Collision | Proportion of Crashes by Severity Level for Specific Intersection Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3ST | | 3SG | | 4ST | | 4SG | |
| | FI | PDO | FI | PDO | FI | PDO | FI | PDO |
| Rear-end collision | 0.391 | 0.395 | 0.536 | 0.553 | 0.296 | 0.339 | 0.438 | 0.490 |
| Head-on collision | 0.013 | 0.005 | 0.009 | 0.004 | 0.009 | 0.006 | 0.010 | 0.005 |
| Angle collision | 0.124 | 0.112 | 0.093 | 0.066 | 0.364 | 0.273 | 0.178 | 0.112 |
| Sideswipe | 0.026 | 0.065 | 0.022 | 0.073 | 0.022 | 0.061 | 0.023 | 0.084 |
| Other multiple-vehicle collisions | 0.446 | 0.424 | 0.340 | 0.304 | 0.308 | 0.321 | 0.351 | 0.308 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-32**

**TABLE B-3-13: ILLINOIS DISTRICT 1 FOR YEARS 2006 TO 2008 FOR HSM TABLE 12-13**

**HSM Table 12-13.** Distribution of Single-Vehicle Crashes for Intersection by Collision Type

| Manner of Collision | Proportion of Crashes by Severity Level for Specific Intersection Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3ST | | 3SG | | 4ST | | 4SG | |
| | FI | PDO | FI | PDO | FI | PDO | FI | PDO |
| Collision with parked vehicle | 0.019 | 0.128 | 0.012 | 0.103 | 0.016 | 0.225 | 0.011 | 0.169 |
| Collision with animal | 0.004 | 0.061 | 0.000 | 0.023 | 0.00 | 0.028 | 0.001 | 0.010 |
| Collision with fixed object | 0.206 | 0.711 | 0.229 | 0.754 | 0.100 | 0.636 | 0.079 | 0.719 |
| Collision with other object | 0.004 | 0.031 | 0.007 | 0.037 | 0.003 | 0.026 | 0.002 | 0.024 |
| Other single-vehicle collision | 0.748 | 0.035 | 0.732 | 0.042 | 0.876 | 0.058 | 0.897 | 0.054 |
| Noncollision | 0.019 | 0.034 | 0.019 | 0.041 | 0.005 | 0.027 | 0.010 | 0.024 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-36**

**TABLE B-3-14: ILLINOIS DISTRICT 1 FOR YEARS 2009 TO 2011 FOR HSM TABLE 12-13**

**HSM Table 12-13.** Distribution of Single-Vehicle Crashes for Intersection by Collision Type

| Manner of Collision | Proportion of Crashes by Severity Level for Specific Intersection Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3ST | | 3SG | | 4ST | | 4SG | |
| | FI | PDO | FI | PDO | FI | PDO | FI | PDO |
| Collision with parked vehicle | 0.005 | 0.118 | 0.010 | 0.058 | 0.006 | 0.169 | 0.006 | 0.144 |
| Collision with animal | 0.000 | 0.008 | 0.000 | 0.003 | 0.001 | 0.006 | 0.000 | 0.002 |
| Collision with fixed object | 0.165 | 0.768 | 0.194 | 0.863 | 0.065 | 0.727 | 0.068 | 0.721 |
| Collision with other object | 0.003 | 0.024 | 0.000 | 0.023 | 0.006 | 0.020 | 0.005 | 0.028 |
| Other single-vehicle collision | 0.807 | 0.053 | 0.785 | 0.029 | 0.913 | 0.055 | 0.911 | 0.074 |
| Noncollision | 0.021 | 0.028 | 0.010 | 0.023 | 0.009 | 0.024 | 0.010 | 0.031 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-36**

**Table B-3-15: Illinois District 1 for years 2006 to 2008 for HSM Table 12-16**

**HSM Table 12-16.** Pedestrian Crashes Adjustment Factors for Stop-Controlled Intersections

| Intersection Type | Pedestrian Crash Adjustment Factor ($f_{pedi}$) |
|---|---|
| 3ST | 0.016 |
| 4ST | 0.033 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-38**

**Table B-3-16: Illinois District 1 for years 2009 to 2011 for HSM Table 12-16**

**HSM Table 12-16.** Pedestrian Crashes Adjustment Factors for Stop-Controlled Intersections

| Intersection Type | Pedestrian Crash Adjustment Factor ($f_{pedi}$) |
|---|---|
| 3ST | 0.022 |
| 4ST | 0.038 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-38**

**Table B-3-17: Illinois District 1 for years 2006 to 2008 for HSM Table 12-17**

**HSM Table 12-17.** Bicycle Crash Adjustment Factor for Intersections

| Intersection Type | Bicycle Crash Adjustment Factor ($f_{bikei}$) |
|---|---|
| 3ST | 0.014 |
| 3SG | 0.008 |
| 4ST | 0.016 |
| 4SG | 0.012 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-38**

**Table B-3-18: Illinois District 1 for years 2009 to 2011 for HSM Table 12-17**

**HSM Table 12-17.** Bicycle Crash Adjustment Factor for Intersections

| Intersection Type | Bicycle Crash Adjustment Factor ($f_{bikei}$) |
|---|---|
| 3ST | 0.027 |
| 3SG | 0.014 |
| 4ST | 0.023 |
| 4SG | 0.018 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-38**

**Table B-3-19: Illinois District 1 for years 2006 to 2008 for HSM Table 12-23**

**HSM Table 12-23.** Nighttime Crash Proportions for Unlighted Roadway Segments

| Roadway Segment Type | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| | Fatal and Injury $p_{nr}$ | PDO $p_{pnr}$ | $p_{nr}$ |
| 2U | 0.222 | 0.778 | 0.504 |
| 3T* | 0.429 | 0.571 | 0.304 |
| 4U | 0.254 | 0.746 | 0.486 |
| 4D | 0.234 | 0.766 | 0.418 |
| 5T | 0.214 | 0.786 | 0.298 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-42**

**Table B-3-20: Illinois District 1 for years 2009 to 2011 for HSM Table 12-23**

**HSM Table 12-23.** Nighttime Crash Proportions for Unlighted Roadway Segments

| Roadway Segment Type | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| | Fatal and Injury $p_{nr}$ | PDO $p_{pnr}$ | $p_{nr}$ |
| 2U | 0.225 | 0.775 | 0.491 |
| 3T* | 0.429 | 0.571 | 0.304 |
| 4U | 0.261 | 0.739 | 0.491 |
| 4D* | 0.364 | 0.636 | 0.410 |
| 5T* | 0.432 | 0.568 | 0.274 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-42**

**Table B-3-21: Illinois District 1 for years 2006 to 2008 for HSM Table 12-27**

**HSM Table 12-27**. Nighttime Crashes Proportions for Unlighted Intersections

| Intersection Type | Proportion of Crashes that Occur at Night $p_{ni}$ |
|---|---|
| 3ST | 0.259 |
| 4ST | 0.192 |
| 3SG and 4SG* | 0.235 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-45**

**Table B-3-22: Illinois District 1 for years 2009 to 2011 for HSM Table 12-27**

**HSM Table 12-27**. Nighttime Crashes Proportions for Unlighted Intersections

| Intersection Type | Proportion of Crashes that Occur at Night $p_{ni}$ |
|---|---|
| 3ST | 0.268 |
| 4ST* | 0.229 |
| 3SG and 4SG* | 0.235 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-45**

# Appendix B-4: HSM Part C for Rural Two-Lane, Two-Way Roads (HSM Chapter 10) Default Tables for IDOT District 2 to District 9

**Table B-4-1: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 10-3**

**HSM Table 10-3.** Default Distribution for Crash Severity Level on Rural Two-Lane, Two-Way Roadway Segments

| Crash Severity Level | Percentage of Total Roadway Segment Crashes |
|---|---|
| Fatal | 1.3 |
| Incapacitating Injury | 6.8 |
| Nonincapacitating injury | 12.6 |
| Possible Injury | 3.4 |
| Total fatal plus injury | 24.1 |
| Property damage only | 75.9 |
| **Total** | **100.0** |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-17**

**Table B-4-2: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 10-3**

**HSM Table 10-3.** Default Distribution for Crash Severity Level on Rural Two-Lane, Two-Way Roadway Segments

| Crash Severity Level | Percentage of Total Roadway Segment Crashes |
|---|---|
| Fatal | 1.2 |
| Incapacitating Injury | 7.9 |
| Nonincapacitating injury | 14.4 |
| Possible Injury | 3.8 |
| Total fatal plus injury | 27.3 |
| Property damage only | 72.7 |
| **Total** | **100.0** |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-17**

**Table B-4-3: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 10-4**

**HSM Table 10-4.** Default Distribution by Collision Type for Specific Crash Severity Levels on Rural Two-Lane, Two-Way Roadway Segments

| | Percentage of Total Roadway Segment Crashes by Crash Severity Level | | |
|---|---|---|---|
| **Collision Type** | **Total Fatal and Injury** | **Property Damage Only** | **Total** |
| **SINGLE-VEHICLE CRASHES** | | | |
| Collision with animal | 7.5 | 52.4 | 41.5 |
| Collision with bicycle | 0.3 | 0.0 | 0.1 |
| Collision with pedestrian | 0.9 | 0.0 | 0.2 |
| Overturned | 24.8 | 6.9 | 11.2 |
| Ran off road | 44.1 | 25.8 | 30.2 |
| Other single-vehicle crashes | 3.2 | 3.0 | 3.1 |
| Total single-vehicle crashes | 80.8 | 88.1 | 86.3 |
| **MULTIPLE-VEHICLE CRASHES** | | | |
| Angle collision | 1.3 | 1.1 | 1.1 |
| Head-on collision | 3.9 | 0.4 | 1.2 |
| Rear-end collision | 6.0 | 3.4 | 4.1 |
| Sideswipe collision | 3.6 | 3.0 | 3.2 |
| Other multiple-vehicle collision | 4.4 | 4.0 | 4.1 |
| Total multiple-vehicle crashes | 19.2 | 11.9 | 13.7 |
| **Total Crashes** | **100.0** | **100.0** | **100.0** |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-17**

**Table B-4-4: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 10-4**

**HSM Table 10-4.** Default Distribution by Collision Type for Specific Crash Severity Levels on Rural Two-Lane, Two-Way Roadway Segments

| | Percentage of Total Roadway Segment Crashes by Crash Severity Level | | |
|---|---|---|---|
| **Collision Type** | **Total Fatal and Injury** | **Property Damage Only** | **Total** |
| **SINGLE-VEHICLE CRASHES** | | | |
| Collision with animal | 6.3 | 49.8 | 37.9 |
| Collision with bicycle | 0.5 | 0.0 | 0.1 |
| Collision with pedestrian | 1.0 | 0.0 | 0.3 |
| Overturned | 23.4 | 7.3 | 11.7 |
| Ran off road | 47.0 | 27.5 | 32.9 |
| Other single-vehicle crashes | 2.7 | 2.7 | 2.7 |
| Total single-vehicle crashes | 80.9 | 87.3 | 85.6 |
| **MULTIPLE-VEHICLE CRASHES** | | | |
| Angle collision | 1.2 | 1.3 | 1.3 |
| Head-on collision | 3.6 | 0.6 | 1.4 |
| Rear-end collision | 6.1 | 4.0 | 4.5 |
| Sideswipe collision | 3.7 | 2.6 | 2.9 |
| Other multiple-vehicle collision | 4.5 | 4.2 | 4.3 |
| Total multiple-vehicle crashes | 19.1 | 12.7 | 14.4 |
| **Total Crashes** | **100.0** | **100.0** | **100.0** |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-17**

**Table B-4-5: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 10-5**

**HSM Table 10-5.** Default Distribution for Crash Severity Level at Rural Two-Lane, Two-Way Intersections

| | Percentage of Total Crashes | | |
|---|---|---|---|
| **Crash Severity Level** | **Three-Leg Stop-Controlled Intersections** | **Four-Leg Stop-Controlled Intersections** | **Four-Leg Signalized Intersections** |
| Fatal | 0.7 | 1.3 | 0.7 |
| Incapacitating injury | 6.6 | 12.0 | 5.0 |
| Nonincapacitating injury | 13.9 | 17.5 | 12.3 |
| Possible injury | 5.4 | 5.8 | 6.5 |
| Total fatal plus injury | 26.6 | 36.6 | 24.5 |
| Property damage only | 73.4 | 63.4 | 75.5 |
| **Total** | **100.0** | **100.0** | **100.0** |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-21**

**Table B-4-6: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 10-5**

**HSM Table 10-5.** Default Distribution for Crash Severity Level at Rural Two-Lane, Two-Way Intersections

| | Percentage of Total Crashes | | |
|---|---|---|---|
| **Crash Severity Level** | **Three-Leg Stop-Controlled Intersections** | **Four-Leg Stop-Controlled Intersections** | **Four-Leg Signalized Intersections** |
| Fatal | 0.6 | 1.9 | 0.0 |
| Incapacitating injury | 9.2 | 13.7 | 6.9 |
| Nonincapacitating injury | 16.6 | 18.4 | 13.7 |
| Possible injury | 6.2 | 6.8 | 8.9 |
| Total fatal plus injury | 32.6 | 40.8 | 29.5 |
| Property damage only | 67.4 | 59.2 | 70.5 |
| **Total** | **100.0** | **100.0** | **100.0** |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-21**

**Table B-4-7: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 10-6**

**HSM Table 10-6.** Default Distribution for Collision Type and Manner of Collision at Rural Two-Lane, Two-Way Intersections

| | Percentage of Total Crashes by Collision Type | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Three-Leg Stop-Controlled Intersections | | | Four-Leg Stop-Controlled Intersections | | | Four-Leg Signalized Intersections | | |
| **Collision Type** | **Fatal and Injury** | **Property Damage Only** | **Total** | **Fatal and Injury** | **Property Damage Only** | **Total** | **Fatal and Injury** | **Property Damage Only** | **Total** |
| **SINGLE-VEHICLE CRASHES** | | | | | | | | | |
| Collision with animal | 0.8 | 9.3 | 7.0 | 0.2 | 4.3 | 2.8 | 0.0 | 0.0 | 0.0 |
| Collision with bicycle | 0.7 | 0.0 | 0.2 | 1.5 | 0.0 | 0.6 | 5.9 | 0.0 | 1.5 |
| Collision with pedestrian | 0.8 | 0.0 | 0.2 | 0.4 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Overturned | 7.5 | 2.8 | 4.0 | 2.8 | 1.9 | 2.2 | 0.0 | 0.0 | 0.0 |
| Ran off road | 28.3 | 28.1 | 28.1 | 8.4 | 14.2 | 12.1 | 2.9 | 4.8 | 4.3 |
| Other single-vehicle crash | 3.1 | 2.8 | 3.0 | 1.2 | 1.8 | 1.6 | 0.0 | 0.9 | 0.7 |
| Total single-vehicle crashes | 41.2 | 43.0 | 42.5 | 14.5 | 22.2 | 19.4 | 8.8 | 5.7 | 6.5 |
| **MULTIPLE-VEHICLE CRASHES** | | | | | | | | | |
| Angle collision | 8.9 | 6.6 | 7.2 | 54.1 | 31.6 | 39.9 | 29.4 | 9.5 | 14.4 |
| Head-on collision | 1.1 | 0.4 | 0.6 | 1.3 | 0.4 | 0.7 | 0.0 | 0.0 | 0.0 |
| Rear-end collision | 19.0 | 19.5 | 19.4 | 8.8 | 18.6 | 15.0 | 35.3 | 52.4 | 48.2 |
| Sideswipe collision | 2.0 | 3.3 | 2.9 | 1.4 | 2.4 | 2.0 | 0.0 | 1.0 | 0.7 |
| Other multiple-vehicle collision | 27.8 | 27.2 | 27.4 | 19.9 | 24.8 | 23.0 | 26.5 | 31.4 | 30.2 |
| Total multiple-vehicle collision | 58.8 | 57.0 | 57.5 | 85.5 | 77.8 | 80.6 | 91.2 | 94.3 | 93.5 |
| **Total Crashes** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-22**

**Table B-4-8: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 10-6**

**HSM Table 10-6**. Default Distribution for Collision Type and Manner of Collision at Rural Two-Lane, Two-Way Intersections

| | Percentage of Total Crashes by Collision Type | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Three-Leg Stop-Controlled Intersections | | | Four-Leg Stop-Controlled Intersections | | | Four-Leg Signalized Intersections | | |
| **Collision Type** | **Fatal and Injury** | **Property Damage Only** | **Total** | **Fatal and Injury** | **Property Damage Only** | **Total** | **Fatal and Injury** | **Property Damage Only** | **Total** |
| **SINGLE-VEHICLE CRASHES** | | | | | | | | | |
| Collision with animal | 0.1 | 0.6 | 0.5 | 0.0 | 0.7 | 0.4 | 0.0 | 0.0 | 0.0 |
| Collision with bicycle | 0.6 | 0.0 | 0.2 | 0.6 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 |
| Collision with pedestrian | 0.6 | 0.0 | 0.2 | 0.2 | 0.0 | 0.1 | 2.3 | 0.0 | 0.7 |
| Overturned | 4.9 | 2.2 | 3.1 | 2.6 | 1.9 | 2.2 | 0.0 | 1.0 | 0.7 |
| Ran off road | 24.7 | 28.0 | 26.9 | 5.7 | 12.0 | 9.5 | 0.0 | 7.7 | 5.5 |
| Other single-vehicle crash | 2.3 | 2.1 | 2.2 | 0.6 | 1.3 | 1.0 | 0.0 | 0.0 | 0.0 |
| Total single-vehicle crashes | 33.2 | 32.9 | 33.0 | 9.8 | 15.9 | 13.4 | 2.3 | 8.7 | 6.9 |
| **MULTIPLE-VEHICLE CRASHES** | | | | | | | | | |
| Angle collision | 9.1 | 8.0 | 8.3 | 59.2 | 37.2 | 46.1 | 25.6 | 17.5 | 19.8 |
| Head-on collision | 1.3 | 0.4 | 0.7 | 0.3 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 |
| Rear-end collision | 25.7 | 25.1 | 25.3 | 11.2 | 17.8 | 15.1 | 32.5 | 52.4 | 46.6 |
| Sideswipe collision | 1.2 | 3.9 | 3.0 | 0.7 | 2.6 | 1.8 | 4.7 | 1.9 | 2.7 |
| Other multiple-vehicle collision | 29.5 | 29.7 | 29.6 | 18.9 | 26.5 | 23.4 | 34.9 | 19.4 | 24.0 |
| Total multiple-vehicle collision | 66.8 | 67.1 | 66.9 | 90.3 | 84.1 | 86.6 | 97.7 | 91.3 | 93.1 |
| **Total Crashes** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-22**

**Table B-4-9: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 10-12**

**HSM Table 10-12.** Nighttime Crash Proportions for Unlighted Roadway Segments

| | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| **Roadway Type** | **Fatal and Injury $p_{nr}$** | **PDO $p_{pnr}$** | **$p_{nr}$** |
| 2U | 0.189 | 0.811 | 0.722 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-31**

**Table B-4-10: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 10-12**

**HSM Table 10-12.** Nighttime Crash Proportions for Unlighted Roadway Segments

| | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| **Roadway Type** | **Fatal and Injury $p_{nr}$** | **PDO $p_{pnr}$** | **$p_{nr}$** |
| 2U | 0.208 | 0.792 | 0.715 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-31**

**Table B-4-11: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 10-15**

**HSM Table 10-15.** Nighttime Crash Proportions for Unlighted Intersections

| | Proportion of Crashes that Occur at Night |
|---|---|
| **Intersection Type** | **$p_{ni}$** |
| 3ST | 0.657 |
| 4ST | 0.443 |
| 4SG* | 0.286 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 10-33**

**Table B-4-12: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 10-15**

**HSM Table 10-15.** Nighttime Crash Proportions for Unlighted Intersections

| | Proportion of Crashes that Occur at Night |
|---|---|
| **Intersection Type** | **$p_{ni}$** |
| 3ST | 0.600 |
| 4ST | 0.390 |
| 4SG* | 0.286 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010,Page 10-33**

# Appendix B-5:
# HSM Part C for Rural Multilane Highways
# (HSM Chapter 11) Default Tables for IDOT District 2 to District 9

**Table B-5-1: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 11-4**

**HSM Table 11-4.** Default Distribution of Crashes by Collision Type and Crash Severity Level for Undivided Roadway Segments

| Collision Type | Proportion of Crashes by Collision Type and Crash Severity Level | | | |
|---|---|---|---|---|
| | | Severity Level | | |
| | Total | Fatal and Injury | Fatal and Injury [a] | PDO |
| Head-on | 0.042 | 0.171 | 0.184 | 0.000 |
| Sideswipe | 0.054 | 0.049 | 0.053 | 0.056 |
| Rear-end | 0.096 | 0.220 | 0.211 | 0.056 |
| Angle | 0.018 | 0.049 | 0.026 | 0.008 |
| Single | 0.705 | 0.415 | 0.421 | 0.800 |
| Other | 0.084 | 0.098 | 0.105 | 0.080 |

**[a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.**

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-17**

**Table B-5-2: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 11-4**

**HSM Table 11-4.** Default Distribution of Crashes by Collision Type and Crash Severity Level for Undivided Roadway Segments*

| Collision Type | Proportion of Crashes by Collision Type and Crash Severity Level | | | |
|---|---|---|---|---|
| | | Severity Level | | |
| | Total | Fatal and Injury | Fatal and Injury [a] | PDO |
| Head-on | 0.009 | 0.029 | 0.043 | 0.001 |
| Sideswipe | 0.098 | 0.048 | 0.048 | 0.120 |
| Rear-end | 0.246 | 0.305 | 0.217 | 0.220 |
| Angle | 0.356 | 0.352 | 0.348 | 0.358 |
| Single | 0.238 | 0.238 | 0.304 | 0.237 |
| Other | 0.053 | 0.028 | 0.044 | 0.064 |

**[a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.**

*** Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-17**

**Table B-5-3: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 11-6**

**HSM Table 11-6.** Default Distribution of Crashes by Collision Type and Crash Severity Level for divided Roadway Segments

| | Proportion of Crashes by Collision Type and Crash Severity Level | | | |
|---|---|---|---|---|
| | Severity Level | | | |
| **Collision Type** | **Total** | **Fatal and Injury** | **Fatal and Injury [a]** | **PDO** |
| Head-on | 0.005 | 0.025 | 0.032 | 0.001 |
| Sideswipe | 0.055 | 0.066 | 0.064 | 0.052 |
| Rear-end | 0.083 | 0.145 | 0.160 | 0.069 |
| Angle | 0.009 | 0.021 | 0.016 | 0.007 |
| Single | 0.808 | 0.685 | 0.676 | 0.836 |
| Other | 0.039 | 0.058 | 0.053 | 0.035 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-20**

**Table B-5-4: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 11-6**

**HSM Table 11-6.** Default Distribution of Crashes by Collision Type and Crash Severity Level for divided Roadway Segments

| | Proportion of Crashes by Collision Type and Crash Severity Level | | | |
|---|---|---|---|---|
| | Severity Level | | | |
| **Collision Type** | **Total** | **Fatal and Injury** | **Fatal and Injury [a]** | **PDO** |
| Head-on | 0.005 | 0.016 | 0.019 | 0.002 |
| Sideswipe | 0.053 | 0.069 | 0.063 | 0.049 |
| Rear-end | 0.079 | 0.186 | 0.190 | 0.056 |
| Angle | 0.004 | 0.000 | 0.000 | 0.004 |
| Single | 0.834 | 0.681 | 0.677 | 0.866 |
| Other | 0.027 | 0.048 | 0.051 | 0.022 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-20**

**Table B-5-5: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 11-9**

**HSM Table 11-9.** Default Distribution of Intersection Crashes by Collision Type and Crash Severity

| | Proportion of Crashes by Severity Level | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Three-Leg Intersection with Minor-Road Stop Control | | | | Four-Leg Intersection with Minor-Road Stop Control | | | |
| **Collision Type** | **Total** | **Fatal and Injury** | **Fatal and AB-Injury** | **PDO** | **Total** | **Fatal and Injury** | **Fatal and AB-Injury** | **PDO** |
| Head-on | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sideswipe | 0.034 | 0.020 | 0.000 | 0.041 | 0.058 | 0.029 | 0.036 | 0.088 |
| Rear-end | 0.197 | 0.122 | 0.081 | 0.235 | 0.116 | 0.086 | 0.073 | 0.147 |
| Angle | 0.177 | 0.306 | 0.351 | 0.112 | 0.232 | 0.271 | 0.255 | 0.191 |
| Single | 0.136 | 0.082 | 0.054 | 0.163 | 0.109 | 0.100 | 0.073 | 0.118 |
| Other | 0.456 | 0.469 | 0.541 | 0.449 | 0.486 | 0.514 | 0.564 | 0.456 |
| | **Three-Leg Signalized Intersection** | | | | **Four-Leg Signalized Intersection*** | | | |
| **Collision Type** | **Total** | **Fatal and Injury** | **Fatal and AB-Injury** | **PDO** | **Total** | **Fatal and Injury** | **Fatal and AB-Injury** | **PDO** |
| Head-on | -- | -- | -- | -- | 0.054 | 0.083 | 0.093 | 0.034 |
| Sideswipe | -- | -- | -- | -- | 0.106 | 0.047 | 0.039 | 0.147 |
| Rear-end | -- | -- | -- | -- | 0.492 | 0.472 | 0.314 | 0.505 |
| Angle | -- | -- | -- | -- | 0.256 | 0.315 | 0.407 | 0.215 |
| Single | -- | -- | -- | -- | 0.062 | 0.041 | 0.078 | 0.077 |
| Other | -- | -- | -- | -- | 0.030 | 0.041 | 0.069 | 0.023 |

**Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.**

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-24**

**Table B-5-6: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 11-9**

**HSM Table 11-9.** Default Distribution of Intersection Crashes by Collision Type and Crash Severity*

| | Proportion of Crashes by Severity Level | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Three-Leg Intersection with Minor-Road Stop Control** | | | | **Four-Leg Intersection with Minor-Road Stop Control** | | | |
| **Collision Type** | **Total** | **Fatal and Injury** | **Fatal and AB-Injury** | **PDO** | **Total** | **Fatal and Injury** | **Fatal and AB-Injury** | **PDO** |
| Head-on | 0.029 | 0.043 | 0.052 | 0.020 | 0.016 | 0.018 | 0.023 | 0.015 |
| Sideswipe | 0.133 | 0.058 | 0.057 | 0.049 | 0.107 | 0.042 | 0.042 | 0.156 |
| Rear-end | 0.289 | 0.247 | 0.142 | 0.315 | 0.228 | 0.213 | 0.108 | 0.240 |
| Angle | 0.263 | 0.369 | 0.381 | 0.198 | 0.395 | 0.534 | 0.571 | 0.292 |
| Single | 0.234 | 0.219 | 0.284 | 0.244 | 0.202 | 0.148 | 0.199 | 0.243 |
| Other | 0.052 | 0.064 | 0.514 | 0.044 | 0.051 | 0.046 | 0.059 | 0.055 |
| | **Three-Leg Signalized Intersection** | | | | **Four-Leg Signalized Intersection** | | | |
| **Collision Type** | **Total** | **Fatal and Injury** | **Fatal and AB-Injury** | **PDO** | **Total** | **Fatal and Injury** | **Fatal and AB-Injury** | **PDO** |
| Head-on | -- | -- | -- | -- | 0.054 | 0.083 | 0.093 | 0.034 |
| Sideswipe | -- | -- | -- | -- | 0.106 | 0.047 | 0.039 | 0.147 |
| Rear-end | -- | -- | -- | -- | 0.492 | 0.472 | 0.314 | 0.505 |
| Angle | -- | -- | -- | -- | 0.256 | 0.315 | 0.407 | 0.215 |
| Single | -- | -- | -- | -- | 0.062 | 0.041 | 0.078 | 0.077 |
| Other | -- | -- | -- | -- | 0.030 | 0.041 | 0.069 | 0.023 |

**Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.**

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-24**

**Table B-5-7: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 11-15**

**HSM Table 11-15.** Nighttime Crash Proportions for Unlighted Roadway Segments

| Roadway Type | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| | Fatal and Injury $p_{nr}$ | PDO $p_{pnr}$ | $p_{nr}$ |
| 4U | 0.196 | 0.804 | 0.773 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-29**

**Table B-5-8: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 11-15**

**HSM Table 11-15.** Nighttime Crash Proportions for Unlighted Roadway Segments

| Roadway Type | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| | Fatal and Injury $p_{nr}$ | PDO $p_{pnr}$ | $p_{nr}$ |
| 4U | 0.361 | 0.639 | 0.255 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-29**

**Table B-5-9: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 11-19**

**HSM Table 11-19.** Default Nighttime Crash Proportions for Unlighted Roadway Segments*

| Roadway Type | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| | Fatal and Injury $p_{nr}$ | PDO $p_{pnr}$ | $p_{nr}$ |
| 4D | 0.130 | 0.870 | 0.650 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-32**

**Table B-5-10: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 11-19**

**HSM Table 11-19.** Default Nighttime Crash Proportions for Unlighted Roadway Segments

| Roadway Type | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| | Fatal and Injury $p_{nr}$ | PDO $p_{pnr}$ | $p_{nr}$ |
| 4D | 0.121 | 0.879 | 0.703 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-32**

**Table B-5-11: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 11-24**

**HSM Table 11-24.** Nighttime Crash Proportions for Unlighted Intersections*

| Intersection Type | Proportion of Crashes that Occur at Night, $p_{ni}$ |
|---|---|
| 3ST | 0.276 |
| 4ST | 0.273 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-35**

**Table B-5-12: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 11-24**

**HSM Table 11-24.** Nighttime Crash Proportions for Unlighted Intersections*

| Intersection Type | Proportion of Crashes that Occur at Night, $p_{ni}$ |
|---|---|
| 3ST | 0.276 |
| 4ST | 0.273 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 11-35**

# Appendix B-6:
# HSM Part C for Urban and Suburban Arterials
# (HSM Chapter 12) Default Tables for IDOT District 2 to District 9

**Table B-6-1: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 12-4**

**HSM Table 12-4.** Distribution of Multiple-Vehicle Nondriveway Collisions for Roadway Segments by Manner of Collision Type

| Collision Type | Proportion of Crashes by Severity Level for Specific Road Types | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2U | | 3T | | 4U | | 4D | | 5T | |
| | FI | PDO | FI | PDO | FI | PDO | FI | PDO | FI | PDO |
| Rear-end collision | 0.534 | 0.520 | 0.632 | 0.596 | 0.541 | 0.457 | 0.578 | 0.519 | 0.532 | 0.445 |
| Head-on collision | 0.104 | 0.019 | 0.023 | 0.005 | 0.039 | 0.010 | 0.032 | 0.006 | 0.016 | 0.005 |
| Angle collision | 0.078 | 0.112 | 0.076 | 0.098 | 0.102 | 0.109 | 0.086 | 0.071 | 0.111 | 0.105 |
| Sideswipe, same direction | 0.026 | 0.074 | 0.030 | 0.068 | 0.062 | 0.196 | 0.074 | 0.208 | 0.052 | 0.189 |
| Sideswipe, opposite direction | 0.070 | 0.056 | 0.023 | 0.018 | 0.028 | 0.027 | 0.020 | 0.015 | 0.009 | 0.011 |
| Other multiple-vehicle collisions | 0.189 | 0.217 | 0.217 | 0.215 | 0.228 | 0.202 | 0.212 | 0.182 | 0.280 | 0.246 |

**Highway Safety Manual, First Edition, Volume 2, 2010 , Page 12-20**

**Table B-6-2: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 12-4**

**HSM Table 12-4.** Distribution of Multiple-Vehicle Nondriveway Collisions for Roadway Segments by Manner of Collision Type

| Collision Type | Proportion of Crashes by Severity Level for Specific Road Types | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2U | | 3T | | 4U | | 4D* | | 5T | |
| | FI | PDO | FI | PDO | FI | PDO | FI | PDO | FI | PDO |
| Rear-end collision | 0.555 | 0.541 | 0.649 | 0.636 | 0.554 | 0.469 | 0.832 | 0.662 | 0.541 | 0.451 |
| Head-on collision | 0.106 | 0.016 | 0.024 | 0.008 | 0.034 | 0.007 | 0.020 | 0.007 | 0.025 | 0.004 |
| Angle collision | 0.070 | 0.112 | 0.077 | 0.083 | 0.102 | 0.103 | 0.040 | 0.036 | 0.105 | 0.098 |
| Sideswipe, same direction | 0.025 | 0.062 | 0.019 | 0.057 | 0.073 | 0.197 | 0.050 | 0.223 | 0.076 | 0.194 |
| Sideswipe, opposite direction | 0.062 | 0.057 | 0.034 | 0.012 | 0.037 | 0.014 | 0.010 | 0.001 | 0.012 | 0.010 |
| Other multiple-vehicle collisions | 0.182 | 0.211 | 0.197 | 0.204 | 0.201 | 0.211 | 0.048 | 0.071 | 0.241 | 0.243 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010 , Page 12-20**

**Table B-6-3: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 12-6**

**HSM Table 12-6.** Distribution of Single-Vehicle Crashes for Roadway Segments by Collision Type

| | Proportion of Crashes by Severity Level for Specific Road Types | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2U | | 3T | | 4U | | 4D | | 5T | |
| Collision Type | FI | PDO | FI | PDO | FI | PDO | FI | PDO | FI | PDO |
| Collision with animal | 0.082 | 0.434 | 0.068 | 0.393 | 0.041 | 0.041 | 0.081 | 0.428 | 0.069 | 0.436 |
| Collision with fixed object | 0.598 | 0.324 | 0.658 | 0.375 | 0.643 | 0.433 | 0.661 | 0.410 | 0.644 | 0.362 |
| Collision with other object | 0.026 | 0.029 | 0.027 | 0.030 | 0.047 | 0.036 | 0.040 | 0.056 | 0.043 | 0.057 |
| Other single-vehicle collision | 0.294 | 0.214 | 0.247 | 0.202 | 0.269 | 0.176 | 0.217 | 0.106 | 0.245 | 0.146 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-22**

**Table B-6-4: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 12-6**

**HSM Table 12-6.** Distribution of Single-Vehicle Crashes for Roadway Segments by Collision Type

| | Proportion of Crashes by Severity Level for Specific Road Types | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2U | | 3T* | | 4U* | | 4D* | | 5T* | |
| Collision Type | FI | PDO | FI | PDO | FI | PDO | FI | PDO | FI | PDO |
| Collision with animal | 0.052 | 0.410 | 0.054 | 0.408 | 0.047 | 0.391 | 0.001 | 0.063 | 0.101 | 0.484 |
| Collision with fixed object | 0.621 | 0.346 | 0.750 | 0.408 | 0.642 | 0.388 | 0.50 | 0.813 | 0.601 | 0.366 |
| Collision with other object | 0.023 | 0.030 | 0.018 | 0.035 | 0.028 | 0.078 | 0.028 | 0.016 | 0.047 | 0.051 |
| Other single-vehicle collision | 0.304 | 0.214 | 0.179 | 0.149 | 0.283 | 0.144 | 0.471 | 0.108 | 0.250 | 0.099 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-22**

**Table B-6-5: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 12-7**

**HSM Table 12-7.** SPF Coefficients for Multiple-Vehicle Driveway Related Collisions

| | Coefficients for Specific Road Types | | | | |
|---|---|---|---|---|---|
| **Driveway Type (j)** | **2U** | **3T** | **4U** | **4D** | **5T** |
| **Proportion of Fatal-and-Injury Crashes** | | | | | |
| All driveways | 0.245 | 0.19 | 0.269 | 0.268 | 0.257 |
| **Proportion of Property-Damage-Only Crashes** | | | | | |
| All driveways | 0.755 | 0.81 | 0.731 | 0.732 | 0.743 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-24**

**Table B-6-6: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 12-7**

**HSM Table 12-7.** SPF Coefficients for Multiple-Vehicle Driveway Related Collisions

| | Coefficients for Specific Road Types | | | | |
|---|---|---|---|---|---|
| **Driveway Type (j)** | **2U*** | **3T** | **4U** | **4D*** | **5T** |
| **Proportion of Fatal-and-Injury Crashes** | | | | | |
| All driveways | 0.323 | 0.252 | 0.244 | 0.284 | 0.24 |
| **Proportion of Property-Damage-Only Crashes** | | | | | |
| All driveways | 0.677 | 0.748 | 0.756 | 0.716 | 0.76 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-24**

**Table B-6-7: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 12-8**

**HSM Table 12-8.** Pedestrian Crash Adjustment Factor for Roadway Segments

| Road Type | Pedestrian Crash Adjustment Factor | |
|---|---|---|
| | Posted Speed 30 mph or Less | Posted Speed Greater than 30 mph |
| 2U | 0.005 | 0.003 |
| 3T* | 0.041 | 0.013 |
| 4U | 0.008 | 0.007 |
| 4D | 0.006 | 0.005 |
| 5T | 0.005 | 0.008 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, HSM Page 12-27**

**Table B-6-8: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 12-8**

**HSM Table 12-8.** Pedestrian Crash Adjustment Factor for Roadway Segments

| Road Type | Pedestrian Crash Adjustment Factor | |
|---|---|---|
| | Posted Speed 30 mph or Less | Posted Speed Greater than 30 mph |
| 2U | 0.006 | 0.004 |
| 3T* | 0.041 | 0.013 |
| 4U | 0.011 | 0.007 |
| 4D* | 0.067 | 0.019 |
| 5T | 0.006 | 0.010 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-27**

**Table B-6-9: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 12-9**

**HSM Table 12-9.** Bicycle Crash Adjustment Factor for Roadway Segments

| Road Type | Bicycle Crash Adjustment Factor ($f_{biker}$) | |
|---|---|---|
| | **Posted Speed 30 mph or Less** | **Posted Speed Greater than 30 mph** |
| 2U | 0.004 | 0.002 |
| 3T* | 0.027 | 0.007 |
| 4U | 0.004 | 0.004 |
| 4D | 0.003 | 0.003 |
| 5T | 0.003 | 0.005 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-28**

**Table B-6-10: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 12-9**

**HSM Table 12-9.** Bicycle Crash Adjustment Factor for Roadway Segments

| Road Type | Bicycle Crash Adjustment Factor ($f_{biker}$) | |
|---|---|---|
| | **Posted Speed 30 mph or Less** | **Posted Speed Greater than 30 mph** |
| 2U | 0.005 | 0.002 |
| 3T* | 0.027 | 0.007 |
| 4U* | 0.011 | 0.002 |
| 4D* | 0.013 | 0.005 |
| 5T | 0.006 | 0.006 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-28**

**Table B-6-11: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 12-11**

**HSM Table 12-11**. Distribution of Multiple-Vehicle Collision for Intersections by Collision Type

| Manner of Collision | Proportion of Crashes by Severity Level for Specific Intersection Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3ST | | 3SG | | 4ST | | 4SG | |
| | FI | PDO | FI | PDO | FI | PDO | FI | PDO |
| Rear-end collision | 0.409 | 0.436 | 0.505 | 0.573 | 0.237 | 0.291 | 0.392 | 0.491 |
| Head-on collision | 0.014 | 0.004 | 0.003 | 0.001 | 0.008 | 0.004 | 0.003 | 0.002 |
| Angle collision | 0.133 | 0.109 | 0.085 | 0.055 | 0.442 | 0.353 | 0.238 | 0.137 |
| Sideswipe | 0.023 | 0.052 | 0.019 | 0.05 | 0.014 | 0.039 | 0.013 | 0.049 |
| Other multiple-vehicle collisions | 0.421 | 0.399 | 0.389 | 0.319 | 0.298 | 0.314 | 0.354 | 0.320 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-32**

**Table B-6-12: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 12-11**

**HSM Table 12-11**. Distribution of Multiple-Vehicle Collision for Intersections by Collision Type

| Manner of Collision | Proportion of Crashes by Severity Level for Specific Intersection Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3ST | | 3SG | | 4ST | | 4SG | |
| | FI | PDO | FI | PDO | FI | PDO | FI | PDO |
| Rear-end collision | 0.413 | 0.416 | 0.543 | 0.574 | 0.233 | 0.277 | 0.431 | 0.486 |
| Head-on collision | 0.010 | 0.004 | 0.012 | 0.002 | 0.003 | 0.003 | 0.005 | 0.004 |
| Angle collision | 0.133 | 0.119 | 0.071 | 0.068 | 0.453 | 0.378 | 0.218 | 0.148 |
| Sideswipe | 0.020 | 0.044 | 0.013 | 0.035 | 0.013 | 0.034 | 0.012 | 0.041 |
| Other multiple-vehicle collisions | 0.424 | 0.417 | 0.361 | 0.322 | 0.297 | 0.308 | 0.334 | 0.322 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-32**

**TABLE B-6-13: ILLINOIS DISTRICT 2 TO DISTRICT 9 FOR YEARS 2006 TO 2008 FOR HSM TABLE 12-13**

**HSM Table 12-13.** Distribution of Single-Vehicle Crashes for Intersection by Collision Type

| Manner of Collision | Proportion of Crashes by Severity Level for Specific Intersection Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3ST | | 3SG | | 4ST | | 4SG | |
| | FI | PDO | FI | PDO | FI | PDO | FI | PDO |
| Collision with parked vehicle | 0.014 | 0.086 | 0.000 | 0.068 | 0.015 | 0.136 | 0.005 | 0.092 |
| Collision with animal | 0.012 | 0.097 | 0.012 | 0.047 | 0.003 | 0.054 | 0.000 | 0.015 |
| Collision with fixed object | 0.408 | 0.703 | 0.365 | 0.784 | 0.220 | 0.717 | 0.212 | 0.790 |
| Collision with other object | 0.018 | 0.039 | 0.012 | 0.047 | 0.018 | 0.029 | 0.014 | 0.037 |
| Other single-vehicle collision | 0.517 | 0.038 | 0.600 | 0.041 | 0.696 | 0.034 | 0.742 | 0.035 |
| Noncollision | 0.032 | 0.037 | 0.012 | 0.014 | 0.048 | 0.031 | 0.027 | 0.031 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-36**

**Table B-6-14: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 12-13**

**HSM Table 12-13.** Distribution of Single-Vehicle Crashes for Intersection by Collision Type

| Manner of Collision | Proportion of Crashes by Severity Level for Specific Intersection Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3ST | | 3SG | | 4ST | | 4SG | |
| | FI | PDO | FI | PDO | FI | PDO | FI | PDO |
| Collision with parked vehicle | 0.013 | 0.073 | 0.000 | 0.022 | 0.003 | 0.114 | 0.013 | 0.068 |
| Collision with animal | 0.000 | 0.008 | 0.000 | 0.032 | 0.000 | 0.013 | 0.000 | 0.009 |
| Collision with fixed object | 0.389 | 0.794 | 0.284 | 0.86 | 0.190 | 0.746 | 0.186 | 0.809 |
| Collision with other object | 0.005 | 0.039 | 0.012 | 0.032 | 0.009 | 0.036 | 0.003 | 0.037 |
| Other single-vehicle collision | 0.536 | 0.042 | 0.654 | 0.022 | 0.778 | 0.049 | 0.770 | 0.037 |
| Noncollision | 0.057 | 0.044 | 0.049 | 0.032 | 0.020 | 0.042 | 0.028 | 0.040 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-36**

**Table B-6-15: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 12-16**

**HSM Table 12-16.** Pedestrian Crashes Adjustment Factors for Stop-Controlled Intersections

| Intersection Type | Pedestrian Crash Adjustment Factor ($f_{pedi}$) |
|---|---|
| 3ST | 0.007 |
| 4ST | 0.009 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-38**

**Table B-6-16: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 12-16**

**HSM Table 12-16.** Pedestrian Crashes Adjustment Factors for Stop-Controlled Intersections

| Intersection Type | Pedestrian Crash Adjustment Factor ($f_{pedi}$) |
|---|---|
| 3ST | 0.009 |
| 4ST | 0.011 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-38**

**Table B-6-17: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 12-17**

**HSM Table 12-17.** Bicycle Crash Adjustment Factor for Intersections

| Intersection Type | Bicycle Crash Adjustment Factor ($f_{bikei}$) |
|---|---|
| 3ST | 0.013 |
| 3SG | 0.009 |
| 4ST | 0.015 |
| 4SG | 0.008 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-38**

**Table B-6-18: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 12-17**

**HSM Table 12-17.** Bicycle Crash Adjustment Factor for Intersections

| Intersection Type | Bicycle Crash Adjustment Factor ($f_{bikei}$) |
|---|---|
| 3ST | 0.014 |
| 3SG | 0.010 |
| 4ST | 0.021 |
| 4SG | 0.010 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-38**

**Table B-6-19: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 12-23**

**HSM Table 12-23.** Nighttime Crash Proportions for Unlighted Roadway Segments

| Roadway Segment Type | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| | Fatal and Injury $p_{nr}$ | PDO $p_{pnr}$ | $p_{nr}$ |
| 2U | 0.187 | 0.813 | 0.643 |
| 3T | 0.112 | 0.888 | 0.506 |
| 4U | 0.192 | 0.808 | 0.648 |
| 4D | 0.188 | 0.812 | 0.628 |
| 5T | 0.114 | 0.886 | 0.369 |

**Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-42**

**Table B-6-20: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 12-23**

**HSM Table 12-23.** Nighttime Crash Proportions for Unlighted Roadway Segments

| Roadway Segment Type | Proportion of Total Nighttime Crashes by Severity Level | | Proportion of Crashes that Occur at Night |
|---|---|---|---|
| | Fatal and Injury $p_{nr}$ | PDO $p_{pnr}$ | $p_{nr}$ |
| 2U | 0.210 | 0.790 | 0.648 |
| 3T* | 0.429 | 0.571 | 0.304 |
| 4U | 0.200 | 0.800 | 0.638 |
| 4D | 0.364 | 0.636 | 0.410 |
| 5T | 0.219 | 0.781 | 0.366 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-42**

**Table B-6-21: Illinois District 2 to District 9 for years 2006 to 2008 for HSM Table 12-27**

**HSM Table 12-27**. Nighttime Crashes Proportions for Unlighted Intersections

| Intersection Type | Proportion of Crashes that Occur at Night<br>$p_{ni}$ |
|---|---|
| 3ST | 0.340 |
| 4ST | 0.201 |
| 3SG and 4SG* | 0.235 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-45**

**Table B-6-22: Illinois District 2 to District 9 for years 2009 to 2011 for HSM Table 12-27**

**HSM Table 12-27**. Nighttime Crashes Proportions for Unlighted Intersections

| Intersection Type | Proportion of Crashes that Occur at Night<br>$p_{ni}$ |
|---|---|
| 3ST | 0.310 |
| 4ST | 0.221 |
| 3SG and 4SG* | 0.235 |

***Data taken from Highway Safety Manual, First Edition, Volume 2, 2010, Page 12-45**