Final Report

PREPARING FLORIDA FOR DEPLOYMENT OF *SAFETYANALYST* FOR ALL ROADS

Contract No. BDK80 977-07

May 2012

Prepared by:

Lehman Center for Transportation Research
Florida International University

In cooperation with:

Research Center
State of Florida Department of Transportation

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Preparing Florida for Deployment of *SafetyAnalyst* for All Roads

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METRIC CONVERSION CHART

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
NOTE: volumes greater than 1000 L shall be shown in m^3				

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SafetyAnalyst is an advanced software system designed to provide the state and local highway agencies with a comprehensive set of tools to enhance their programming of site-specific highway safety improvements. As one of the 27 states that sponsored the development of SafetyAnalyst, the Florida Department of Transportation (FDOT) is interested in deploying the system for Florida for both state and local roads. This project was initiated to accomplish six major tasks as part of FDOT's overall SafetyAnalyst deployment effort. First, Florida-specific Safety Performance Functions (SPFs) for all roadway types for which data are available were developed. They included the SPFs for 17 segment subtypes, 4 signalized intersection subtypes, and 10 ramp subtypes. Second, the availability of the required average annual daily traffic (AADT) data for local roads from local agencies was investigated and summarized. Third, existing methods for estimating AADTs were reviewed and a new method for estimating AADTs for local roads using a parcel-based travel demand modeling approach was developed. Fourth, an existing mapping program developed by the University of South Florida (USF) to generate SafetyAnalyst data sets was reviewed and some mapping problems were identified and corrected. Fifth, a standalone desktop Geographic Information System (GIS) system customized for SafetyAnalyst input and output files was developed. Specifically, the system allows the user to graphically select site locations and to map SafetyAnalyst output. Finally, by applying the results from the tasks above, including the Florida-specific SPFs, the corrected mapping program, and the GIS system, statewide and district-wide lists of high crash locations for segments, signalized intersections, and ramps were successfully generated using SafetyAnalyst and presented in this report.</td></tr>
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Many individuals helped to provide data and information needed in his project, in particular:

- Mr. Benjamin Jacobs of the FDOT Safety Office helped with the crash data used in this project.
- Mr. Dan Tomich of ITT Exelis helped with the *SafetyAnalyst* GIS interface and the required input file structures.
- Dr. John Lu of the University of South Florida (USF) provided a software program to convert Roadway Characteristics Inventory (RCI) and crash data for *SafetyAnalyst* application.
- Mr. Mark Knoblauch of URS Corporation provided information on a method to estimate annual average daily traffic (AADT) for all roads.
- Ms. Tina Hatcher of the FDOT Transportation Statistics Office provided RCI data.

We would also like to thank the many local county officials for providing useful information on available traffic count data in their jurisdictions. Their timely responses were very much appreciated.

The software support provided by Dr. Kaiyu Liu and Mr. Haifeng Wang of the FIU Lehman Center for Transportation Research (LCTR) was critical to the completion of this project. Their contributions are gratefully acknowledged.

Last but certainly not the least, we would like to thank Ms. Vicki Morrison of the FDOT Research Center for her detailed review and editing of this report.

EXECUTIVE SUMMARY

SafetyAnalyst is a state-of-the-art analytical tool for making system-wide safety decisions. The software incorporates all the steps in the roadway safety management process and could act as a complete "safety toolbox" for any safety office. The main goal of this project is to prepare Florida for statewide deployment of *SafetyAnalyst* by accomplishing the following six objectives:

1. Develop Florida-specific SPFs for all roadway types for which data are available.
2. Investigate the availability of Annual Average Daily Traffic (AADT) data for local roads from local agencies.
3. Review AADT estimation methods and adopt or develop a method to estimate AADTs for local roads in Florida.
4. Verify and correct, as needed, the existing mapping program to generate *SafetyAnalyst* data sets using the latest roadway and crash data.
5. Develop a GIS system to allow easy selection of site locations and display *SafetyAnalyst* output.
6. Apply *SafetyAnalyst* and the GIS system to generate and visualize high crash locations based on the Florida-specific SPFs.

Development of Florida-specific Safety Performance Functions (SPFs)

To perform network screening, *SafetyAnalyst* implements the empirical Bayes (EB) method, which is data intensive, requiring the use of SPFs. *SafetyAnalyst* is equipped with a set of national default SPFs, and the software calibrates the default SPFs to represent the agency's safety performance. Agencies are recommended to generate agency specific SPFs whenever possible. Many investigators support the view that the agency-specific SPFs represent the agency data better than the national default SPFs calibrated to agency data. Further, it is believed that the crash trends in Florida are different from the states whose data were used to develop the national default SPFs.

In this project, Florida-specific SPFs were developed using 2008 Roadway Characteristics Inventory (RCI) data and crash and traffic data from 2007-2010 for both total and fatal and injury (F+I) crashes. As per the predefined subtypes used in *SafetyAnalyst*, segments were divided into 17 site subtypes based on area type, functional classification, and number of lanes. Florida-specific SPFs were developed for all the 17 predefined subtypes using the procedure similar to the development of national default SPFs. Florida-specific SPFs were then compared to the national default SPFs calibrated to Florida data using Freeman-Tukey R^2 statistic and overdispersion parameter.

Compared to segments, the data requirements to generate intersection SPFs are intense. One of the required variables for *SafetyAnalyst* to divide intersections into subtypes is traffic control type, and is not available in the required detail in the RCI database. Therefore, SPFs were developed for only four types of signalized intersections (rural and urban with three-leg and four-leg each). At this point, analysis of unsignalized intersections is not possible due to the lack of detailed data on traffic control type.

SafetyAnalyst classifies ramps into 16 subtypes based on ramp configuration, ramp type, and area type. This classification could not be used to generate Florida-specific SPFs as Florida has different ramp classifications. Therefore, SPFs for ramps were generated using Florida-specific subtypes.

Acquisition of Average Annual Daily Traffic

Average annual daily traffic (AADT) is one of the variables which must be imported into *SafetyAnalyst*. Nonetheless, AADT is sparsely available for local roads. Review of the segments database identified over 13,000 segments with missing traffic data, forcing these segments to be excluded from the analysis. Therefore, to be able to successfully import local roads into *SafetyAnalyst*, AADT has to be either acquired from local sources or estimated.

Out of the 67 counties, traffic data were successfully obtained from 42 counties. Twenty-five counties provided AADT, 13 provided average daily traffic (ADT), while three counties (Broward, Hillsborough, and Indian River) provided both AADT and ADT counts. The data were collected in four different formats (some counties provided information in more than one format). Thirty-two counties provided information in PDF, seven in Excel file, three as maps, and two counties provided their information in GIS format.

To estimate AADT values on local roads, a number of existing AADT estimation methods were reviewed, and a parcel-level travel demand model method was developed. The advantage of this method is that it optimizes the traditional four-step travel demand model method at the parcel level, and the trips between the parcels and the traffic count sites are distributed and assigned to estimate AADTs for local roads. The method was applied to study areas in Broward County, Florida and compared with two existing methods developed by the University of South Florida (USF) and the URS Corporation. The results show that the parcel-level travel demand method produces lower estimation errors than the other two methods. However, the evaluation was based on relatively limited traffic count data that were available to this project and further evaluation of the method with additional actual traffic counts will be needed to derive at a more definite conclusion of its performance.

Visualization of *SafetyAnalyst* Results

SafetyAnalyst provides only the data interface needed to exchange GIS data. Given the spatial nature of crash analysis, a GIS component to allow the user to graphically select locations and to display results from *SafetyAnalyst* would be an asset to Florida's application of *SafetyAnalyst*.

The following two major functions are served in the developed GIS system:

- Provide an alternate method for selecting locations for analysis by *SafetyAnalyst* using a graphical display and create new input file from graphical selections.
- Provide a graphical display of the output from the network screening module of *SafetyAnalyst*.

The developed GIS application presents an intuitive way to visualize both the input data and output data of *SafetyAnalyst*. With this application, the user will be able to perceive data in relation to space.

Generation of Import Files for *SafetyAnalyst*

SafetyAnalyst has stringent data requirements and a steep learning curve, often hindering its extensive adoption. In 2009, University of South Florida (Lu et al., 2009) had developed a software program, *SafetyAnalyst* Data Converter (SADC), to automate the process of generating import files. The program is able to generate *SafetyAnalyst* import files for roadway segments using a sample data set based on the 2007 crash data. However, the program is not able to generate data sets for intersections and ramps.

Review of SADC source code and the generated import files revealed a few mapping issues. Fewer and fixable issues were found with the segments file. The major problem lies with intersections and ramps. Import files for intersections cannot be generated because of lack of detailed information on traffic control type. Ramps present a different issue. The predefined classification of ramps used in *SafetyAnalyst* could not be used with Florida data as Florida uses entirely different ramp configuration types.

In summary, SADC generates import files for segments along with their corresponding crash and traffic data files. The import files for intersections are incomplete, requiring updated data mapping and complete attributes for traffic control type. The import files generated for ramps might be unusable as the predefined subtypes used in *SafetyAnalyst* are different from Florida-specific categories.

Identification of High Crash Locations

SafetyAnalyst was used to perform network screening (i.e., identify and prioritize locations with greatest potential for safety improvement) on the entire segment (i.e., both state and local roads), ramp, and signalized intersection databases in Florida. Statewide and district-wide lists of high crash locations for each of the 17 predefined segment subtypes from *SafetyAnalyst* were presented. High crash locations on ramps were identified using Florida-specific ramp classifications and Florida-specific SPFs. High crash locations on signalized intersections were identified using Florida-specific SPFs. Only the signalized intersections that have traffic data on all of its approaches were used to generate the list of high crash locations. Detailed investigation of the generated error logs revealed a few issues with the data.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS/ABBREVIATIONS

AADT	Average Annual Daily Traffic
AADW	Average Annual Day-of-Week
AASHTO	American Association of State Highway and Transportation Officials
ADT	Average Daily Traffic
ANN	Artificial Neural Network
ATR	Automatic Traffic Recorder
C	Calibration Factor
CAR	Crash Analysis Reporting
CART	Classification And Regression Tree
CMF	Crash Modification Factors
CSV	Comma-Separated Value
DA	Dissemination Areas
DOR	Department of Revenue
DOT	Department of Transportation
DySeg	Dynamic Segmentation
EB	Empirical Bayes
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
F+I	Fatal and Injury
FIU	Florida International University
GFA	Gross Floor Area
GIS	Geographic Information System
GLM	Generalized Linear Model
HCL(s)	High Crash Location(s)
HPMS	Highway Performance Monitoring System
HSIS	Highway Safety Information System
HSIP	Highway Safety Improvement Program
HSM	Highway Safety Manual
HTBR	Hierarchical Tree-Based Regression
IHSDM	Interactive Highway Safety Design Model
IIA	Interchange Influence Area
ITE	Institute of Transportation Engineers
LCTR	Lehman Center for Transportation Research
LOS	Level of Service
LRS	Linear Referencing System
MADW	Monthly Average Day-of-Week
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
MARS	Multivariate Adaptive Regression Splines
MPO	Metropolitan Planning Organization
MVM	Million Vehicle Miles
NB	Negative Binomial
NCHRP	National Cooperative Highway Research Program
NN	Neural Network

PDO	Property Damage Only
PSI	Potential for Safety Improvement
R^2_{FT}	Freeman-Tukey R^2 Coefficient
RCI	Roadway Characteristics Inventory
RMSE	Root Mean Squared Error
RTM	Regression-to-the-Mean
SADC	*SafetyAnalyst* Data Converter
SPF	Safety Performance Function
SVR	Support Vector Regression
TAZ	Traffic Analysis Zone
TDM	Travel Demand Modeling
TMG	Traffic Monitoring Guide
TPO	Transportation Planning Organization
TWLTL	Two-way Left Turn Lane
UF	University of Florida
USF	University of South Florida
V/C	Volume to Capacity Ratio
VMT	Vehicle Miles Traveled
VRICS	Visual Roadway Inventory Collection System
XML	Extensible Markup Language
ZIP	Zero-Inflated Poisson

CHAPTER 1
INTRODUCTION

1.1 Research Needs

SafetyAnalyst was developed as a cooperative effort by the Federal Highway Administration (FHWA) and participating state and local agencies. First released as an AASHTOware product in 2010, the system is designed to provide the state and local highway agencies with a comprehensive set of tools to enhance their programming of site-specific highway safety improvements. As one of the 27 participating state agencies in the development of *SafetyAnalyst*, the Florida Department of Transportation (FDOT) planned to deploy *SafetyAnalyst* to enhance the safety improvement programs of both state and local roads in Florida. This project was initiated to address the following three research needs as part of the overall deployment plan:

1. *SafetyAnalyst* is designed to account for the regression-to-the-mean (RTM) bias in the traditional practice of selecting locations for safety improvements. The RTM bias results in the overestimation of crash reduction, thus, the effectiveness of safety measures. To address this bias, *SafetyAnalyst* implements the empirical Bayes (EB) method which requires the use of safety performance functions (SPFs). Although *SafetyAnalyst* includes a set of default SPFs developed with data from several states, locally calibrated SPFs that can better reflect Florida's crash experience are preferred.

2. *SafetyAnalyst* requires average annual daily traffic (AADT) as input. The availability of AADT data for local roads in the local jurisdictions was not fully known. However, FDOT was aware that some local jurisdictions had regularly collected traffic counts while some others had not collected any. Research was thus needed to determine the extent of AADT data availability from local jurisdictions. Research was also needed to either adopt or develop a method to estimate AADTs for local roads so that *SafetyAnalyst* can be deployed in jurisdictions that either do not have any AADT data or do not have AADT data that are of sufficient quantity and/or quality.

3. *SafetyAnalyst* does not come with any visualization capability. It assumes that an agency will adapt its existing Geographic Information System (GIS) to provide that capability, if desirable. Accordingly, the system provides only the data interface needed to exchange data between *SafetyAnalyst* and an agency's GIS system. However, FDOT does not have an existing GIS system that can be adapted for *SafetyAnalyst* application. Given the spatial nature of crash analysis, it is highly desirable that GIS be part of Florida's application of *SafetyAnalyst*.

In addition to the above research needs, another major deployment effort involves the conversion of existing roadway and crash data into the format required by *SafetyAnalyst*. In 2008, FDOT contracted with the University of South Florida (USF) to convert its roadway and crash data for Florida's state roadway system. The project included mapping of attribute values and a software program to perform the actual data mapping and generate *SafetyAnalyst* input data sets. The program was able to generate *SafetyAnalyst* data sets for roadway segments using a sample data set based on the 2007 crash data. The program was not able to generate data sets for two other major roadway subtypes defined in *SafetyAnalyst*, i.e., intersections and ramps.

1.2 Project Objectives

The objectives of this project are:

1. Develop Florida-specific SPFs for all roadway types for which data are available.
2. Investigate the availability of AADT data for local roads from local agencies.
3. Review AADT estimation methods and adopt or develop a method to estimate AADTs for local roads in Florida.
4. Verify and correct, as needed, the data mapping scheme developed by USF and apply the mapping program to generate *SafetyAnalyst* data sets for segments, intersections, and ramps using the latest roadway and crash data.
5. Develop a GIS system that allows the user to graphically select site locations and to display *SafetyAnalyst* output.
6. Apply *SafetyAnalyst* and the GIS system to generate and visualize high crash locations based on the Florida-specific SPFs.

1.3 Report Organization

The rest of the report is organized as follows. Chapter 2 is devoted entirely to the calibration of local SPFs for Florida's application of *SafetyAnalyst*. Chapter 3 summarizes findings from a statewide inquiry of traffic counts and AADT data collected by local jurisdictions in Florida. It also details the development of a new AADT estimation method. Chapter 4 briefly summarizes the working of the USF conversion program and documents the corrections made to the original data mapping scheme and the steps taken to overcome some of the problems encountered in the program. Chapter 5 describes the working and functionalities of a standalone desktop GIS system developed for selecting site locations and display high crash locations and associated statistics generated by *SafetyAnalyst*. Chapter 6 presents the high crash locations generated by *SafetyAnalyst* based on the SPFs developed in this project. Finally, Chapter 7 provides a summary of this project effort and makes several recommendations for further improvements.

CHAPTER 2
DEVELOPMENT OF FLORIDA-SPECIFIC SAFETY PERFORMANCE FUNCTIONS (SPFs)

This chapter is devoted to the development of local Safety Performance Functions (SPFs) for Florida's application of *SafetyAnalyst*. A comprehensive review of studies for developing SPFs for various roadway types, including segments, intersections, and ramps is provided. As *SafetyAnalyst* is being advertised as a software tool to automate Part B of the Highway Safety Manual (HSM), the HSM and *SafetyAnalyst* are discussed in detail along with the differences between the two tools. Following the literature review and discussion of the two tools, the methods used to develop Florida-specific SPFs are described. These local SPFs are then compared with the national default SPFs that are calibrated to Florida data. Finally, a summary of the analysis approach and the results are presented.

2.1 Literature Review

This section provides a comprehensive review of studies about SPFs, including full SPFs, simple SPFs, and the SPFs used in the HSM. The differences between the HSM and *SafetyAnalyst* are also discussed.

2.1.1 Full SPFs

The HSM (2010) defines SPFs as regression models for estimating the predicted average crash frequency of individual roadway sections or intersections. There are two main types of SPFs: full SPFs and simple SPFs. Review of the full SPFs for roadway segments and intersections is presented in this section.

2.1.1.1 Roadway Segments

Arterials

The mathematical relationships between crashes and roadway geometric design features (lane width, shoulder width, horizontal curvature, vertical grade, etc.) have been widely studied. As summarized in NCHRP Report 197 (1978), multiple linear regression models were frequently employed in establishing the relationship between crashes and geometric features. However, the undesirable outcome of using a multiple linear regression model was evidenced by the following studies. For example, Zegeer et al. (1990) used multiple linear regression models and the results showed that more than half of the roadway sections had no crashes during the observed period. Jovanis and Chang (1986) discussed in their paper that the distribution of crash occurrences is positively skewed, and that the underlying normal distributional assumption for linear regression is not a good approximation for investigating this relationship.

In contrast to multiple linear regression models, the Poisson regression models became widely used for modeling crashes and influencing factors. Joshua and Garber (1990) provided Poisson regression models to establish mathematical relationships between large truck crashes on Virginia rural highways, and traffic and geometric variables. The length of each roadway section was restricted to a maximum of two miles. All the selected sites were grouped into the following three environments by roadway configurations and traffic volumes: Environment I (primary highways, undivided, four-lane and two-lane, with AADT < 15,000 veh/day); Environment II (primary highways, divided, four-lane, with AADT ≤ 15,000 veh/day); and Environment III (Interstate/primary highways, divided, four-lane, with AADT > 15,000 veh/day). Equations (2-1), (2-2), and (2-3) show the prediction models for Environments I, II, and III, respectively.

$$Crashes/year = 0.015237 \times (SCR)^{0.0577} \times (AADT)^{0.5024} \times (TPERCNT)^{0.5731} \tag{2-1}$$

$$Crashes/year = 9 \times 10^{-8} \times (SCR)^{0.0471} \times (AADT)^{1.4358} \times (TPERCNT)^{1.5232} \times (SEGLEN)^{0.3826} \tag{2-2}$$

$$\begin{aligned} Crashes/year &= 0.001465 \times (CCR)^{0.0336} \times (AADT)^{0.7086} \times (TPERCNT)^{0.2064} \\ &\times (SEGLEN)^{0.3318} \times (SPDIFSQ)^{0.0475} \end{aligned} \tag{2-3}$$

where,

SCR	=	slope change rate,
AADT	=	average annual daily traffic,
TPERCNT	=	truck percentage,
SEGLEN	=	segment length,
CCR	=	curvature change rate, and
SPDIFSQ	=	speed difference.

These models indicated that slope change rate, AADT, truck percentage, and speed differences between trucks and non-trucks influenced crash occurrence. However, these models did not consider any exposure (AADT or segment length) for predicting crash occurrence, which leads to the conclusion that crash frequency would be zero if any of the variables were equal to zero (e.g., crashes would occur on a roadway section with no slope change).

Miaou et al. (1992) presented empirical relationships obtained through Poisson regression analyses, relating truck crashes with key highway geometric design variables by using a data source administered by Federal Highway Administration (FHWA), from the Highway Safety Information System (HSIS). Miaou et al. (1991) provides the descriptions of the HSIS database. In the aforementioned study, four models were developed using different horizontal curvature and vertical grade measures. For example, the following model was developed from 5,105 rural interstate highway sections based on the data from 1985 to 1987:

$$Accidents/truck - mile/year = e^{-14.6833 + 0.044691X_1 + 0.172513X_2 + 0.162218X_3 + 0.03859X_4} \tag{2-4}$$

where,

X_1	=	AADT per lane (thousands of vehicles),
X_2	=	horizontal curvature (degree/100 ft arc),
X_3	=	vertical grade (%), and
X_4	=	deviation from ideal shoulder width.

The final model suggested that AADT, horizontal curvature, and vertical grade were significantly correlated with truck crash occurrences, but shoulder width had comparatively less correlation. Due to the use of the exponential form in the model, it did not predict zero crashes when the variables were equal to zero. As such, it is found to be more reasonable than the earlier discussed Joshua and Garber models (1990).

Maher and Summersgill (1996) indicated the weaknesses and technical difficulties, such as the low mean value problem, overdispersion, disaggregation of data over time, uncertainty of predictions, random errors in flow estimates, and aggregation of predictions, for the application of the pure Poisson model. Given these shortcomings, the authors emphasized that the technique of generalized linear models (GLMs) with Poisson error structure offered the most appropriate and sound approach for data analysis. These models were then used by the U.K. Transport Research Laboratory.

A known limitation in applying the Poisson regression model is that the variance is constrained to be equal to the mean of the data set (Dean and Lawless, 1989). However, unlike the property of the most common count-data modeling approach, the variance of the crash counts for crash frequency exceeds the mean. Therefore, when overdispersed data are present, the Poisson regression model will result in biased and inconsistent parameter estimates, which in turn could lead to erroneous inferences regarding the factors that determine crash frequencies (Lord and Mannering, 2010).

Miaou's (1994) paper evaluated and compared the performance of Poisson, Zero-Inflated Poisson (ZIP), and Negative Binomial (NB) regression models in establishing the relationship between truck crashes and the geometric design of road sections. The HSIS data were used to estimate the performance of these models, and unknown parameters were estimated by maximum likelihood. The author concluded that the Poisson regression model could be used as an initial model in developing the relationship between truck crashes and geometric features. If the overdispersion of crash frequency data was found to be moderate or high, the ZIP or NB regression models could be considered.

The ZIP regression model is believed to be an appropriate model when data are characterized by a significant percentage of zero values. Qin, Ivan, and Ravishanker (2004) used ZIP regression in estimating crash predicting models for crash types (single-vehicle, multi-vehicle same direction, multi-vehicle opposite direction, and multi-vehicle intersecting) as a function of AADT, segment length, speed limit, and roadway width for roadway segments in Michigan using crash and roadway characteristics data from HSIS. They came to the conclusion that, as opposed to the relationship between crashes and segment length for all crash types, the relationship between crashes and AADT is nonlinear and varies by crash type.

The NB model is an extension of the Poisson model to overcome possible overdispersion in the data. Overdispersion means that the variance of the crash data is greater than its mean. The NB distribution contains two parameters: the mean μ and the dispersion parameter α or its inverse $(1/\alpha)$. The dispersion parameter is used to capture the extra-variation observed in the crash data. Miaou (1996) found that the dispersion parameter α can be used as a measure of goodness-of-fit. Wood (2005) also used the dispersion parameter to estimate the confidence intervals for the

Poisson mean and gamma mean. Zhang et al. (2007) used the bootstrapped maximum likelihood method to estimate the dispersion parameter of the NB model for analyzing crash data. Furthermore, Park and Lord (2008) used simulation to adjust the maximum likelihood estimate of the NB dispersion parameter, where simulation scenarios were used to develop a relationship between the estimated and the true dispersion parameters.

Sawalha (2002) collected crash data on 58 arterials from the cities of Vancouver and Richmond for years 1994 through 1996, and generated a prediction model using the NB method. The crash data collected consisted of crash locations, severities, and crash types, as well as the light, weather, and road conditions at the time of crash. The following model form was used:

$$\lambda = a_0 \times L^{a_1} \times V^{a_2} \times e^{\sum_{j=1}^{m} b_j x_j} \tag{2-5}$$

where,

λ	=	predicted crash frequency,
L	=	section length,
V	=	section annual average daily traffic,
x_j	=	any of m variables additional to *L*, and *V*, and
a_0, a_1, a_2, b_j	=	model parameters.

The roadway sections were divided into segments between consecutive signalized intersections. The geometric data considered were segment length, number of lanes, number of driveways, number of bus stops, number of crosswalks, median types, land use, etc. This crash prediction model appeared to be one of the strongest as it demonstrated a robust goodness-of-fit.

Various studies have been conducted on the relationship between crash occurrences and relative variables for specific roadway facilities and characteristics using the NB regression model. This research confirmed the advantages of the NB model over the Poisson model. Based on the NB regression, Bowman et al. (1995) generated vehicle crash models for different median types (raised median, two-way-left-turn (TWLT) median, and undivided cross-section) in urban and suburban unlimited access arterials. The prediction ratio plots derived from the data displayed a relatively equal distribution of predicted vehicle crashes. The prediction models further showed that the raised curb and undivided cross-section models had the largest deviation, while the TWLT median had the smallest. The number of signalized intersections was not included in the models because it was not as significant as the other independent variables. Moreover, Mountain et al. (1996) developed crash prediction models for roads with minor junctions at both single- and dual-carriageway roads in urban and rural areas in the U.K. Using the NB regression model based on data for 3,800 km of highway, this study included more than 5,000 minor junctions. In addition to the aforementioned research, safety analysis employing the NB regression model can also be found in many other references (Anastasopoulos and Mannering, 2009; Abdel-Aty and Radwan, 2000; Sawalha and Sayed, 2006).

Freeways

Since the 1990s, crash prediction models for freeways have been gaining importance. Fazio et al. (1993) used freeway conflict rates as an alternative to crash rate to perform the safety analysis by simulating freeway weaving sections on Interstate 294. The conflict rates were found to be significantly related to crash rates.

Persaud and Dzbik (1993) developed the generalized linear crash prediction models with NB error structure. The study showed that the crash patterns on freeway sections during congested periods differ from that of uncongested periods. Resende and Benekohal (1997) calibrated a crash prediction model for rural freeways based on volume-to-capacity ratio by using multiple linear regression techniques. Capacity was considered to be an important variable in this model.

Kraus et al. (1993) explored the relationship between crashes by type and independent variables such as geometric features, time of day, and traffic flow rate by developing a nonlinear prediction model for urban freeway sections regardless of their locations in relation to interchanges. Khan et al. (1999) also developed a nonlinear regression model, but focused on the relationship between crashes stratified by severity and traffic volume, segment length, and vehicle mile traveled. Traffic volume, topological characteristics, and weather conditions were considered as the independent variables by Konduri and Sinha (2002) when they generated the crash prediction model using a nonlinear modeling approach.

Garber and Ehrhart (2000) developed mathematical relationships that describe the combined influence that traffic and geometric characteristics have on crash occurrences. The study was limited to roadways in Virginia with speed limits of 55 or 65 mph. Using the variables of mean speed, standard deviation of speed, flow per lane, lane width, and shoulder width to predict crash rates, different types of deterministic models, such as multiple linear regression, robust regression, and multivariate ratio of polynomials were fitted to the data. R^2 and minimum Akaike Information Criterion (*AIC*) were seen as the standards to choose the best models. For example, the best model of freeway with 65 mph speed limit is:

$$
\begin{aligned}
&\mathrm{Ln}(CRASHRATE) = 2629.697 - 0.424 \times SD^2 - (5.427\mathrm{E}-04 \times SD^4)\ - \\
&2254323 \times 1/FPL^2 + 4.490 \times SD^2 \times 1/FPL^2\ - (5.397\,\mathrm{E}+08 \times 1/FPL^2)^2 \\
&- 510.682 \times \mathrm{sqrt}(MEAN) + (5.171\mathrm{E}-02 \times SD^2) \times \mathrm{sqrt}(MEAN) \\
&+ 224565.2 \times 1/FPL^2 \times \mathrm{sqrt}(MEAN) + [24.69 \times \mathrm{sqrt}(MEAN)]^2
\end{aligned}
\tag{2-6}
$$

where,

CRASHRATE	=	crash rate,
SD	=	standard deviation of speed,
FPL	=	flow per lane, and
MEAN	=	mean speed.

Even though complex, these models showed the relationship between crash rates and the independent variables, standard deviation of speed, mean speed, and flow per lane. These models also showed that the crash rate is not solely determined by any one of the independent variables, but by a complex interaction of these independent variables.

Several new ideas and techniques were used in the safety analysis of freeways. Golob et al. (2004) assessed the level of safety on freeways in terms of crash type, crash locations, and severity by using a clustering technique. Lord et al. (2005) studied the crash-flow-density and crash-flow-v/c ratio relationships for rural and urban freeway segments located both downtown and outside of Montreal, Quebec. These results showed that single-vehicle crashes and multi-vehicle crashes should be separated in the analysis. The prediction model using vehicle density and v/c ratio as a covariate thus offered a better characterization of the crash.

Machine learning refers to a system capable of autonomous acquisition and integration of knowledge. This capacity to learn from experience, analytical observation, and other means, results in a system that can improve its own performance. Machine learning has received increasingly more attention from transportation researchers as a promising technique in safety analysis. To overcome the weakness of Poisson or NB regression models, the underlying relationship between dependent and independent variables were predefined by Classification And Regression Tree **(**CART**)**. Employed by Chang (2005) to analyze freeway crash frequency, CART is one of the most widely applied data mining techniques. The CART findings indicated that the average daily traffic volume and precipitation variables were the key determinants for freeway crash frequencies.

Pande and Abdel-Aty (2006) used both the historical crash and real-time traffic parameters obtained from loop detectors to calibrate the neural network (NN) models for the purpose of predicting the occurrence of lane-change related freeway crashes. The results indicated that these models may be applied for identifying real-time traffic conditions prone to lane-change related crashes. Relative studies of the NN model on freeways could be found in several references (Cheu and Ritchie, 1995; Chang, 2005; Kononov et al., 2008). Abdel-Aty et al. (2004) also applied another machine learning method, matched case-control logistic regression, to predict freeway crashes based on loop detector data.

In addition to safety analysis on freeways, the machine learning technique has also been widely used in other roadway facilities and fields related to traffic safety. For example, Kuhnert et al. (2000) employed logistic regression, CART, and Multivariate Adaptive Regression Splines (MARS) to analyze motor-vehicle injury data. Karlaftis and Golias (2002) applied hierarchical tree-based regression (HTBR) to analyze the effects of road geometric and traffic characteristics on crash rates for rural two-lane and multilane roads. Haleem et al. (2010) fitted and compared the NB and MARS models by using data collected on unsignalized intersections in Florida. The results showed MARS to be a promising technique for predicting crashes, especially for continuous response variables.

2.1.1.2 Intersections

About 50% of crashes occur at intersections, and severe crashes are disproportionately higher due to the high frequency of left turn and angle collisions. Therefore, it is important to identify the methods that can assess the effects that intersection geometry, traffic flow, traffic control type, and environmental and operational characteristics have on traffic crashes at intersections (Abdel-Aty and Keller, 2005).

Several approaches were developed to study the relationship between the safety of roadway intersections and influencing factors. The multiple logistic regression model, multiple linear regression model, Poisson regression model, NB regression model, random effects model, and the CART model are reviewed herein.

Yan et al. (2005) used the Quasi-induced exposure concept and the multiple logistic regression technique to identify the risk elements related to the roadway environment and operational characteristics in rear-end crashes for 2001 in the state of Florida. The concept of Quasi-induced exposure is described in a paper by Stamatiadis and Deacon (1997).

Bauer and Harwood (2000) applied multiple linear regression analysis in developing crash prediction models for at-grade intersections in California, using three years of crash data from 1990 to 1992 and geometric design, traffic control, and traffic volume data. Five types of intersections were modeled: rural four-leg stop-controlled intersections, rural three-leg stop-controlled intersections, urban four-leg stop-controlled intersections, urban three-leg stop-controlled intersections, and urban four-leg signalized intersections. The multiple linear regression was used for four-leg stop-controlled and signalized intersection, while Poisson and NB regression were used for the remaining types.

The advantages of Poisson and NB regression models over the multiple regression models have been confirmed by previous investigations. Several studies (Poch and Mannering, 1996; Sayed and Rodriguez, 1999; Vogt, 1999; Bauer and Harwood, 2000; Harnen et al., 2003; and Salifu, 2004) presented the empirical relationships obtained through the Poisson regression analyses and/or NB techniques, relating the crashes with traffic flow, traffic control, and key highway geometric design variables. The results from all models indicated that roadway geometric, vehicular, and operational features had an effect on crash frequency. Therefore, those factors that significantly affect crashes should be given more attention in crash analyses at intersections. These regression models were also employed in other studies at intersections (e.g., Wang and Abdel-Aty, 2006).

Random effects models assume that intersection crash data are hierarchical in nature, with crash-level and intersection-level hierarchies. The crashes represent the lowest level of the hierarchy, while the intersection at which the crashes occurred represents the higher-level hierarchy or cluster. In this model, crash frequencies and types observed at a particular location are correlated. Studies using the random effects model (Kim et al., 2007; Huang et al., 2007), confirmed the contributions of traffic flow, traffic control, geometric and driver characteristics, vehicle types, and environmental characteristics to the crashes at intersections.

The report prepared by Nambuusi et al. (2008) introduced the crash prediction models for urban intersections based on CART technique, which is used to group crashes based on crash and intersection types by splitting the data into branches on a tree diagram. The prediction model involved three levels: Level 1-Generation of the base model, Level 2-Grouping intersections by CART, and Level 3-Adjustment by Crash History. This technique can be used to obtain the number of crashes for each injury severity, and the number of crashes for each intersection type.

Various techniques were used to assess the goodness-of-fit of different models, including the deviance, the Chi-square statistic, the adjusted R-square, and the pseudo R-square (likelihood ratio index). It was difficult to compare the goodness-of-fit among the models because different measures are used and the fitted models had different objectives (Nambuusi et al., 2008).

2.1.2 Simple SPFs

Simple SPFs, also referred to as traffic SPFs, are mathematical models that link crash occurrence to traffic volume alone at specific roadway types. The simple SPFs take the form of an NB model, as adopted in the HSM. For simple SPFs, Crash Modification Factors (CMFs) are applied for prediction purposes to adjust from the base conditions to the prevailing conditions.

2.1.2.1 Roadway Segments

Arterials

Persaud (1992) developed an SPF using the data from 1988 to 1989 for rural two-lane roads in Ontario. The functional form is shown as follows:

$$Crashes/(km\text{-}year) = a \times (AADT/1000)^{b} \tag{2-7}$$

Table 2-1 gives the regression coefficients a and b.

Table 2-1: Regression Coefficient Estimates

Lane width	Total Crashes				Fatal and Injury Crashes			
	< 6.1 m	< 6.1 m	> 6.1 m	> 6.1 m	< 6.1 m	< 6.1 m	> 6.1 m	> 6.1 m
Shoulder width	< 1.8 m	> 1.8 m	> 1.8 m	< 1.8 m	< 1.8 m	> 1.8 m	> 1.8 m	< 1.8 m
b	0.73300	0.89200	0.89200	0.7330	0.78300	0.97100	0.97100	0.78300
a	0.00287	0.00096	0.00069	0.0025	0.00067	0.00018	0.00012	0.00054

Using data on two-lane rural roads in New York State for the period of 1971 through 1987, Hauer (1994) developed the following SPF to estimate total crashes:

$$Crashes/(km\text{-}year) = 0.00244 \times (AADT)^{0.776} \tag{2-8}$$

Using the 1988 and 1989 data for urban two-lane roads in Ontario, Persaud (1992) developed the following SPF:

$$Crashes/(km\text{-}year) = 0.00369 \times (AADT)^{0.72} \tag{2-9}$$

Freeways

Persaud (1991) presented a method for estimating the underlying crash potential of Ontario using 404 freeway sections. The NB regression models were initially used to produce an initial estimate of a section's crash potential on the basis of its traffic and geometric characteristics. This estimate was then refined by combining with the section's crash count, using an empirical Bayes (EB) procedure. The NB prediction model is as follows:

$$Accidents\ /\ year = 0.6278 \times SCL \times \left(AADT/1000\right)^{1.024} \tag{2-10}$$

where,

SCL	=	section length and
$AADT$	=	annual average daily traffic.

The author emphasized that the geometric features were not considered in the prediction model because these variables occurred with remarkable consistency on freeways with higher design criteria. The precision of the model, therefore, would not be improved with any additional variables.

Persaud (1992) developed the following SPF for freeways based on the 1988 and 1989 data from Ontario. Table 2-2 gives the regression coefficients *a* and *b*.

$$Crashes/km/yr = a \times (AADT)^{\ b} \tag{2-11}$$

Table 2-2: Regression Coefficient Estimates

Crash Type	Number of Lanes	a	b
Total	4	0.0000474	1.155
Total	> 4	0.0000978	1.113
Fatal and Injury	4	0.0000206	1.136
Fatal and Injury	> 4	0.0000122	1.212

Huang et al. (1991) developed the following SPFs for total and F+I crashes, respectively, based on the data from California freeways:

$$Total\ crashes = 0.65 + 0.666 \times Million\ Vehicle\ Miles \tag{2-12}$$

$$Fatal + Injury\ crashes = 0.166 + 0.263 \times Million\ Vehicle\ Miles \tag{2-13}$$

Kiattikomol et al. (2008) generated regression models for crash prediction on interchange and non-interchange segments for urban freeways, at a planning level. The impacts of interchanges on freeways were discussed, and prediction models were generated for both interchange and non-interchange segments. For example, the following equations show the modeling approaches used for Tennessee freeways:

For non-interchange segments:

$$N = a(L)^{b_1}(AADT)^{b_2} \tag{2-14}$$

For interchange segments with four lanes:

$$N = (L)^{b_1}(AADT)^{b_2} \tag{2-15}$$

where,

N	=	expected number of crashes in a three-year period,
$a, b_1, and\ b_2$	=	estimated parameters,
AADT	=	annual average daily traffic (vehicles per day), and
L	=	segment length (miles).

2.1.2.2 Intersections

Lau et al. (1989) used signalized intersections data from 1986 through 1988 from California to develop SPFs for intersections. Separate models were developed for fatal, injury, and PDO crashes using three levels of estimation. At level 1, the following three SPFs were used if the volume of traffic entering an intersection is known:

$$Fatal\ crashes/year = 0.018 \qquad (2\text{-}16)$$

$$Injury\ crashes/year = 0.61856 + 0.16911 \times Million\ Entering\ Vehicles \qquad (2\text{-}17)$$

$$PDO\ crashes/year = 4.6029 + 0.5142 \times Million\ Entering\ Vehicles \qquad (2\text{-}18)$$

If further information is available about an intersection, such as intersection design, control characteristics, proportion of cross street traffic, and environmental features, level 2 estimates were used. At level 2, intersections were classified by group and a "group constant" was added to the value estimated by the SPFs in Equations (2-16), (2-17), and (2-18). Groups were separated by fatal, injury, and PDO crashes. Level 3 was used when the individual crash history of an intersection was available, in addition to the information for levels 1 and 2. It is noted that level 3 was based on EB, and the results represent future safety estimates of existing intersections. In addition, Lau et al. (1989) used a four-leg urban signalized intersection with AADT of 49,000 veh/day and 10,000 veh/day for major and minor streets, respectively. All approaches in this investigation were two-lane and the signal control was a pre-timed cycle with a permitted left turn phase. The design speed was 50-54 mph.

McDonald (1953) used data from rural unsignalized intersections located on divided highways to develop the following SPF:

$$Crashes/year = 0.000783 \times (AADTmajor)^{0.455} \times (AADTminor)^{0.633} \qquad (2\text{-}19)$$

Using the HSIS data from 1985 to 1987 for 125 rural unsignalized intersections in Minnesota, Bonneson and McCoy (1993) developed the following SPF:

$$Crashes/year = 0.000379 \times (AADTmajor)^{0.256} \times (AADTminor)^{0.831} \qquad (2\text{-}20)$$

Webb (1955) used data from 96 signalized intersections on high-speed rural state roadways in California to develop the following SPF:

$$Crashes/year = 0.00703 \times (AADTmajor)^{0.51} \times (AADTminor)^{0.29} \qquad (2\text{-}21)$$

Using the HSIS data for rural signalized intersections, Bonneson and McCoy (1993) developed the following SPF:

$$Crashes/year = 0.00703 \times (AADTmajor)^{0.7213} \times (AADTminor)^{0.3663} \qquad (2\text{-}22)$$

McGee and Blankenship (1989) developed the crash rates (as shown in Table 2-3) using data from urban unsignalized intersections in Seattle, Milwaukee, Rapid City, and Madison.

Table 2-3: Crash Rate (Crashes/Million Entering Vehicles)

Major Street AADT	Minor Street AADT						
	100	**300**	**500**	**700**	**900**	**1250**	**2000**
250	2.19	2.09	2.01	1.99	2.03	1.72	1.22
750	1.06	1.44	1.53	1.57	1.58	1.49	1.14
1250	0.73	1.15	1.25	1.31	1.34	1.36	1.09
1750	0.64	0.92	1.12	1.26	1.19	1.17	0.91
2500	0.53	0.73	0.90	1.02	1.04	0.99	0.88
3500	0.43	0.57	0.69	0.80	0.83	0.81	0.75

Using data on urban signalized intersection of one-way streets in Philadelphia, Persaud et al. (1995) developed the following SPF:

$$Crashes/year = a \times (AADTmajor)^{b} \times (AADTminor)^{c} \tag{2-23}$$

Table 2-4 gives the regression coefficients *a* and *b*.

Table 2-4: Regression Coefficient Estimates

Parameter	**Crash Types**		
	Right-angle and Turn	Rear-end	Pedestrian
a	0.0002037	0.0002099	0.0009039
b	0.5941000	0.6758000	0.5150000
c	0.3540000	0.0000000	0.0000000

2.1.2.3 Ramps

Jovanis and Chang (1986) used Poisson regression to model the relationships between crash frequency, traffic volumes, and weather conditions. A more general form of Poisson regression, NB model was later used to explore the relationship between crash frequencies, daily traffic and highway geometric design variables (Miaou, 1994; Le and Porter, 2012). In the NB model, the expected number of crashes of type *i* on segment *j* is expressed as:

$$\mu_{ij} = E(Y_{ij}) = e^{(x_j\beta + ln(L_j))} \tag{2-24}$$

where,

μ_{ij} = the expected number of crashes of type *i* on segment *j*,
x_j = a set of traffic and geometric variables characterizing segment *j*,
β = regression coefficients estimated with maximum likelihood that quantify the relationship between $E(Y_{ij})$ and variables in *X*, and
L_j = length of segment *j*.

Parajuli et al. (2006) developed the following simple SPFs for ramps considering AADT as the only independent variable:

$$Collisions\ /\ year = a(AADT)^{b} e^{(length)} \tag{2-25}$$

where,

AADT = annual average daily traffic volume (vehicles per day),

Length = ramp length (mile), and
a, b = regression coefficients.

2.1.3 Advanced Safety Analysis Tools

The past decade has developed momentum for much awaited change in the highway safety culture resulting in understanding the need for more advanced and statistically proven techniques of highway safety improvement. The HSM, *SafetyAnalyst*, and the Interactive Highway Safety Design Model (IHSDM) are three major safety analysis tools developed and funded by the federal government. These tools have the potential to define a new era in highway safety. The HSM was released in July 2010, while *SafetyAnalyst* and IHSDM were released in March 2010 and 2003, respectively.

For their complete implementation, advanced tools require a wide range of data in comparison to the basic methods. For example, *SafetyAnalyst* and the HSM require SPFs which are rarely available at the state level. As such, both tools come with a set of default SPFs. The default SPFs for *SafetyAnalyst* were developed using multiple year data from California, Minnesota, Ohio, and Washington. The default SPFs for HSM were from various states and different analysis periods. On another note, IHSDM and HSM require complete geometric alignment information. For IHSDM, this requirement only includes geometric data for the sections under evaluation. For calibrating the default SPFs in the HSM, complete geometric and roadside information for 30-50 roadway locations with a minimum of 100 crashes/year are required.

Even though the three tools use (or recommend using) empirical Bayes analysis, they are quite different from one another. IHSDM "is a suite of software analysis tools for evaluating safety and operational effects of geometric design decisions on highways" (FHWA, 2001). The HSM "presents tools and methodologies for consideration of 'safety' across the range of highway activities: planning, programming, project development, construction, operations, and maintenance" (HSM, 2010). *SafetyAnalyst* "provides state-of-the-art analytical tools for use in the decision-making process to identify and manage a system-wide program of site-specific improvements to enhance highway safety by cost-effective means" (AASHTO, 2010). In summary, IHSDM is geared toward roadway safety relating to geometric design, while the HSM and *SafetyAnalyst* deal with comprehensive safety data analyses and roadway safety management process. The following sections discuss the HSM and *SafetyAnalyst*, and their differences.

2.1.3.1 Highway Safety Manual

The HSM provides analytical tools for quantifying effects of potential changes at individual sites. The HSM is designed mainly for site-specific analysis. Even though the HSM can be used for statewide analysis, its extensive data needs can become burdensome. The HSM "presents tools and methodologies for consideration of 'safety' across the range of highway activities: planning, programming, project development, construction, operations, and maintenance". The HSM can be used to perform the following (HSM, 2010):

- Identify factors contributing to crashes and associated potential countermeasures to address these issues.

- Identify sites with the most potential for crash frequency or severity reduction.
- Conduct economic appraisals of improvements and prioritize projects.
- Evaluate the crash reduction benefits of implemented treatments.
- Calculate the effect of various design alternatives on crash frequency and severity.
- Estimate potential crash frequency and severity on highway networks.
- Estimate potential effects on crash frequency and severity of planning, design, operations, and policy decisions.

The HSM is divided into the following four parts:

- Part A: Introduction and Fundamentals
    - Chapter 1: Introduction and Overview
    - Chapter 2: Human Factors
    - Chapter 3: Fundamentals

- Part B: Safety Management Process
    - Chapter 4: Network Screening
    - Chapter 5: Diagnosis
    - Chapter 6: Select Countermeasures
    - Chapter 7: Economic Appraisal
    - Chapter 8: Prioritize Projects
    - Chapter 9: Safety Effectiveness Evaluation

- Part C: Predictive Methods
    - Chapter 10: Rural Two Lane Roads
    - Chapter 11: Rural Multilane Highways
    - Chapter 12: Urban and Suburban Arterials

- Part D: Crash Modification Factors
    - Chapter 13: Roadway Segments
    - Chapter 14: Intersections
    - Chapter 15: Interchanges
    - Chapter 16: Special Facilities
    - Chapter 17: Road Networks

In summary, the HSM is a comprehensive safety analysis tool that discusses all the steps in the roadway safety management process. The manual discusses all the available safety analysis methods including the empirical Bayes (EB) approach. However, the analysis procedures are available for only three types of roadways: rural two lane roads, rural multilane highways, and urban and suburban arterials. Analysis of other facility types such as freeways is currently unavailable.

2.1.3.2 SafetyAnalyst

SafetyAnalyst is a state-of-the-art analytical tool for making system wide safety decisions. The software provides a suite of analytical tools to identify and manage system-wide safety improvements by incorporating all the steps in the roadway safety management process. It incorporates the EB approach for network screening. It also includes many modules and could act as a complete "safety toolbox" for any safety office. The modules in *SafetyAnalyst* include (AASHTO, 2010):

1. *Network Screening Module:* It identifies and ranks sites with potential for safety improvements.
2. *Diagnosis and Countermeasure Selection Module:* This module is used to diagnose the nature of safety problems at specific sites. The countermeasure selection module assists the user in selecting the countermeasures to reduce crash frequency and severity at specific sites.
3. *Economic Appraisal and Priority Ranking Module:* This module performs an economic appraisal of a specific countermeasure or several alternative countermeasures for a specific site while the priority ranking module provides a priority ranking of sites and proposed improvement projects based on the benefit and cost estimates determined by the economic appraisal tool.
4. *Countermeasure Evaluation Module:* It provides the capability to conduct before/after evaluations of implemented safety improvements.

SafetyAnalyst includes the Data Management Tool, the Analytical Tool, the Administration Tool, and the Implemented Countermeasure Tool to perform the complete roadway safety management process. The Data Management Tool is used to import, post-process, and calibrate data. The Analytical Tool is used to perform analysis on the data. The four *SafetyAnalyst* modules described above could be performed in this tool. The Administration Tool is used to perform a variety of tasks such as adding and removing data items (with an exception of mandatory data elements). Data recoding of various data elements' attributes could also be performed. This tool also gives access to the national default SPFs used within the software which could be replaced with agency-specific SPFs, if available. Further, diagnostic questions and countermeasures could also be edited within this tool.

In summary, *SafetyAnalyst* is a suite of software tools that implement the advanced EB method and automates all the steps of the roadway safety management process. Even though the data requirements are intense, once the data are imported, the analysis procedures are easy requiring minimum statistical expertise.

2.1.3.3 HSM versus SafetyAnalyst

As discussed in the earlier sections, the HSM and *SafetyAnalyst* are two of the many safety analysis tools developed and funded by the federal government. The HSM is a comprehensive document addressing various aspects of roadway safety including human factors. On the other hand, *SafetyAnalyst* is more focused toward addressing site-specific improvements that require engineering solutions.

Even though *SafetyAnalyst* has been advertised as a software package compatible with Part B (Safety Management Process) of the HSM, there are several differences between the two tools that an agency has to understand prior to embracing either one (or both) of the tools.

The HSM discusses all the available analysis procedures for each step of the roadway safety management process, along with their advantages and limitations. For example, for network screening, the HSM discusses 13 types of analyses such as crash frequency, crash rate, critical crash rate, empirical Bayes analysis, Level of Service of Safety, etc. Of all the discussed methods, the EB method identifies and prioritizes sites with greatest potential for safety improvement. Yet, its adoption depends on several factors including data availability, available statistical expertise, etc. On the other hand, *SafetyAnalyst* uses only the EB approach in its analysis (the user may choose different types of analyses using the EB approach). This approach is not a setback because *SafetyAnalyst* requires minimum statistical expertise as most of the steps are automated. Data availability is also not a point of concern as the software uses only the imported data and data requirements are not as stringent as the HSM requirements.

Road network is broadly classified into segments, intersections, and ramps, each with distinctive characteristics. In this regard, the HSM is incomplete as the SPFs, crash modification factors (CMFs), and analysis procedures are discussed only for the following three roadway types: rural two lane roads, rural multilane highways, and urban and suburban arterials. Most importantly, analysis procedures for freeways (with and without interchange influence areas) are currently unavailable in the HSM. On the contrary, *SafetyAnalyst* uses a very detailed classification of the road network, dividing segments, intersections, and ramps into 17, 12, and 16 subtypes, respectively. Further, *SafetyAnalyst* is equipped with SPFs for all the subtypes for both Total and Fatal and Injury (F+I) crashes. Tables 2-5 and 2-6 list the categories of SPFs included in the HSM and *SafetyAnalyst*, respectively.

Table 2-5: Categories of SPFs in HSM

Roadway Segments-SPFs for Specific Site Subtypes
- Rural 2-lane roads - Rural 4-lane undivided roads - Rural 4-lane divided roads - Urban 2-lane arterial streets - Urban 4-lane undivided arterial streets - Urban 4-lane divided arterial streets - Urban 3-lane with TWLTL arterials streets - Urban 5-lane with TWLTL arterials streets
Intersections-SPFs for Specific Site Subtypes
- Rural three-leg intersections with minor road STOP control on 2-lane and 4-lane roadways - Rural four-leg intersections with minor road STOP control on 2-lane and 4-lane roadways - Rural four-leg intersections with signal control on 2-lane and 4-lane roadways - Urban three-leg intersections with minor road STOP control on 2-lane and 4-lane roadways - Urban three-leg intersections with signal control on 2-lane and 4-lane roadways - Urban four-leg intersections with minor road STOP control on 2-lane and 4-lane roadways - Urban four-leg intersections with signal control on 2-lane and 4-lane roadways

Table 2-6: Categories of SPFs in *SafetyAnalyst*

Roadway Segments-SPFs for Specific Site Subtypes
- Rural 2-lane roads - Rural multilane undivided roads - Rural multilane divided roads - Rural freeways-4 lanes - Rural freeways-6+ lanes - Rural freeways within interchange area-4 lanes - Rural freeways within interchange area-6+ lanes - Urban 2-lane arterial streets - Urban multilane undivided arterial streets - Urban multilane divided arterial streets - Urban one-way arterial streets - Urban freeways-4 lanes - Urban freeways-6 lanes - Urban freeways-8+ lanes - Urban freeways within interchange area-4 lanes - Urban freeways within interchange area-6 lanes - Urban freeways within interchange area-8+ lanes
Intersections-SPFs for Specific Site Subtypes
- Rural three-leg intersection with minor-road STOP control - Rural three-leg intersection with all-way STOP control - Rural three-leg intersection with signal control - Rural four-leg intersection with minor-road STOP control - Rural four-leg intersection with all-way STOP control - Rural four-leg intersection with signal control - Urban three-leg intersection with minor-road STOP control - Urban three-leg intersection with all-way STOP control - Urban three-leg intersection with signal control - Urban four-leg intersection with minor-road STOP control - Urban four-leg intersection with all-way STOP control - Urban four-leg intersection with signal control
Ramps-SPFs for Specific Site Subtypes
- Rural diamond off-ramp - Rural diamond on-ramp - Rural parclo loop off-ramp - Rural parclo loop on-ramp - Rural free-flow loop off-ramp - Rural free-flow loop on-ramp - Rural free-flow outer connection ramp - Rural direct or semi direct connection - Urban diamond off-ramp - Urban diamond on-ramp - Urban parclo loop off-ramp - Urban parclo loop on-ramp - Urban free-flow loop off-ramp - Urban free-flow loop on-ramp

The EB approach requires either state-specific SPFs or the default SPFs calibrated to local data. The SPFs available in the HSM were generated using sites with “base conditions”. In other words, the sites used to generate base SPFs have similar “base” roadway characteristics. As these base SPFs were generated using other states’ data, they need to be calibrated to reflect the local crash experience. The HSM recommends generating calibration factors for each subtype at least once every 2-3 years using data from 30-50 locations with a total of 100 crashes/year. On the contrary, the default SPFs used in *SafetyAnalyst* were generated using all sites irrespective of base conditions. Similar to the HSM, *SafetyAnalyst* uses a calibration factor to account for differences between the default SPFs and the agencies’ safety performance. This calibration factor is calculated as the ratio of observed to predicted crashes for all the sites. In summary, consideration of base conditions while generating SPFs is a major difference between the HSM and *SafetyAnalyst*.

In the EB approach, CMFs are used in two instances: to account for the variations in base conditions, and to select and evaluate countermeasures. Since the SPFs in the HSM were generated using sites with base conditions, deviation of the target sites from predefined base conditions have to be addressed using CMFs. Further, CMFs are used to evaluate the performance of one countermeasure over the other, and therefore play a vital role in selecting and evaluating countermeasures, and in benefit cost analysis. With regard to *SafetyAnalyst*, CMFs are used only for countermeasure selection and evaluation as SPFs to be used with *SafetyAnalyst* were generated without accounting for base conditions.

Compared to the traditional site selection methods such as crash frequency and crash rate, the advanced methods that use empirical Bayes approach are data intensive. Tables 2-7 and 2-8 list the required data elements for *SafetyAnalyst* and the HSM, respectively. The HSM needs very detailed roadway characteristics data to estimate calibration factors and to perform analysis at a particular location. Therefore, even though data requirements to adopt the HSM are intense, they are required only for 30-50 sites that will be used for calculating calibration factor. Additionally, detailed data are required on locations that are being analyzed.

Table 2-7: The Minimum Set of Data Elements Required to Use *SafetyAnalyst*

Roadway Segment Characteristics	Intersection Characteristics	Ramp Characteristics	Crash
• Segment number • Segment location • Segment length • Area type • Number of through traffic lanes • Median type • Access control • Two-way vs. one-way operation • Traffic volume (AADT)	• Intersection number • Intersection location • Area type • Number of intersection legs • Type on intersection traffic control • Major-road traffic volume (AADT) • Minor-road traffic volume (AADT)	• Ramp number • Ramp location • Area type • Ramp length • Ramp type • Ramp configuration • Ramp traffic volume (AADT)	• Crash location • Date • Collision type • Severity • Relationship to junction • Maneuvers by involved vehicles

Source: (AASHTO, 2010)

Table 2-8: Data Requirements for Part C of the HSM

Roadway Segment Characteristics	Intersection Characteristics	Crash
• Area Type • Length of Roadway Segment • Number of lanes • Functional Classification • Traffic volume (AADT) • Median type and width • Lane width • Shoulder width and type • Presence of a concrete median barrier • Presence of passing lane • Presence of short-four lane section • Presence of two way left turn lane • Horizontal curve location • Length, radius, superelevation of horizontal curve • Number of luminaries • Speed limit • Type of parking • Vertical grade • Centerline Rumble strips • Roadside Hazard Rating • Side slope • Driveway density • Roadside fixed objects • Automated speed enforcement	• Area Type • Number of lanes • Traffic volume (AADT) • Geographic coordinates • Number of legs • Control type • Intersection skew angle • Intersection left-turn lanes • Intersection right-turn lanes • Intersection Sight Distance • Terrain • Lighting • Right-turn-on-red • Left-Turn Signal Phasing • Red-Light Cameras • Bus stops (1000ft) • Schools (1000ft) • Alcohol Sales Establishments (1000ft) • Pedestrian Activity Level • Max. Pedestrian Lanes Crossed	• Crash location • Date • Collision type • Severity • Relationship to junction • Distance from intersection

Source: (HSM, 2010)

SafetyAnalyst is designed for system-wide analysis with capabilities to perform site-specific analysis in the later stages of the roadway safety management process. The HSM is inclined toward site-specific analysis, mainly due to its intense data requirements. The HSM also encourages performing project-level analysis if the agency is not limited by its data. It is also anticipated that data acquisition per HSM requirements could be extremely tedious. However, several of the required elements could be collected from the existing satellite images and default values could be assumed as needed. Similarly, the data import process in *SafetyAnalyst* is tedious and might involve extensive manual work yearly. However, once an agency is past the initial learning curve, repetition of the import process is less tedious, and could even be automated (Lu et al., 2009).

SafetyAnalyst performs basic data quality checks and logs a list of errors, warnings, and potential issues with the data. During the import, post-process, and calibration steps of the Data Management Tool, *SafetyAnalyst* identifies and flags shorter segments, segments with unrealistic traffic volumes, and segments with missing roadway characteristics information. Additionally, sites that do not belong to any predefined site subtype will also be flagged. This capability is very helpful as not-so-obvious issues with data quality can be easily identified. This option is unavailable in the HSM, making data quality checks difficult and tedious.

Another major difference between the two tools is that *SafetyAnalyst* is an automated tool while the HSM is a three-volume manual. Most of the steps within *SafetyAnalyst* are automated requiring minimal statistical expertise. On the other hand, adoption of the HSM requires extensive statistical expertise and in-depth knowledge of roadway safety management processes. However, there are a few third-party software tools that implement Part C of the HSM. For example, as part of NCHRP 17-38, three spreadsheets were developed for the three roadway types discussed in Part C of the manual. HiSafe is also being advertised as a companion software to the manual. It is to be noted that, unlike the Highway Capacity Manual (HCM), the HSM is relatively subjective involving human factors and various other considerations. Thus, it is more difficult to develop software that automates all the steps discussed in the HSM.

Cost is another major factor that decides, to an extent, the adoption of the tools. The HSM is $390 per manual, while *SafetyAnalyst* is $15,000 per year for single user license and $25,000 per year for multi-user license.

In summary, *SafetyAnalyst* and the HSM are the advanced safety analysis tools that use EB approach. However, as discussed above, there are several major differences between the two tools. Table 2-9 summarizes the major differences between *SafetyAnalyst* and the HSM.

Table 2-9: Major Differences Between *SafetyAnalyst* and the HSM

SafetyAnalyst	**HSM**
Network screening could be performed by only EB analysis.	Network screening could be performed using a variety of traditional and other EB methods.
EB method is available for all site subtypes for segments, intersections, and ramps.	EB method is available for segments and intersections of only three site types: rural two lane roads, urban multilane highways, and urban and suburban arterials.
All segments (irrespective of base conditions) were used to develop default SPFs.	Segments with base conditions were only used to develop base SPFs.
CMFs are used only for countermeasure selection and evaluation.	CMFs are used to address the variations in base conditions, and for countermeasure selection and evaluation.
Data requirements are less intense compared to HSM requirements.	Has intense data requirements for calculating the calibration factor and for each site to be analyzed.
SafetyAnalyst is designed more for system-wide analysis.	HSM is designed more for site specific analysis.
Import process may involve a lot of manual work yearly.	Data acquisition could be extremely tedious.
SafetyAnalyst generates a log with errors and warnings during import, post-process, and calibration steps.	A log file with errors and warnings is not available.
Cost: $15,000 for single user license.	Cost: $390 per manual (for AASHTO members).

2.2 Methodology

The main objective of this section is to document the development of Florida-specific SPFs for use with *SafetyAnalyst*. As required by *SafetyAnalyst*, negative binomial (NB) models were used to develop simple SPFs.

2.2.1 Negative Binomial (NB) Models

The NB (or Poisson-gamma) regression model has been widely used to predict crash frequency. The NB model assumes that the crash frequency follows a gamma distribution and the variance of the crash counts exceeds the mean. The NB-based expected crashes are given as:

$$\lambda_i = exp(\beta x_i + \varepsilon_i) \tag{2-26}$$

where, $exp(\varepsilon_i)$ is a gamma distributed error term with a mean of 1 and a variance of α. The addition of this term allows the variance to differ from the mean as $Var = \lambda_i + \alpha\lambda_i^2$, where α is the overdispersion parameter. The Poisson regression model is a limiting model of NB regression models as α approaches zero. The probability function of the NB distribution is given as follows:

$$P(Y = y_i) = \frac{\Gamma(y_i + (1/\alpha))}{y_i!\Gamma(1/\alpha)} \times \left(\frac{\alpha\lambda_i}{1+\alpha\lambda_i}\right)^{y_i} \times \left(\frac{1}{1+\alpha\lambda_i}\right)^{1/\alpha} \tag{2-27}$$

where,

$\Gamma(x) =$ gamma function, and

y_i = number of crashes per period for roadway segment i.

The likelihood function for the probability function is:

$$L(\lambda_i) = \prod_i \frac{\Gamma(y_i + (1/\alpha))}{y_i!\Gamma(1/\alpha)} \times \left(\frac{\alpha\lambda_i}{1+\alpha\lambda_i}\right)^{y_i} \times \left(\frac{1}{1+\alpha\lambda_i}\right)^{1/\alpha} \tag{2-28}$$

The advantage of this technique is that the NB model can overcome the possible overdispersion in crash frequency data which generally follows a gamma probability distribution.

2.2.2 SPF Functional Form

2.2.2.1 Segments and Ramps

The SPF functional form for roadway segments and ramps is as follows:

$$N_{predicted} = e^{a} \times AADT^{b} \tag{2-29}$$

For fitting the NB regression models, Equation 2-29 is rewritten as:

$$N_{predicted} = \exp(a + b \times \ln(AADT)) \tag{2-30}$$

where,

$N_{predicted}$	=	predicted crash frequency per mile per year,
$AADT$	=	annual average daily traffic volume (vehicles per day), and
a, b	=	regression coefficients.

The overdispersion parameter (k), which indicates the statistical reliability of the SPF, was used to account for dispersion in the data. The closer the k is to zero, the more statistically reliable the SPF is. To assess NB regression performance, the goodness-of-fit statistic, Freeman-Tukey R^2 coefficient (R^2_{FT}) was used.

Calibration of the default SPFs was performed by multiplying the default SPFs by a "calibration factor", C, which is calculated using the following equation:

$$C = \frac{\sum_{All\ sites} observed\ crashes}{\sum_{All\ sites} predicted\ crashes} \tag{2-31}$$

As shown in this equation, calibration factor is calculated as the ratio of the total observed crashes to total predicted crashes obtained from the default national SPFs. Note that "*All sites*" in the equation refers to the reference sites within a specific category. Moreover, the calibration factor is not needed if a local jurisdiction chooses to develop its own SPFs as the local safety trends are inherently addressed in the coefficients per Equation 2-30.

2.2.2.2 Intersections

The SPF functional form for intersections is as follows:

$$N_{predicted} = e^{a} \times AADT_{major}^{\ b} \times AADT_{minor}^{\ c} \tag{2-32}$$

For fitting the NB regression models, Equation 2-32 is rewritten as:

$$N_{predicted} = exp(a + b \times ln(AADT_{major}) + c \times ln(AADT_{minor})) \tag{2-33}$$

where,

$N_{predicted}$	=	predicted target crash frequency per intersections per year,
$AADT_{major}$	=	average annual daily traffic volume on the major-road approaches,
$AADT_{minor}$	=	average annual daily traffic volume on the minor-road approaches, and
a, b, c	=	regression coefficients that are estimated from the available data.

2.3 Data Processing

<u>*2.3.1 Segments*</u>

2.3.1.1 Interchange Influence Areas

Figure 2-1 shows an interchange influence area as discussed in the *SafetyAnalyst* User Manual (2010). The interchange influence area of a particular interchange covers the length of the freeway section extending approximately 0.3 miles upstream of the gore point of the first exit/entrance ramp to approximately 0.3 miles downstream of the gore point of the last entrance/exit ramp of the same interchange. The area between two successive interchange influence areas is considered as a basic freeway segment.

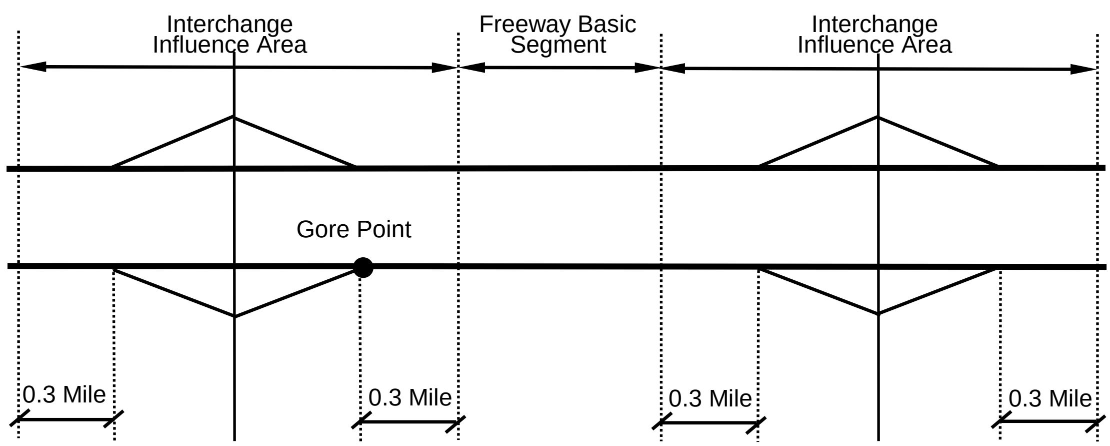


Figure 2-1: Interchange Influence Area

Interchange influence areas are not explicitly identified within FDOT's roadway inventory database. Therefore, the interchange influence areas were first separated from the freeway segments by creating 0.3-mile buffer for each ramp of the interchange and dissolving the overlapped buffers. The dissolved buffer areas were considered to be the interchange influence areas. Mile posts of interchange influence areas were then identified by spatially comparing the coordinates of the original freeway segments and coordinates of the interchanges. Figure 2-2 shows the basic freeway segments and interchange influence areas.

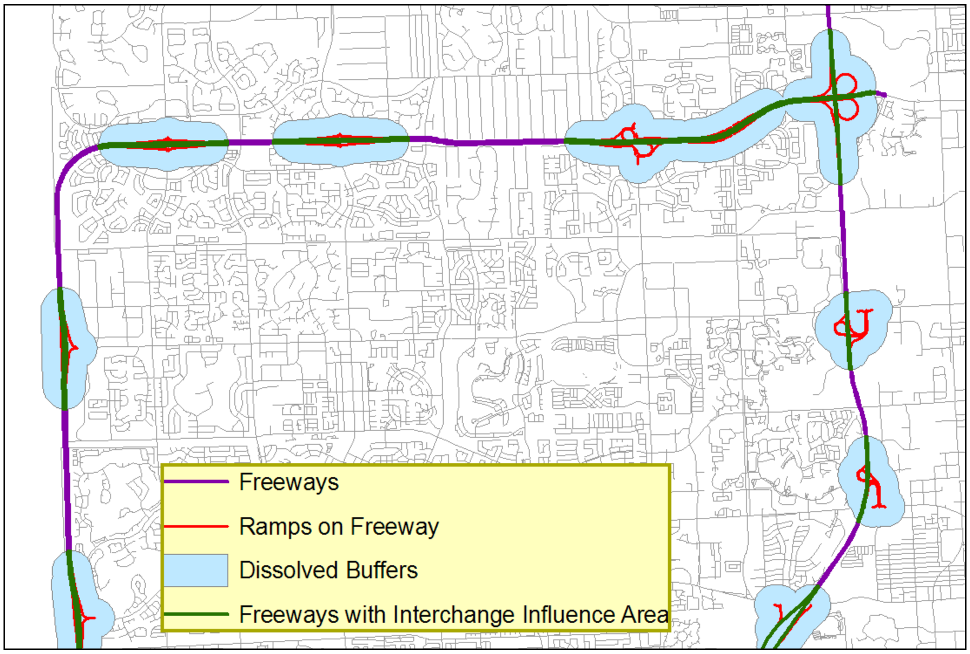


Figure 2-2: Freeways with Interchange Influence Area

2.3.1.2 Roadway Segmentation

A Dynamic Segmentation (DySeg) program developed by the Lehman Center for Transportation Research (LCTR) at Florida International University (FIU) was used to divide the road network into segments. The DySeg program dynamically divides the roadway sections based on several categories, including equal length segments, uniform segments with unique attributes, or based on a specified range of segment lengths, desired roadway features, and crash types, and computes the crash frequency associated with each roadway segment. Figure 2-3 shows the screen capture of the DySeg Roadway Characteristics Inventory (RCI) user interface for specifying the input for geometric variables. Figure 2-4 shows the general user interface of DySeg for specifying crash year, location, and crash severity.

All the data variables required to import the segment database into *SafetyAnalyst* were used to generate segments. The following are the list of roadway attributes used for segment division:

- Number of lanes (NOLANES)
- Surface width (SURWIDTH)
- Functional classification (FUNCLASS)
- Maximum speed limit (MAXSPEED)
- Median width (MEDWIDTH)
- Shoulder type (SHLDTYPE)
- Shoulder width (SLDWIDTH)
- Inside shoulder width (ISLDWDTH)
- Urban size (URBSIZE)
- Access control type (RDACCESS)
- Section ADT (SECTADT)

For freeways and undivided arterial streets, the attribute “road side” has to be considered because the geometric and operational features might vary on each side of the roadway.

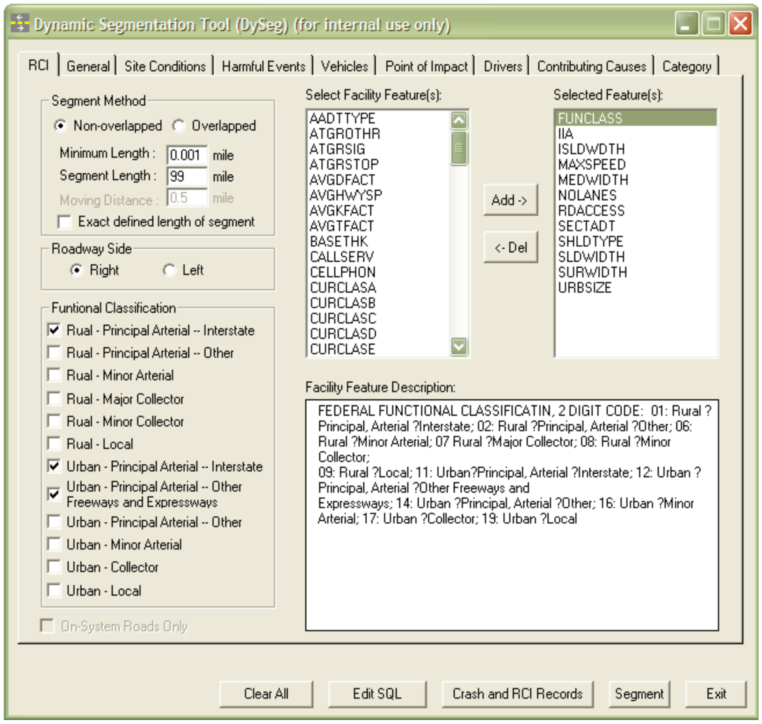


Figure 2-3: DySeg RCI User Interface

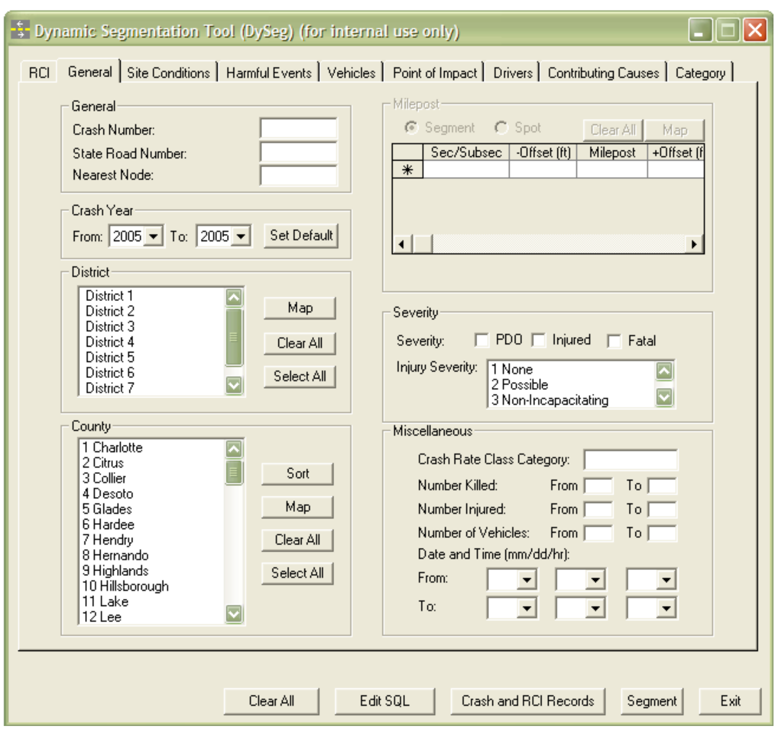


Figure 2-4: DySeg General User Interface

2.3.1.3 Data Used for SPF Development

Roadway inventory data from 2008, and the most recent four years of crash and traffic data (i.e., from 2007 to 2010) were used to develop Florida-specific SPFs. Table 2-10 provides the summary statistics of segments used to generate SPFs based on the segment subtypes identified in *SafetyAnalyst*.

Table 2-10: Summary Statistics of Roadway Segments

Category		Total Length of Segments (miles)	# of Sites	Crash Data (2007-2010)	
				Total Crashes	Fatal and Injury Crashes
Rural					
2-lane Roads		3257.44	2408	15703	9610
Multilane Undivided Roads*		9.80	37	118	63
Multilane Divided Roads		1189.03	1048	11432	6630
Basic Freeway Segment	4 Lanes	442.86	264	6222	3587
	6+ Lanes	181.73	101	2400	994
Segments within Interchange Influence Area	4 Lanes	49.70	156	717	423
	6 Lanes	38.38	69	502	228
Urban					
2-lane Arterial Streets		802.71	2038	17643	9695
Multilane Undivided Arterial Streets		63.23	245	3562	1801
Multilane Divided Arterial Streets		2473.98	6923	124154	63563
One-way Arterial Streets		126.72	433	5319	1989
Basic Freeway Segment	4 Lanes	319.26	375	8592	4223
	6 Lanes	198.12	272	10317	4694
	8+ Lanes	42.28	75	2229	1010
Segments within Interchange Influence Area	4 Lanes	280.58	620	11210	5404
	6 Lanes	263.71	558	27115	11851
	8+ Lanes	125.46	330	25748	12311

* Sample size was insufficient to accurately estimate regression coefficients

2.3.2 Intersections

Due to data constraints, SPFs were developed only for signalized intersections. RCI data from 2008 were used to identify signalized intersections. 2007-2010 crash and traffic data were used in the analysis. In addition to the intersection-related crashes, crashes that occurred within 250 ft from the center of an intersection were included in the analysis.

Figure 2-5 illustrates the steps followed to process the data. To identify the locations of signalized intersections, the location data were first extracted from FDOT's Geographic Information System - Traffic Signal Location database. In this database, a signalized intersection is represented by a set of roadway IDs associated with corresponding milepost of one of the roadways (usually major roads) that cross the intersection. A GIS-aided process was then used to merge the location information with geographical coordinates. By using geographical coordinates, information of minor roads was linked to the corresponding intersection. Information of all roadways crossing the intersection was retrieved. This data set was then joined with AADT, leg-count, functional class, and crash data. The output data set was used to generate the SPFs.

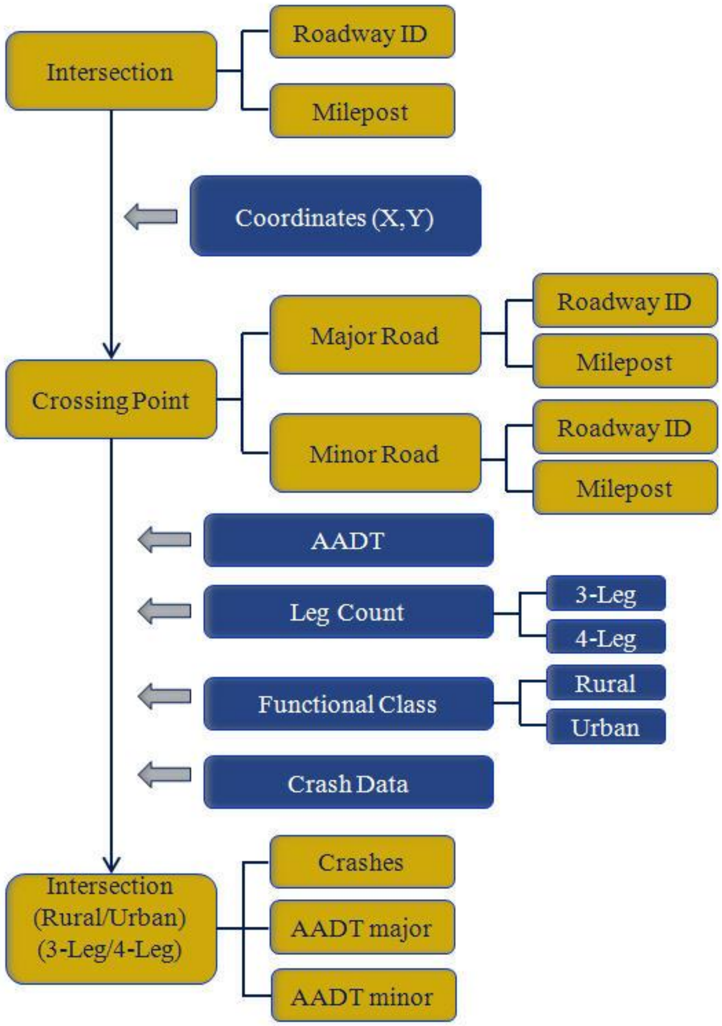


Figure 2-5: Data Processing Framework

Unsignalized intersections could not be analyzed due to the following reasons:

- data limitations in the RCI database,
- fewer number of all-way stop-controlled intersections, and
- unavailability of AADT data for minor approaches as most of these approaches are located on local roads.

Florida-specific SPFs were developed for only four subtypes: rural and urban, three-leg and four-leg signalized intersections. Table 2-11 gives the summary statistics of signalized intersections used to generate SPFs. It is to be noted that only a small sample size of signalized intersections was used due to data limitations. Traffic data is one of the required variables, and is only available for all state roads and a few county roads. Therefore, only signalized intersections with traffic data for all approaches are used in the analysis.

Table 2-11: Summary Statistics of Signalized Intersections

Area Type	Category	# of Sites	Crash Data (2007-2010)	
			Total Crashes	Fatal and Injury Crashes
Rural	Three-Leg	88	1,781	866
	Four-Leg	111	3,877	1,736
Urban	Three-Leg	314	11,471	4,783
	Four-Leg	641	39,517	16,400

2.3.3 Ramps

For developing Florida-specific SPFs for ramps, crash and traffic data for the years 2008 to 2010, and the processed ramp data from 2008 were used. Traffic data are complete only for the most recent year, 2010. Therefore, AADT is assumed to be the same for the earlier years (i.e., 2008 and 2009).

SafetyAnalyst categorizes ramps into 16 subtypes based on ramp type and configuration. However, Florida's classification of ramps is different from the *SafetyAnalyst*'s classification. Table 2-12 lists the ramp configurations used in *SafetyAnalyst* and in Florida. To analyze the maximum number of ramps, SPFs for ramps were generated as per the classification used in Florida.

Table 2-12: Differences Between the Default Ramp Configuration used in *SafetyAnalyst* and the Ramp Configuration in Florida's RCI Database

Ramp Configuration in *SafetyAnalyst*	INTERCHG (Type of Interchange) Variable in Florida RCI Database
1 – Diamond 2 – Parclo loop 3 – Free-flow loop 4 – Free-flow outer connection 5 – Direct or semi-direct connection 6 – C-D road or other connector 0 – Other 99 – Unknown	01 – Diamond 02 – Partial Diamond 03 – Trumpet 04 – Y Intersection 05 – 2 Quadrant Cloverleaf or Partial Cloverleaf 06 – 4 Quadrant Cloverleaf with Collector Road 07 – 4 Quadrant Cloverleaf 08 – Direct Connection Design 09 – Other

In the RCI database, off-ramp or on-ramp information is incomplete. Therefore, the first step in data processing dealt with this classification. Visual Roadway Inventory Collection System (VRICS) program developed by LCTR at FIU was used to collect on-ramp and off-ramp information. Figure 2-6 shows the screen capture of the VRICS user interface.

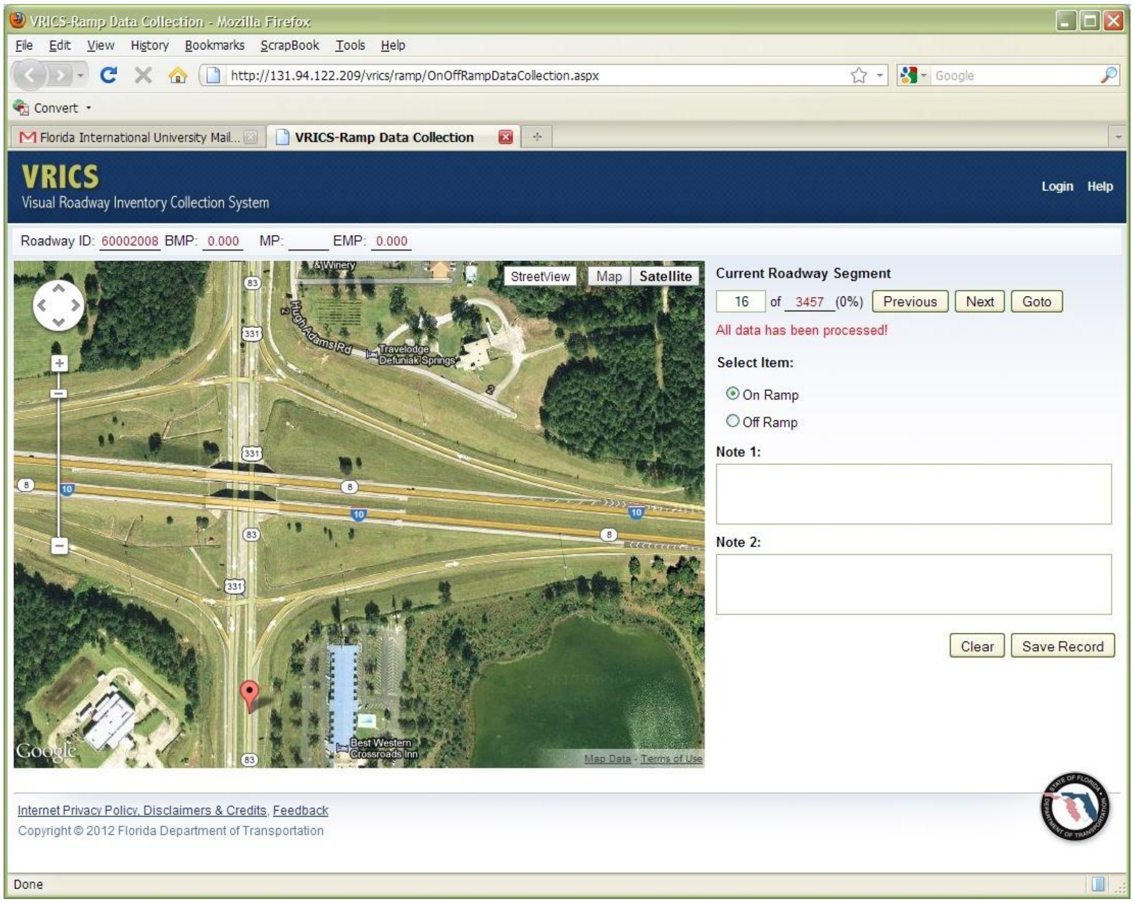


Figure 2-6: VRICS User Interface

A GIS-aided process was used to merge functional classification with ramp type information. The data set was then joined with AADT, crash data, and the off-ramp or on-ramp information extracted from VRICS. The output data were used to generate SPFs. Table 2-13 provides the summary statistics of ramps used to generate SPFs.

2.4 Segment SPFs

Florida-specific SPFs were developed for each of the 17 categories of segments, for both total crashes and F+I crashes. Tables 2-14 and 2-15 compare the two models (Florida-specific SPFs and default SPFs calibrated to Florida data) based on the goodness-of-fit, represented by Freeman-Tukey R^2 (R^2_{FT}). For urban roadway segments, Florida-specific SPFs yielded better prediction performance than the national default SPFs calibrated to Florida data. Even though the R^2_{FT} values for both models are low, Florida-specific SPFs are slightly better-fitted. For rural roadway segments, the R^2_{FT} for both models are similar.

The overdispersion parameter (or k), which indicates the statistical reliability of the SPF, was used to account for dispersion in the data. The closer k is to zero, the more statistically reliable the SPF is. For urban roadway segments, the overdispersion values associated with Florida-specific SPFs are much lower than the corresponding default models, indicating that the Florida-specific SPFs are statistically more reliable.

Table 2-13: Summary Statistics of Ramps

Category		Total Length of Segments (miles)	# of Ramps	Crash Data (2008-2010)	
				Total Crashes	Fatal and Injury Crashes
Rural					
Diamond	off-ramp	27.99	74	262	113
	on-ramp	27.68	73	134	71
Partial Cloverleaf (Parclo Loop) *	off-ramp	7.03	20	101	41
	on-ramp	7.23	20	33	12
Urban					
Diamond	off-ramp	167.41	389	5143	2372
	on-ramp	151.35	382	2117	978
Partial Diamond	off-ramp	59.87	148	1152	516
	on-ramp	54.47	134	1122	474
Trumpet	off-ramp	15.54	30	190	93
	on-ramp	12.28	26	108	46
Partial Cloverleaf (Parclo Loop)	off-ramp	91.35	200	1887	805
	on-ramp	92.35	204	1304	634
Direct Connection		21.92	33	285	111

* sample size was insufficient to accurately estimate regression coefficients

Three SPFs (Florida-specific SPF, *SafetyAnalyst* default SPF, and *SafetyAnalyst* default SPF calibrated to Florida data) were plotted against the observed crash data for rural and urban roadway segments for both total and F+I crashes. Figures 2-7 to 2-17 show the plots of the predicted annual crash frequency per mile against AADT and observed crash frequency for all categories of roadway segments. As noted in the figures, the plotted data points are the observed crash frequency based on Florida data, the red line represents the Florida-specific SPF, the blue line indicates the national default SPF used in *SafetyAnalyst*, and the green line represents the *SafetyAnalyst* default SPF calibrated to Florida data using a calibration factor.

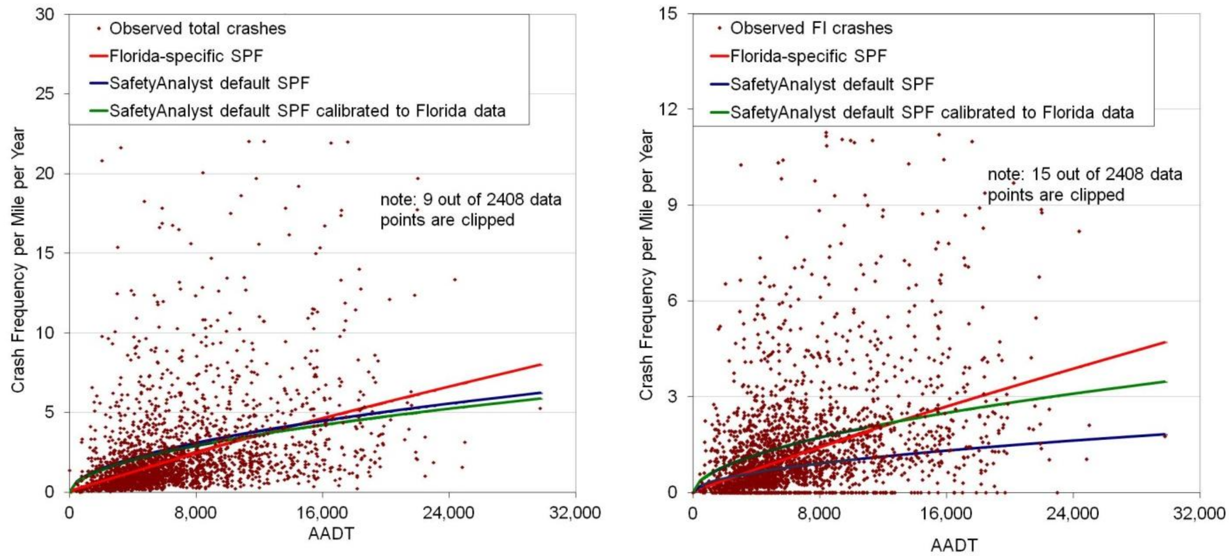
Table 2-14: Florida-specific SPFs and *SafetyAnalyst* Default SPFs Calibrated to Florida Data for Rural Roads and Urban Arterial Streets

		Calibrated Florida SPFs						*SafetyAnalyst* Default SPFs Calibrated to Florida Data				
		Coefficient						Coefficient				
		A		b								
Category	**Severity**	**Estimate**	**P-Value**	**Estimate**	**P-Value**	**k**	R^2_{FT}	**a**	**b**	**k**	**Calib. Factor (C)**	R^2_{FT}
Rural												
2-lane Roads	Total	-6.923	<0.0001	0.874	<0.0001	0.464	0.166	-3.630	0.530	0.500	0.942	0.170
	F+I	-7.660	<0.0001	0.894	<0.0001	0.444	0.118	-4.860	0.530	0.670	1.903	0.130
Multilane Undivided Roads	Total	-	-	-	-	-	-	-3.170	0.490	0.530	-	-
	F+I	-	-	-	-	-	-	-4.200	0.500	0.530	-	-
Multilane Divided Roads	Total	-5.356	<0.0001	0.689	<0.0001	0.446	0.153	-5.050	0.660	0.320	1.070	0.146
	F+I	-6.016	<0.0001	0.694	<0.0001	0.413	0.118	-7.460	0.720	0.090	3.783	0.107
Urban												
2-lane Arterial Streets	Total	-5.877	<0.0001	0.833	<0.0001	0.748	0.094	-7.160	0.840	4.400	3.503	0.081
	F+I	-6.264	<0.0001	0.805	<0.0001	0.678	0.087	-8.840	0.890	4.540	6.121	0.071
Multilane Undivided Arterial Streets	Total	-5.440	<0.0001	0.853	<0.0001	0.694	0.047	-10.240	1.290	0.850	1.525	-0.03
	F+I	-4.261	0.0003	0.655	<0.0001	0.571	0.052	-12.070	1.390	0.810	1.578	-0.12
Multilane Divided Arterial Streets	Total	-7.545	<0.0001	0.988	<0.0001	0.652	0.174	-11.850	1.340	5.910	1.836	0.160
	F+I	-8.134	<0.0001	0.976	<0.0001	0.545	0.179	-14.870	1.520	5.810	2.764	0.123
One-way Arterial Streets	Total	-3.144	0.0001	0.600	<0.0001	0.929	0.016	-3.530	0.600	1.380	1.476	0.019
	F+I	-2.810	0.0006	0.465	<0.0001	0.819	0.021	-5.150	0.650	1.450	1.727	-0.01

Table 2-15: Florida-specific SPFs and *SafetyAnalyst* Default SPFs Calibrated to Florida Data for Freeways

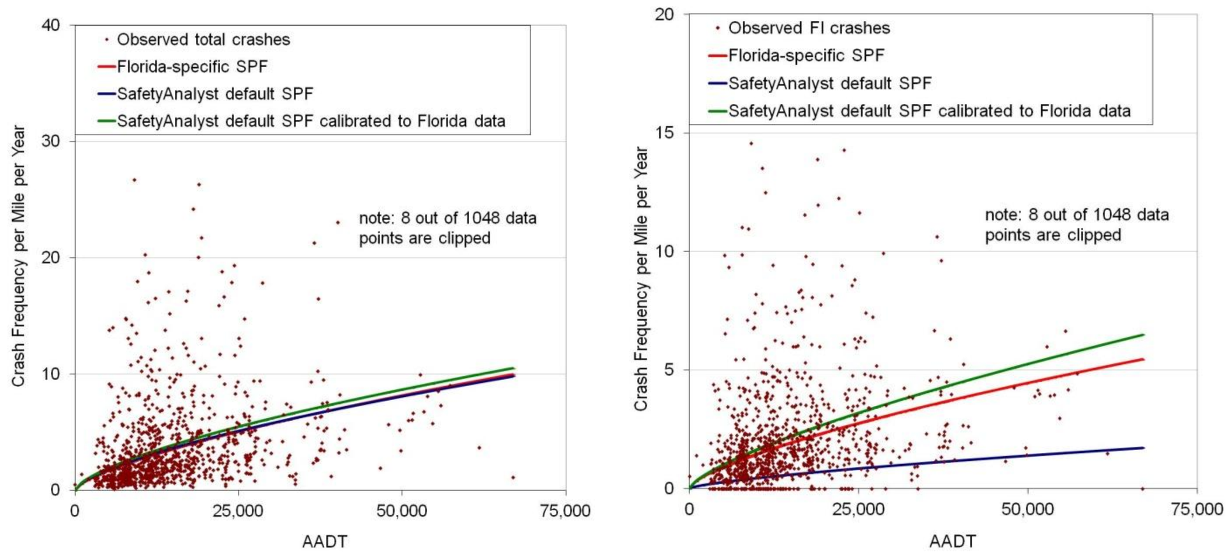
Category	Severity	Calibrated Florida SPFs						*SafetyAnalyst* Default SPFs Calibrated to Florida Data				
		Coefficient				k	R^2_{FT}	Coefficient		k	Calib. Factor (C)	R^2_{FT}
		a		b				a	b			
		Estimate	P-Value	Estimate	P-Value							
Rural Freeways with 4 Lanes												
Basic Freeway Segments	Total	-11.429	<0.0001	1.254	<0.0001	0.317	0.213	-6.820	0.810	0.170	1.032	0.206
	F+I	-11.080	<0.0001	1.165	<0.0001	0.306	0.144	-8.820	0.890	0.160	1.967	0.149
Segments within Interchange Influence Area	Total	-10.003	<0.0001	1.139	<0.0001	0.346	0.242	-7.760	0.970	0.150	0.640	0.246
	F+I	-9.460	<0.0001	1.031	<0.0001	0.326	0.176	-8.860	0.960	0.240	1.231	0.173
Rural Freeways with 6+ Lanes												
Basic Freeway Segments	Total	-10.910	<0.0001	1.182	<0.0001	0.218	0.252	-8.280	0.940	0.090	1.045	0.253
	F+I	-13.283	<0.0001	1.319	<0.0001	0.150	0.207	-10.250	1.030	0.090	1.180	0.216
Segments within Interchange Influence Area	Total	-10.693	0.0002	1.193	<0.0001	0.346	0.102	-9.630	1.060	0.210	1.478	0.121
	F+I	-11.886	<0.0001	1.233	<0.0001	0.261	0.175	-10.480	1.040	0.200	2.034	0.195
Urban Freeways with 4 Lanes												
Basic Freeway Segments	Total	-9.000	<0.0001	1.052	<0.0001	0.688	0.245	-7.850	1.000	0.990	0.581	0.230
	F+I	-10.260	<0.0001	1.102	<0.0001	0.631	0.220	-8.820	1.020	1.150	0.607	0.206
Segments within Interchange Influence Area	Total	-12.403	<0.0001	1.376	<0.0001	0.363	0.455	-11.230	1.300	0.810	0.736	0.444
	F+I	-12.799	<0.0001	1.345	<0.0001	0.301	0.439	-12.890	1.380	0.790	0.782	0.434
Urban Freeways with 6 Lanes												
Basic Freeway Segments	Total	-15.422	<0.0001	1.630	<0.0001	0.650	0.366	-5.960	0.780	0.480	1.483	0.199
	F+I	-16.657	<0.0001	1.667	<0.0001	0.562	0.374	-7.600	0.850	0.540	1.518	0.235
Segments within Interchange Influence Area	Total	-13.191	<0.0001	1.440	<0.0001	0.418	0.449	-11.250	1.280	0.600	0.954	0.425
	F+I	-13.914	<0.0001	1.434	<0.0001	0.347	0.452	-13.620	1.420	0.550	0.905	0.445
Urban Freeways with 8+ Lanes												
Basic Freeway Segments	Total	-8.355	0.0018	1.009	<0.0001	0.822	0.052	-16.240	1.670	0.450	0.953	-0.01
	F+I	-8.310	0.0019	0.941	<0.0001	0.705	0.060	-19.160	1.850	0.520	0.942	-0.05
Segments within Interchange Influence Area	Total	-8.434	<0.0001	1.041	<0.0001	0.487	0.247	-26.760	2.580	0.520	0.613	-0.01
	F+I	-10.576	<0.0001	1.156	<0.0001	0.427	0.295	-25.630	2.420	0.530	0.676	0.121

Figures 2-7 (a) and 2-7 (b) display the SPFs for rural 2-lane roads for both total and F+I crashes, respectively. Figure 2-7 (a) shows very similar results between the default and Florida-specific SPFs. Figure 2-7 (b) shows that the default SPF underestimates the crash frequency of F+I crashes. Figure 2-8 shows the SPFs for rural multilane divided roads. Figure 2-8 (a) shows that the observed crash data are better represented by all the three models for total crashes. Similar to the SPFs for rural 2-lane roads, F+I crashes are underestimated by the *SafetyAnalyst* default model.



(a) Total Crashes **(b) F+I Crashes**

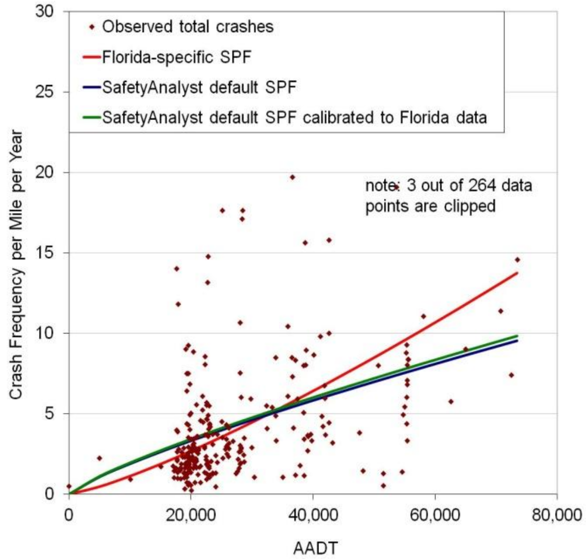
Figure 2-7: SPFs for Rural 2-Lane Roads



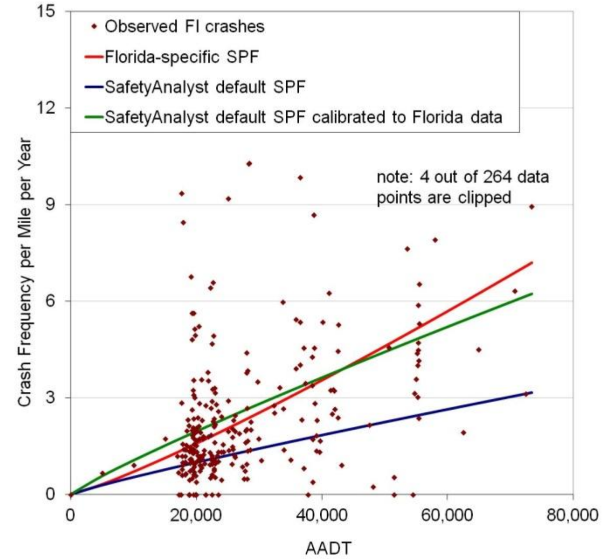
(a) Total Crashes **(b) F+I Crashes**

Figure 2-8: SPFs for Rural Multilane Divided Roads

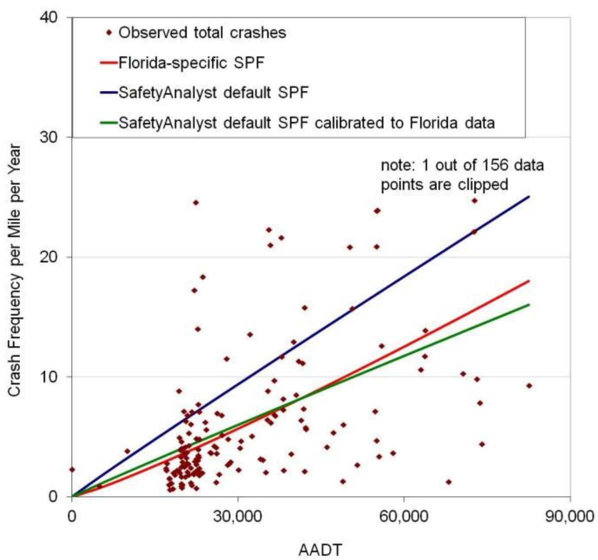
Figures 2-9 and 2-10 display the SPFs for rural freeways with 4 lanes and 6+ lanes, respectively. It is observed that the curves of default models calibrated to Florida data and Florida-specific SPFs are very similar, especially for interchange areas.



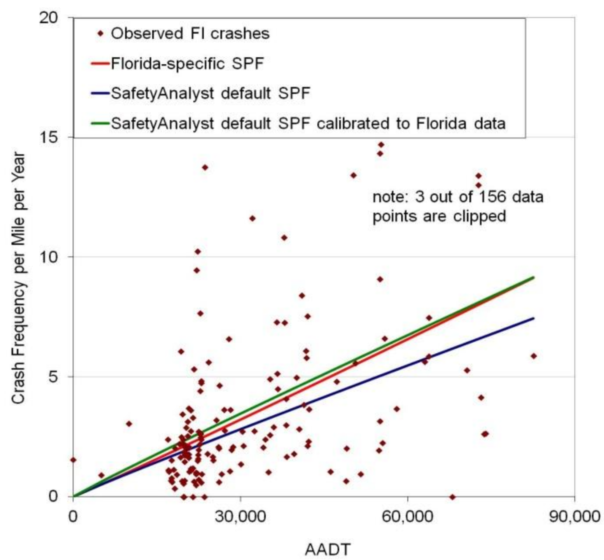
(a) Total Crashes for Basic Segments



(b) F+I Crashes for Basic Segments

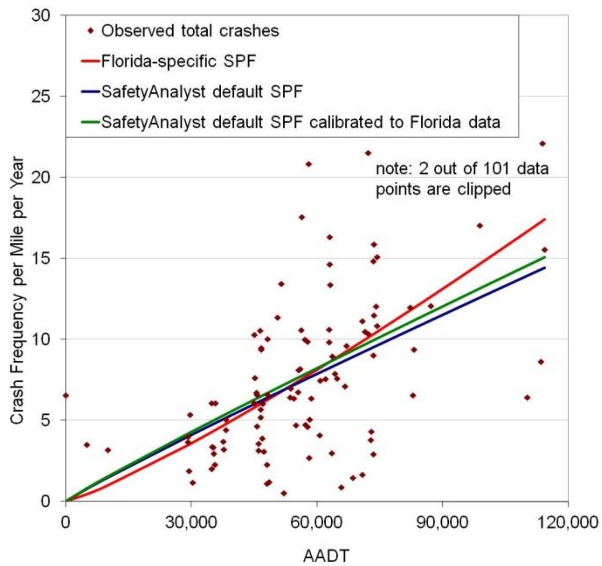


(c) Total Crashes for Interchange Areas

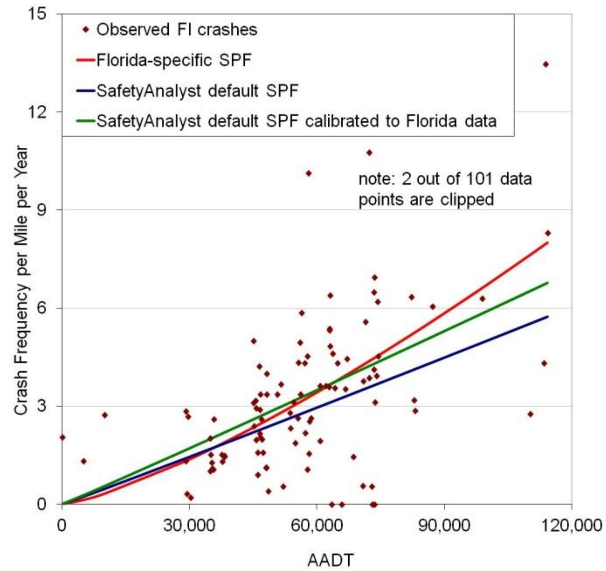


(d) F+I Crashes for Interchange Areas

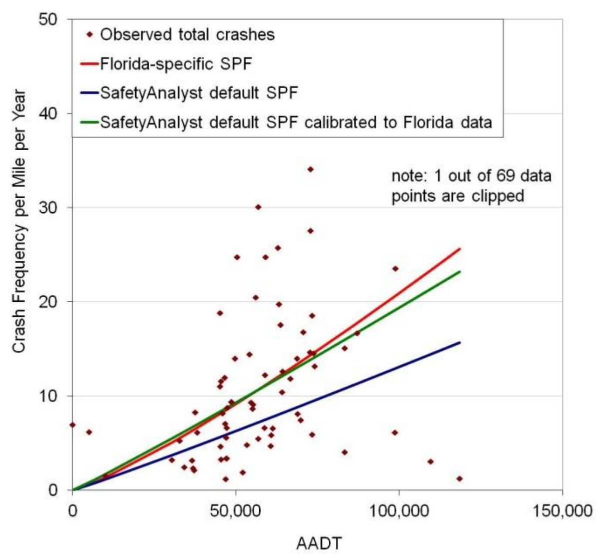
Figure 2-9: SPFs for Rural 4-Lane Freeways



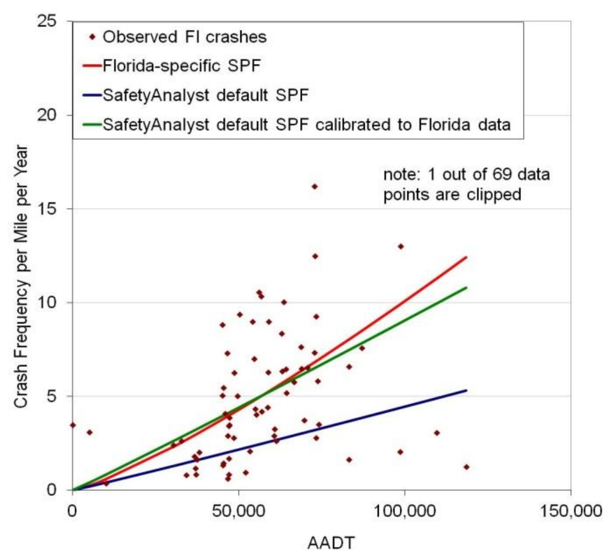
(a) Total Crashes for Basic Segments



(b) F+I Crashes for Basic Segments



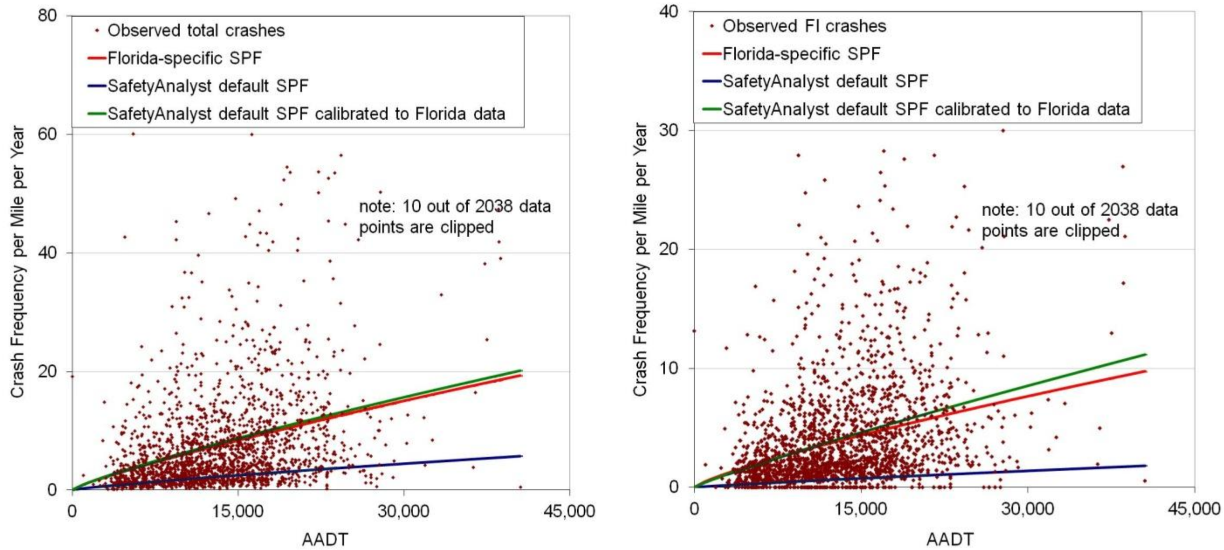
(c) Total Crashes for Interchange Areas



(d) F+I Crashes for Interchange Areas

Figure 2-10: SPFs for Rural 6+ Lane Freeways

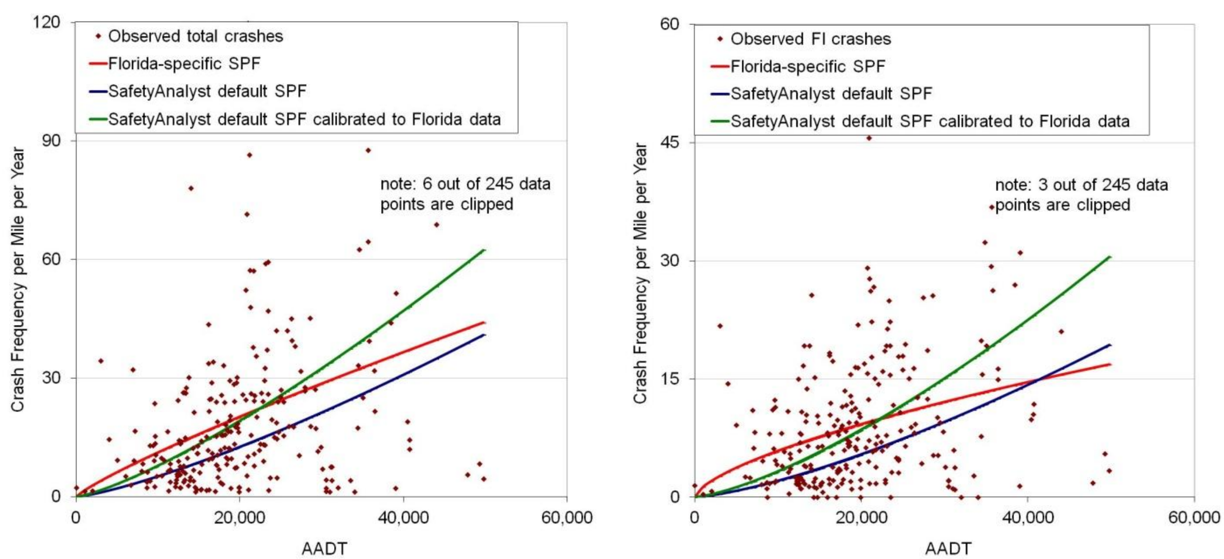
Figure 2-11 plots the SPFs for urban 2-lane arterial streets for both total and F+I crashes. The shapes of the default models calibrated to Florida data and Florida-specific SPFs are very similar.



(a) Total Crashes **(b) F+I Crashes**

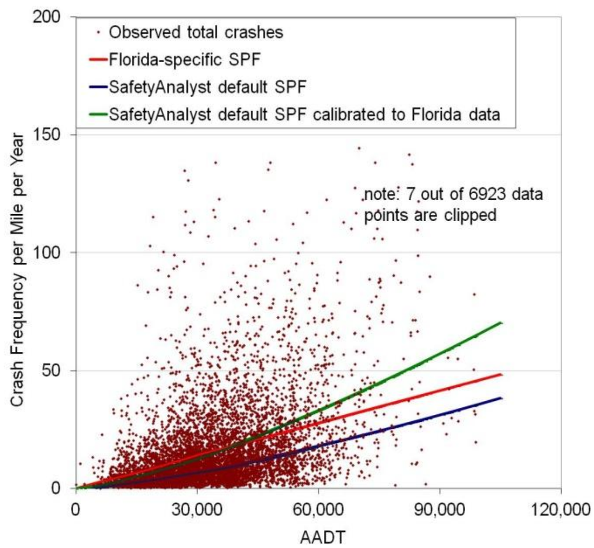
Figure 2-11: SPFs for Urban 2-Lane Arterial Streets

Figures 2-12 and 2-13 display the SPFs for urban multilane undivided and divided arterial streets, respectively. *SafetyAnalyst* default models are found to underestimate the predicted crash frequency. *SafetyAnalyst* default models calibrated to Florida data are very similar to the Florida-specific SPFs; however, slight discrepancy still exists.

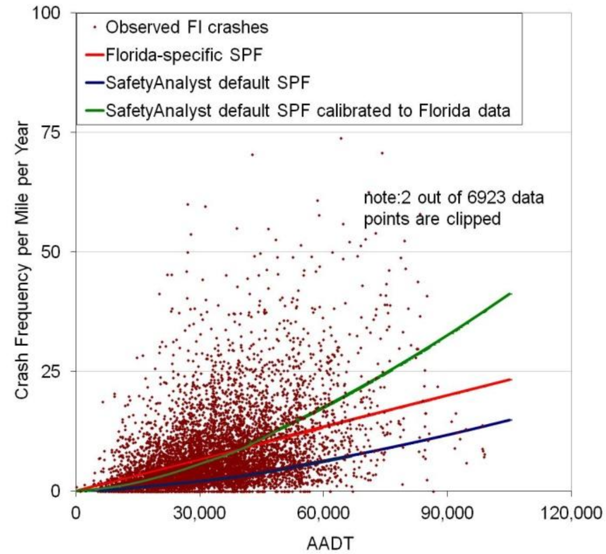


(a) Total Crashes **(b) F+I Crashes**

Figure 2-12: SPFs for Urban Multilane Undivided Arterial Streets



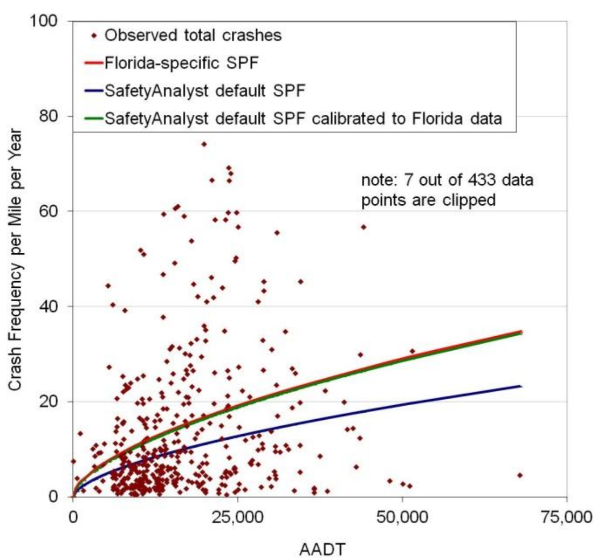
(a) Total Crashes



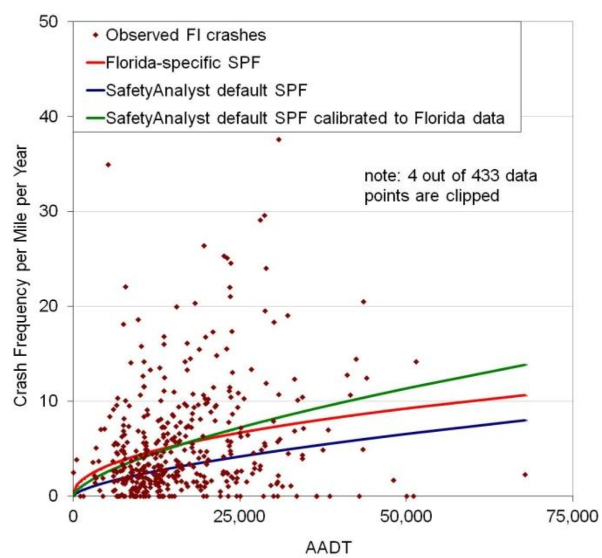
(b) F+I Crashes

Figure 2-13: SPFs for Urban Multilane Divided Arterial Streets

Figure 2-14 show the SPFs for urban one-way arterial streets. The curves of default models calibrated to Florida data and Florida-specific SPFs are very similar, especially for total crashes.



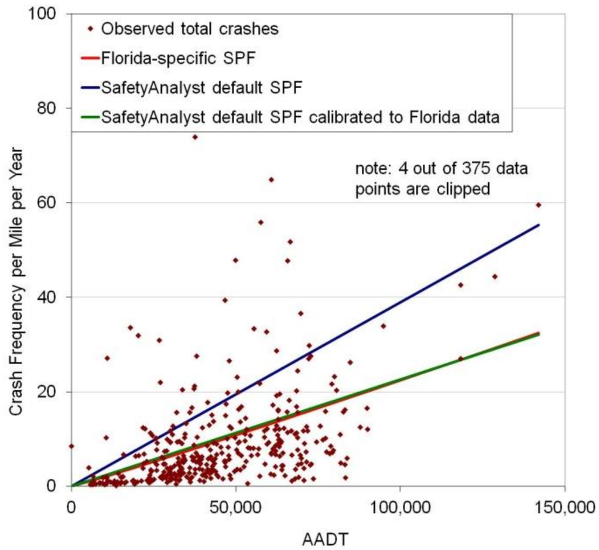
(a) Total Crashes



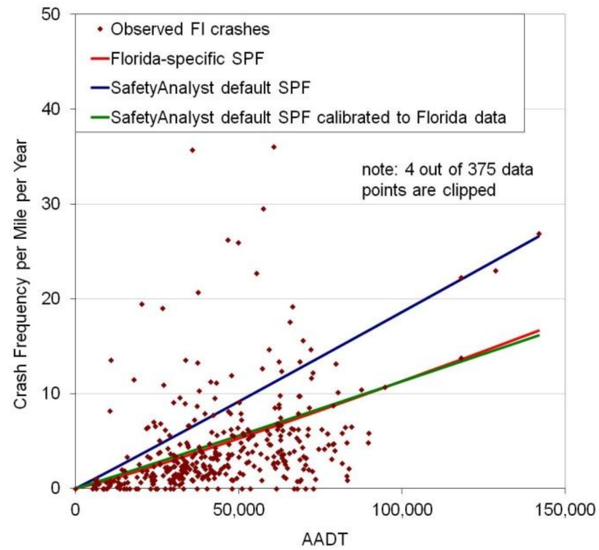
(b) F+I Crashes

Figure 2-14: SPFs for Urban One-way Arterial Streets

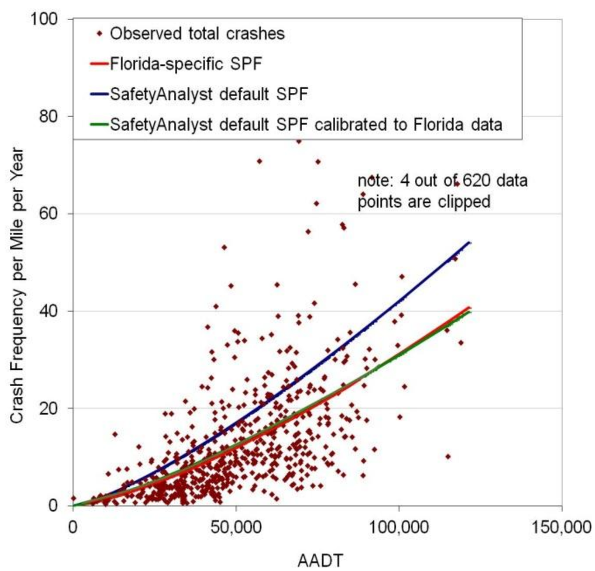
Figure 2-15 plots the SPFs for urban 4-lane freeways. From the plots, it is observed that the predicted crash frequency is overestimated by *SafetyAnalyst* default models. The plots of the default models calibrated to Florida data and Florida-specific SPFs are very similar for both basic segments and interchange areas.



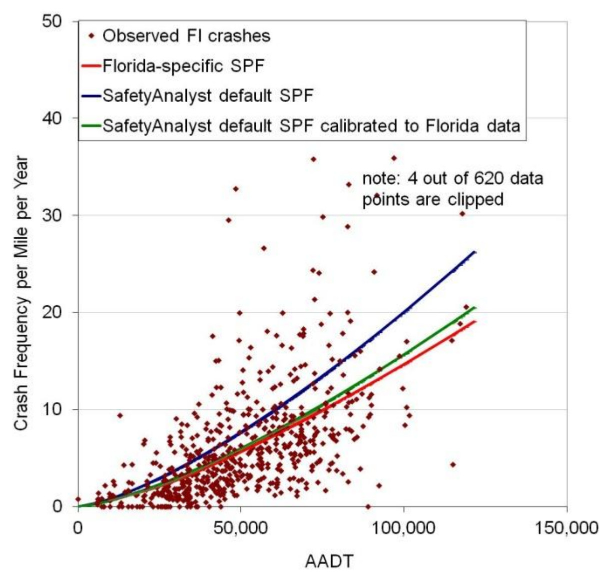
(a) Total Crashes for Basic Segments



(b) F+I Crashes for Basic Segments



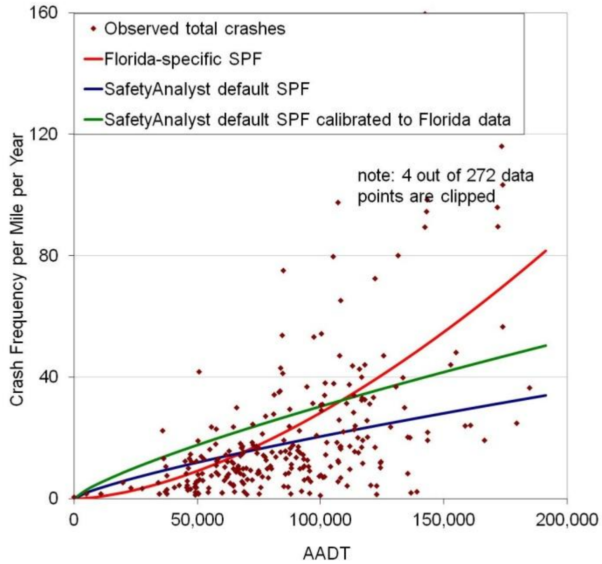
(c) Total Crashes for Interchange Areas



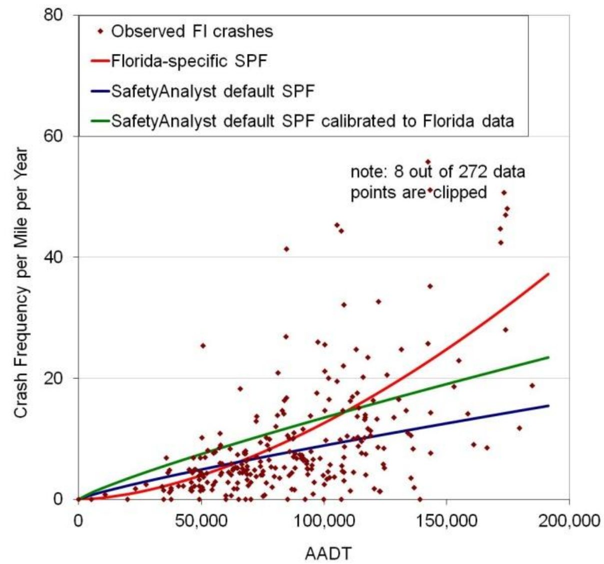
(d) F+I Crashes for Interchange Areas

Figure 2-15: SPFs for Urban 4-Lane Freeways

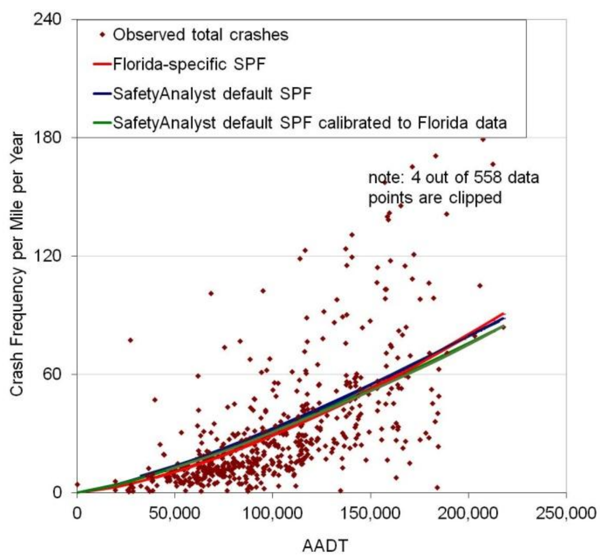
Figure 2-16 displays the SPFs for urban 6-lane freeways. The plots show that the default models calibrated to Florida data and Florida-specific SPFs are similar for freeway segments within interchange areas.



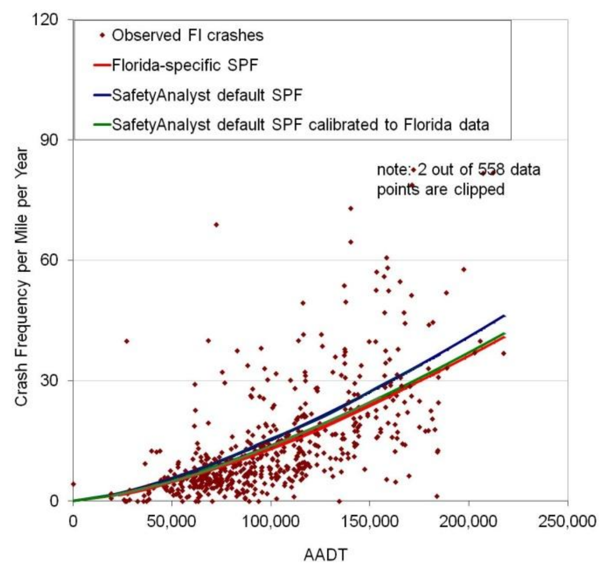
(a) Total Crashes for Basic Segments



(b) F+I Crashes for Basic Segments



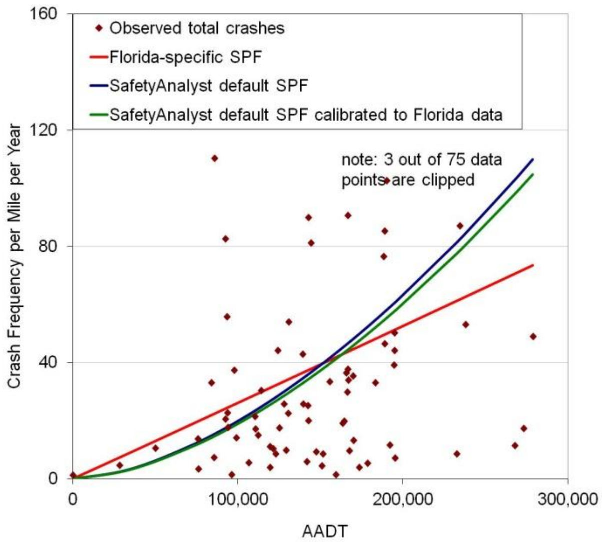
(c) Total Crashes for Interchange Areas



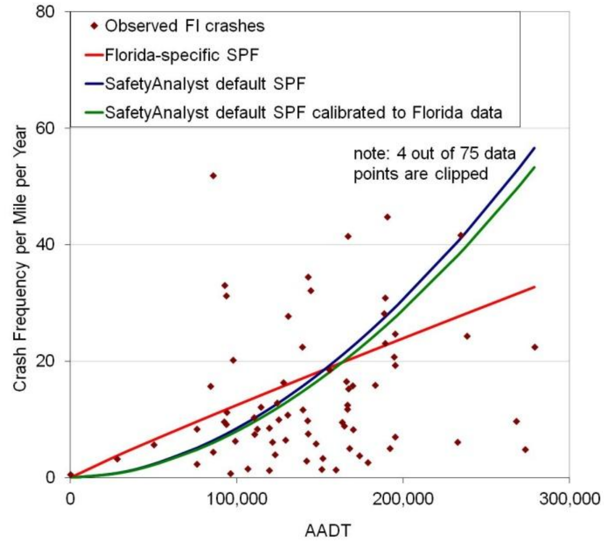
(d) F+I Crashes for Interchange Areas

Figure 2-16: SPFs for Urban 6-Lane Freeways

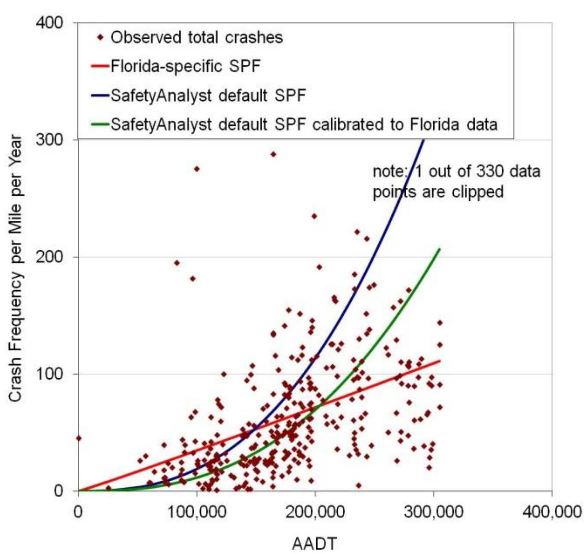
For urban 8+ lane freeways (both basic segments and interchange areas) shown in Figure 2-17, unlike the scenario for 4-lane and 6-lane freeways, it can be seen that the default models calibrated to Florida data and Florida-specific SPFs are different. The differences in total and F+I crash trend for both Florida-specific SPFs and calibrated default SPFs might be due to the complexity of traffic characteristics at these facilities.



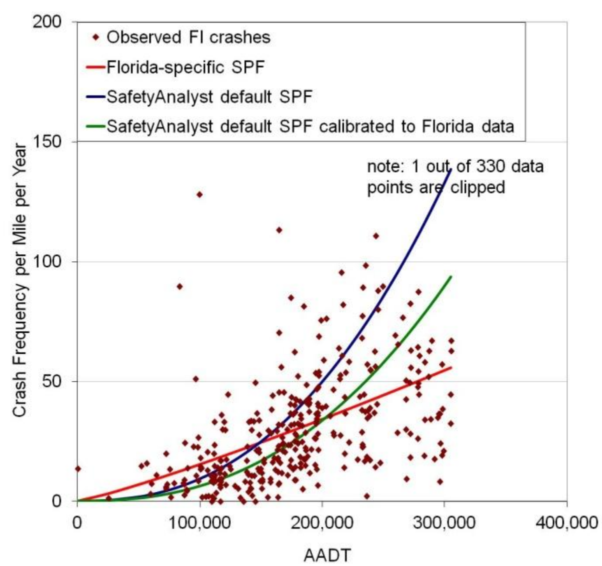
(a) Total Crashes for Basic Segments



(b) F+I Crashes for Basic Segments



(c) Total Crashes for Interchange Areas



(d) F+I Crashes for Interchange Areas

Figure 2-17: SPFs for Urban 8+Lane Freeways

Further, it can be seen from Figures 2-15, 2-16, and 2-17 that at the same level of AADT, the predicted crash frequency for segments within interchange influence areas is higher than that for basic freeway segments. This is likely due to multiple conflict points due to the high tendency of weaving (merging and diverging) maneuvers within these interchange influence areas. These results point to the importance of considering interchange influence area as a separate category instead of developing freeway SPFs regardless of the influence of interchanges.

2.5 Intersection SPFs

Florida-specific SPFs were developed for each of the four categories of signalized intersections, for both total and F+I crashes. Table 2-16 compares the two models (Florida-specific SPFs and default SPFs calibrated to Florida data) based on the goodness-of-fit, represented by Freeman-Tukey R^2 (R^2_{FT}).

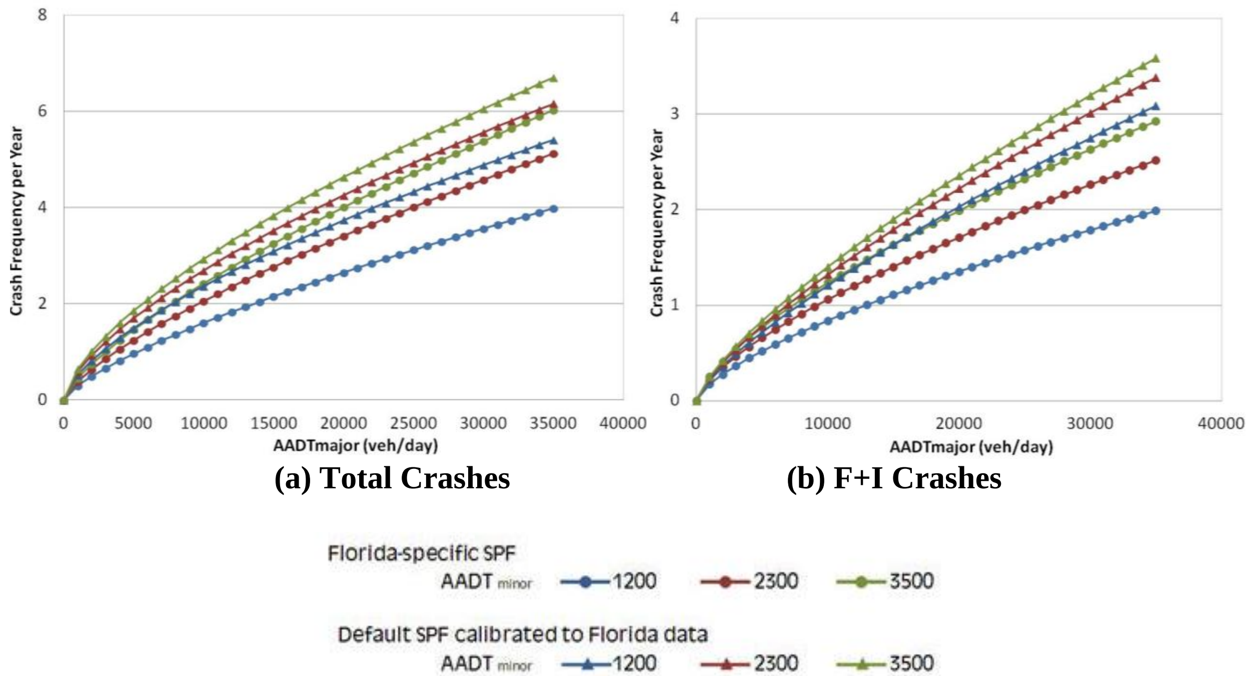
For each type of signalized intersection category, Florida-specific SPF and *SafetyAnalyst* default SPF calibrated to Florida data were plotted for both total and F+I crashes. Figures 2-18 to 2-21 display the plots of the predicted annual crash frequency against AADT for major road approaches.

As indicated in the legend, lines with circle represent Florida-specific SPFs and the lines with triangle represent default national SPFs calibrated to Florida data. The blue line represents SPF assuming AADT for minor-road approaches to be 1200 veh/day. For rural intersections, the red line and the green line represent SPFs assuming AADT for minor-road approaches to be 2300 and 3500 veh/day, respectively. For urban intersections, the red line and the green line represent SPFs assuming AADT for minor-road approaches to be 4100 and 7800 veh/day, respectively.

Figure 2-18 displays the Florida-specific SPF and the *SafetyAnalyst* default SPF calibrated to Florida data developed for total and F+I crash frequency for rural three-leg signalized intersections. Figure 2-19 shows the Florida-specific SPF and the *SafetyAnalyst* default SPF calibrated to Florida data developed for total and F+I crash frequency for rural four-leg signalized intersections. Figure 2-20 displays the Florida-specific SPF and the *SafetyAnalyst* default SPF calibrated to Florida data developed for total and F+I crash frequency for urban three-leg signalized intersections. Figure 2-21 presents the Florida-specific SPF and the *SafetyAnalyst* default SPF calibrated to Florida data developed for total and F+I crash frequency for urban four-leg signalized intersections.

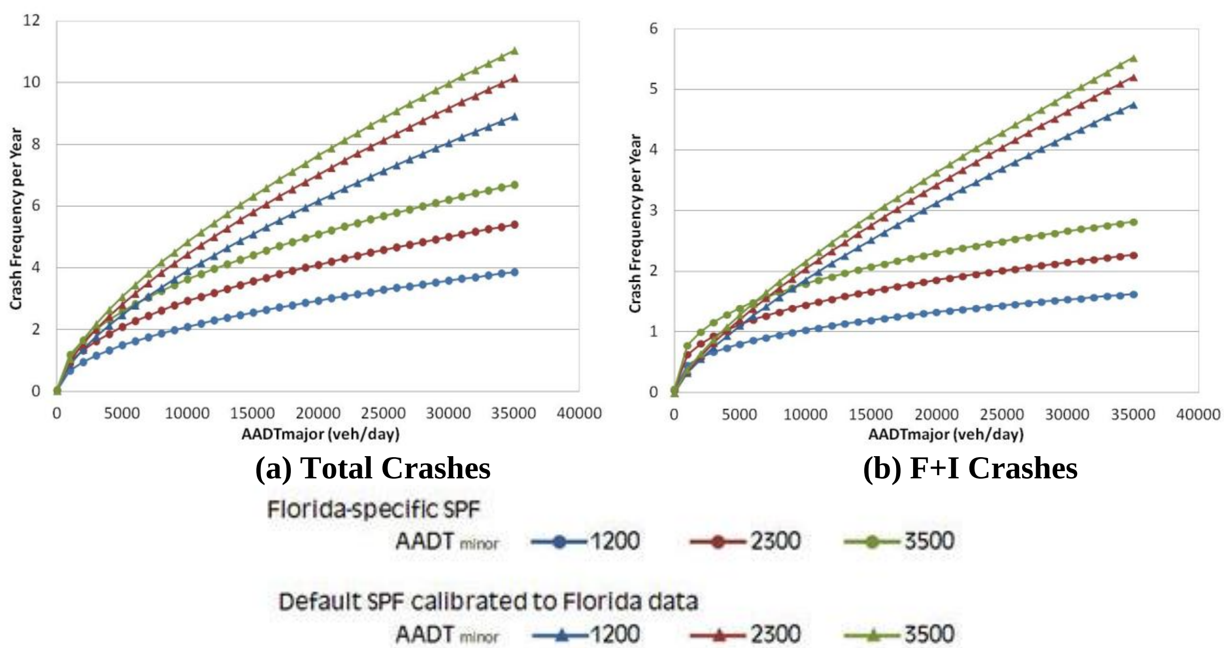
Table 2-16: Florida-specific SPFs and Default National SPFs Calibrated to Florida Data for Signalized Intersections

		Florida-Specific SPFs								*SafetyAnalyst* Default SPFs Calibrated to Florida Data					
Category	Severity	Coefficient						k	R^2_{FT}	Coefficient			k	Calib Factor (C)	R^2_{FT}
		a		b		c				a	b	c			
		Estimate	P-Value	Estimate	P-Value	Estimate	P-Value								
Rural															
Three-Leg	Total	-8.972	<0.0001	0.728	<0.0001	0.386	0.0064	0.529	0.317	-6.57	0.66	0.20	0.33	0.936	0.338
	F+I	-9.081	<0.0001	0.689	<0.0001	0.361	0.0111	0.446	0.345	-7.83	0.75	0.14	0.50	1.125	0.336
Four-Leg	Total	-7.404	<0.0001	0.490	0.0011	0.512	0.0001	0.434	0.604	-6.57	0.66	0.20	0.33	1.543	0.546
	F+I	-6.936	<0.0001	0.361	0.0247	0.514	0.0004	0.441	0.581	-7.83	0.75	0.14	0.50	1.731	0.543
Urban															
Three - Leg	Total	-9.134	<0.0001	0.664	<0.0001	0.471	<0.0001	0.430	0.400	-9.85	0.97	0.18	0.23	1.344	0.328
	F+I	-8.690	<0.0001	0.624	<0.0001	0.378	<0.0001	0.364	0.341	-10.22	0.91	0.21	0.27	1.145	0.287
Four - Leg	Total	-8.765	<0.0001	0.759	<0.0001	0.369	<0.0001	0.458	0.451	-3.47	0.42	0.14	0.32	1.654	0.309
	F+I	-8.549	<0.0001	0.666	<0.0001	0.358	<0.0001	0.372	0.438	-5.11	0.49	0.16	0.30	1.402	0.356



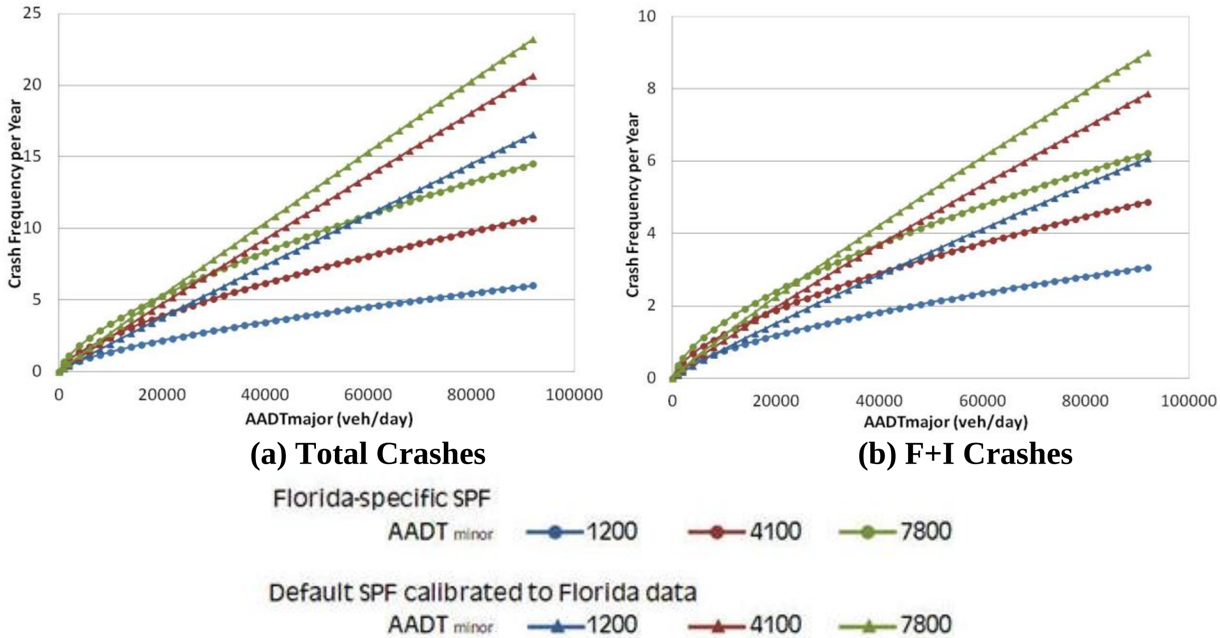
(a) Total Crashes (b) F+I Crashes

Figure 2-18: SPFs for Rural Three-Leg Signalized Intersections



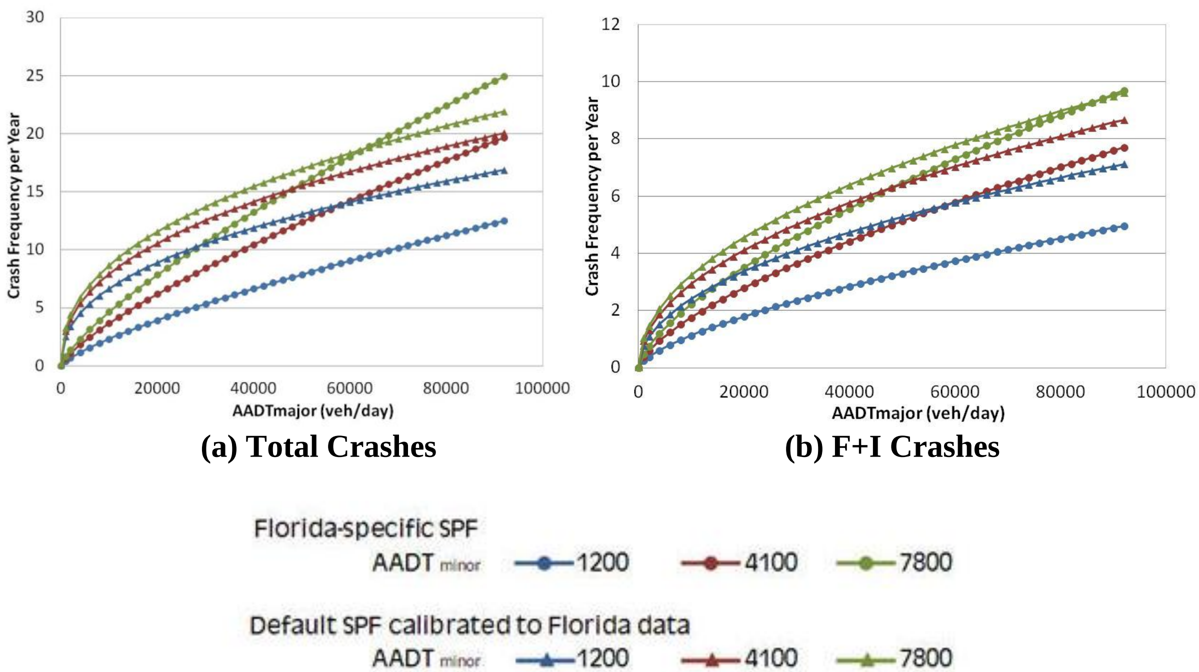
(a) Total Crashes (b) F+I Crashes

Figure 2-19: SPFs for Rural Four-Leg Signalized Intersections



(a) Total Crashes **(b) F+I Crashes**

Figure 2-20: SPFs for Urban Three-Leg Signalized Intersections



(a) Total Crashes **(b) F+I Crashes**

Figure 2-21: SPFs for Urban Four-Leg Signalized Intersections

2.6 Ramp SPFs

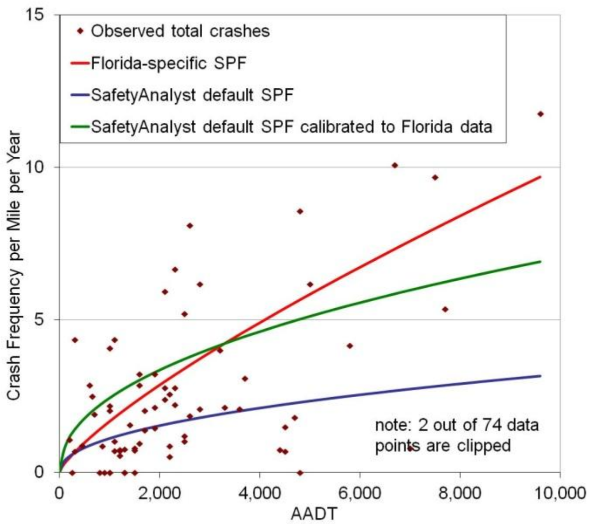
Florida-specific SPFs were developed for each of the four categories of ramps, for both total and F+I crashes. Table 2-17 compares the two models (Florida-specific SPFs and default SPFs calibrated to Florida data) based on the goodness-of-fit, represented by Freeman-Tukey R^2 (R^2_{FT}). As mentioned earlier, the ramp classification in Florida is different from the default classification used in *SafetyAnalyst*. Therefore, the SPFs of only the following subtypes were compared: diamond ramps for both rural and urban areas, and urban partial cloverleaf ramps. The regression coefficients for urban direct connections were insignificant while the sample size of rural partial cloverleaf ramps was insufficient to accurately estimate regression coefficients.

Three SPFs (Florida-specific SPF, *SafetyAnalyst* default SPF, and *SafetyAnalyst* default SPF calibrated to Florida data) were plotted against the observed crash data for rural and urban ramps for both total and F+I crashes. Figures 2-22 to 2-26 display the plots of the predicted annual crash frequency per mile against AADT and observed crash frequency for all the available ramp categories. In the plots, the data points plotted are the observed annual crash frequency per mile, the red line indicates the Florida-specific SPF, the blue line plots the default SPF from *SafetyAnalyst* without applying the calibration factor, and the green line represents the *SafetyAnalyst* default SPF calibrated to Florida data.

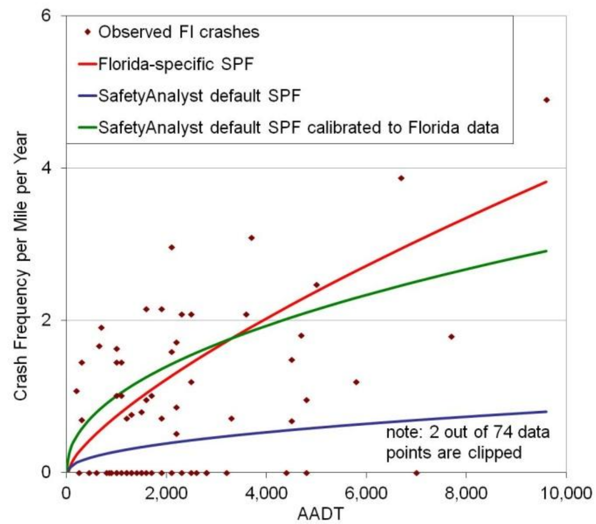
Table 2-17: Florida-specific SPFs and *SafetyAnalyst* Default SPFs Calibrated to Florida Data for Ramps

		Florida-Specific SPFs						*SafetyAnalyst* Default SPFs Calibrated to Florida Data				
		Coefficient						Coefficient				
		a		b								
Category	Severity	Estimate	P-Value	Estimate	P-Value	k	R^2_{FT}	a	b	k	Calib. Factor (C)	R^2_{FT}
Rural Diamond												
Off-ramp	Total	-4.844	<0.0001	0.776	<0.0001	0.615	0.277	-3.07	0.46	1.34	2.191	0.199
	F+I	-5.317	0.0001	0.726	<0.0001	0.627	0.185	-4.54	0.47	2.66	3.658	0.134
On-ramp	Total	-7.783	<0.0001	1.038	<0.0001	0.522	0.369	-2.16	0.19	1.86	3.168	0.075
	F+I	-9.844	<0.0001	1.214	<0.0001	0.433	0.342	-8.12	0.86	0.98	3.311	0.302
Urban Diamond												
Off-ramp	Total	-3.335	<0.0001	0.638	<0.0001	0.883	0.061	-3.52	0.54	1.15	2.965	0.066
	F+I	-3.763	<0.0001	0.598	<0.0001	0.802	0.075	-3.86	0.47	1.94	3.611	0.073
On-ramp	Total	-3.399	<0.0001	0.564	<0.0001	1.050	0.094	-8.20	1.03	1.21	2.042	0.062
	F+I	-4.845	<0.0001	0.635	<0.0001	0.990	0.062	-7.99	0.86	0.69	3.491	0.020
Urban Partial Diamond												
Off-ramp	Total	-3.789	0.0003	0.640	<0.0001	1.100	0.149	---				
	F+I	-4.696	<0.0001	0.662	<0.0001	0.993	0.129					
On-ramp	Total	-8.024	<0.0001	1.095	<0.0001	1.644	0.168					
	F+I	-8.144	<0.0001	1.013	<0.0001	2.253	0.120					
Urban Trumpet												
Off-ramp	Total	-6.428	0.0214	0.862	0.0058	1.108	0.084	---				
	F+I	-6.918	0.0233	0.838	0.0131	0.976	0.100					
On-ramp	Total	-10.228	0.0003	1.282	<0.0001	1.444	0.390					
	F+I	-10.795	0.0016	1.225	0.0009	1.076	0.380					
Urban Partial Cloverleaf (Parclo Loop)												
Off-ramp	Total	-3.202	<0.0001	0.597	<0.0001	0.956	0.176	-1.15	0.26	0.12	2.664	0.089
	F+I	-3.952	<0.0001	0.580	<0.0001	0.906	0.162	-3.68	0.53	0.67	1.227	0.149
On-ramp	Total	-5.722	<0.0001	0.822	<0.0001	0.660	0.225	-5.59	0.82	0.97	0.918	0.218
	F+I	-6.872	<0.0001	0.869	<0.0001	0.754	0.169	-1.34	0.24	1.20	1.147	0.073

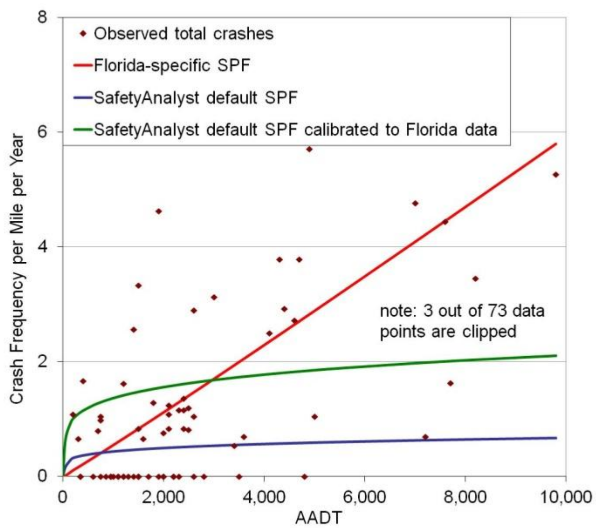
Figure 2-22 displays the SPFs for rural diamond ramps (both on-ramp and off-ramp) for both total and F+I crashes. It is observed that the *SafetyAnalyst* default models underestimate the crash frequency on rural diamond ramps.



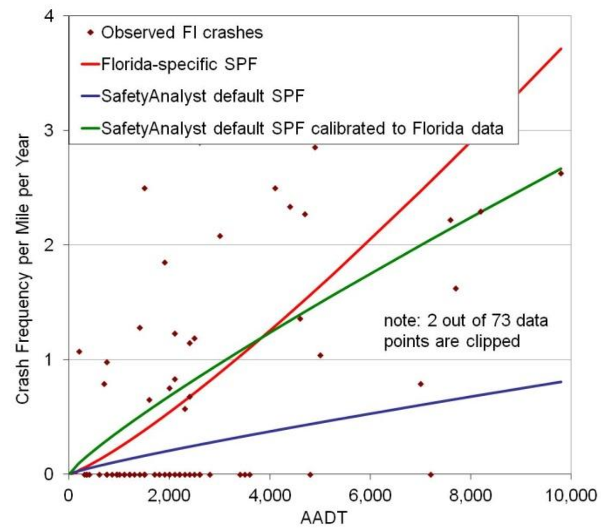
(a) Total Crashes Off-Ramp



(b) F+I Crashes Off-Ramp



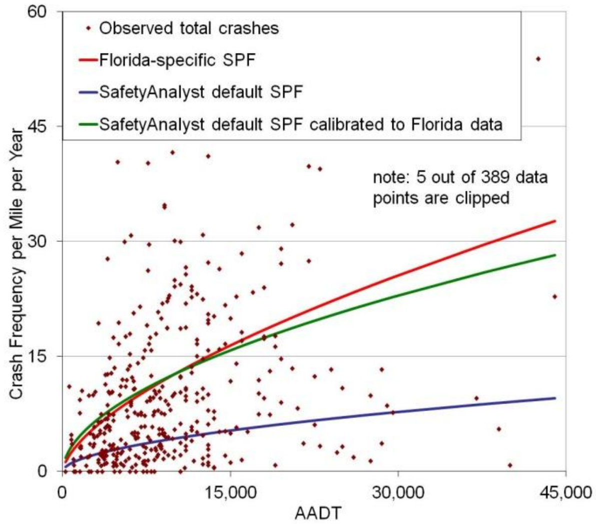
(c) Total Crashes On-Ramp



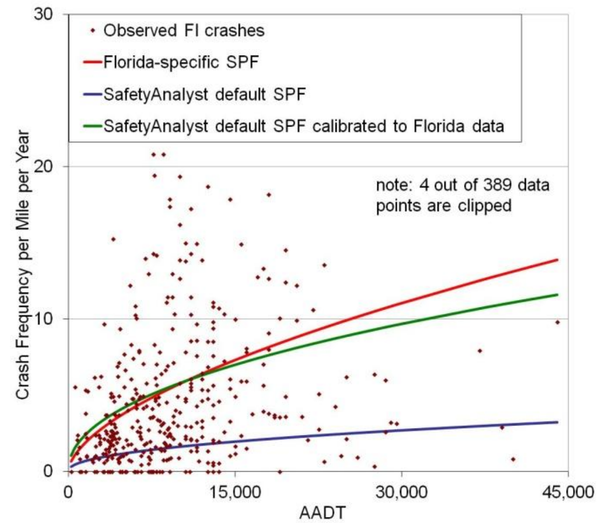
(d) F+I Crashes On-Ramp

Figure 2-22: SPFs for Rural Diamond Ramps

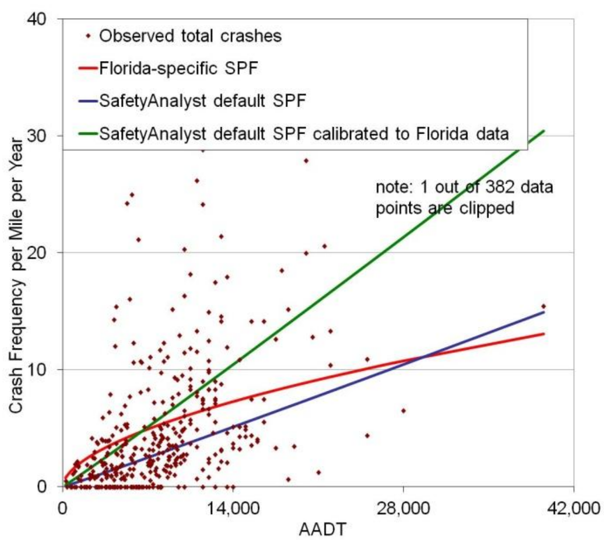
Figure 2-23 displays the SPFs for urban diamond ramps (both on-ramp and off-ramp) for both total and F+I crashes. It is observed *SafetyAnalyst* default models underestimate the crash frequency. By adjusting *SafetyAnalyst* default models using the calibration factor, the curves become much closer to that of Florida-specific SPFs; however, slight discrepancy still exists.



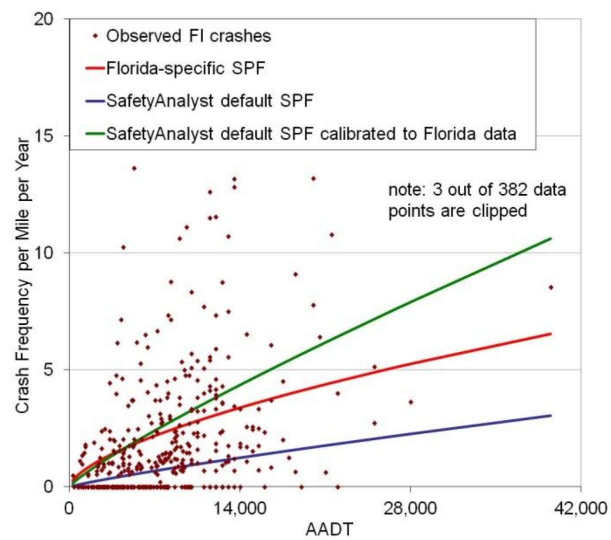
(a) Total Crashes Off-Ramp



(b) F+I Crashes Off-Ramp



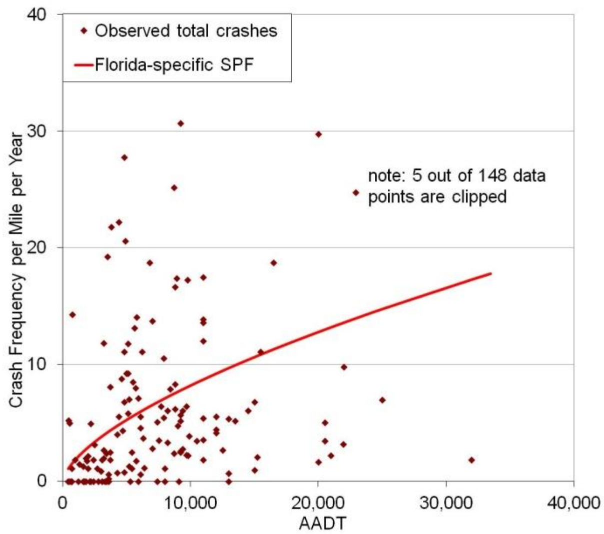
(c) Total Crashes On-Ramp



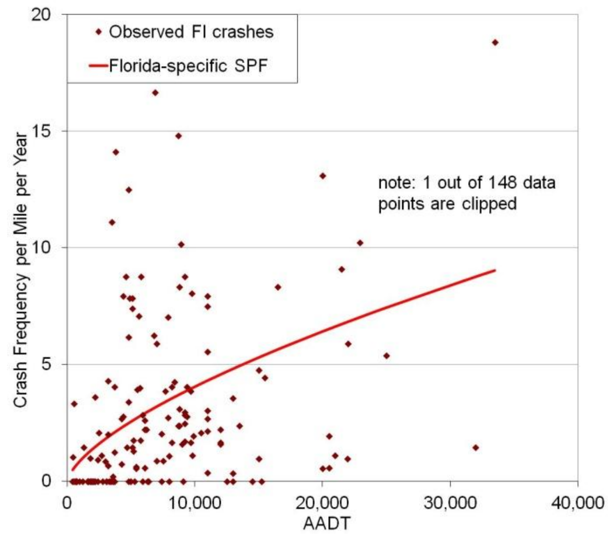
(d) F+I Crashes On-Ramp

Figure 2-23: SPFs for Urban Diamond Ramps

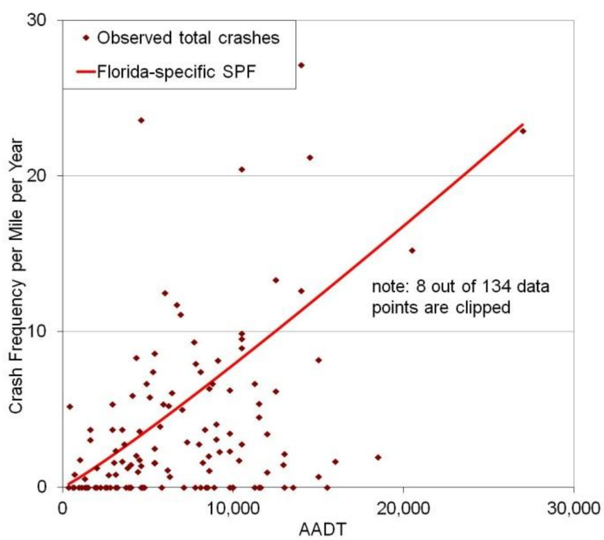
Figures 2-24 and 2-25 display Florida-specific SPFs for urban partial diamond ramps and urban trumpet ramps. National SPFs are unavailable as these categories are not among the 16 default subtypes used in *SafetyAnalyst*.



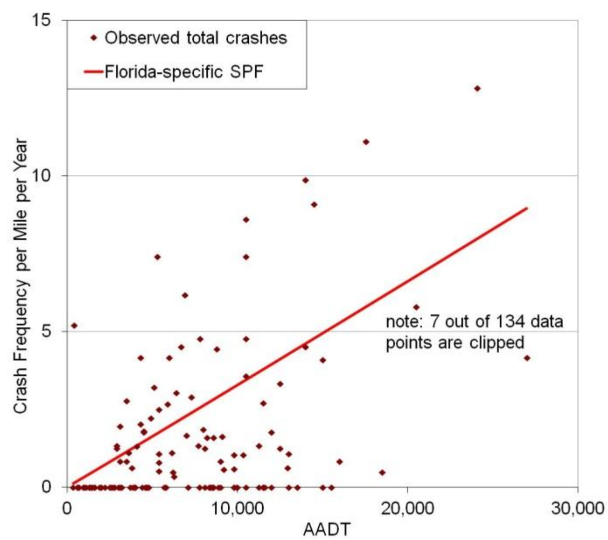
(a) Total Crashes Off-Ramp



(b) F+I Crashes Off-Ramp

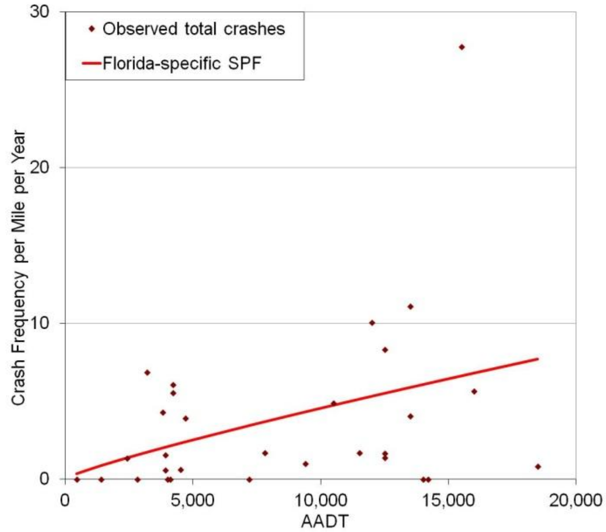


(c) Total Crashes On-Ramp

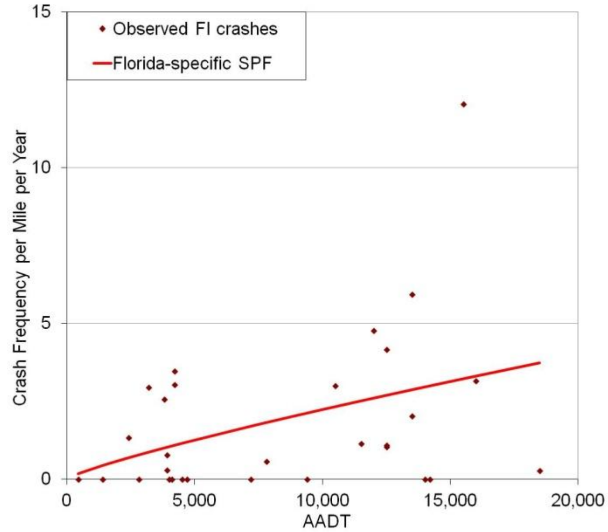


(d) F+I Crashes On-Ramp

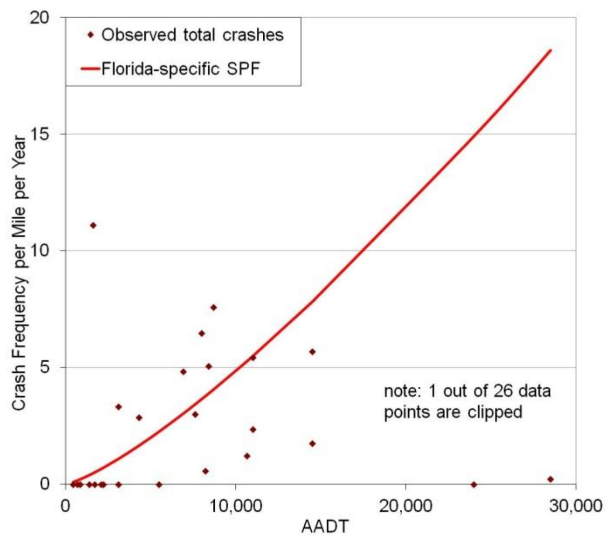
Figure 2-24: SPFs for Urban Partial Diamond Ramps



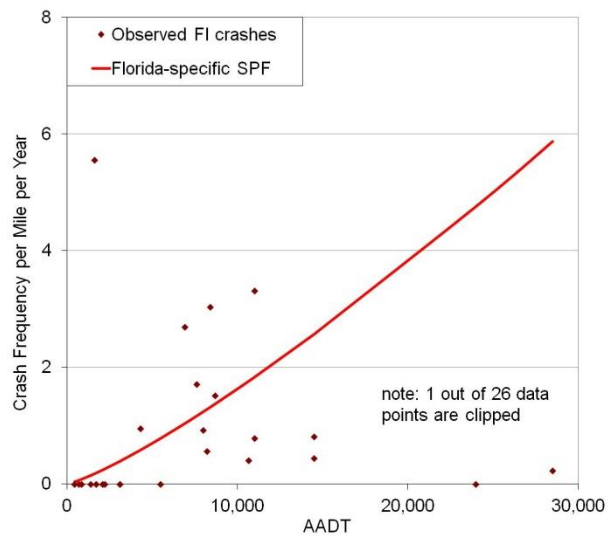
(a) Total Crashes Off-Ramp



(b) F+I Crashes Off-Ramp



(c) Total Crashes On-Ramp



(d) F+I Crashes On-Ramp

Figure 2-25: SPFs for Urban Trumpet Ramps

Figure 2-26 displays the SPFs for urban partial cloverleaf ramps (both on-ramp and off-ramp) for both total and F+I crashes. From the plots, it is observed that the total crashes for off-ramp are underestimated by the *SafetyAnalyst* default model. For F+I crashes on off-ramps and total crashes on on-ramps, the observed crash data are equally well represented by both the Florida-specific SPFs and the calibrated default models.

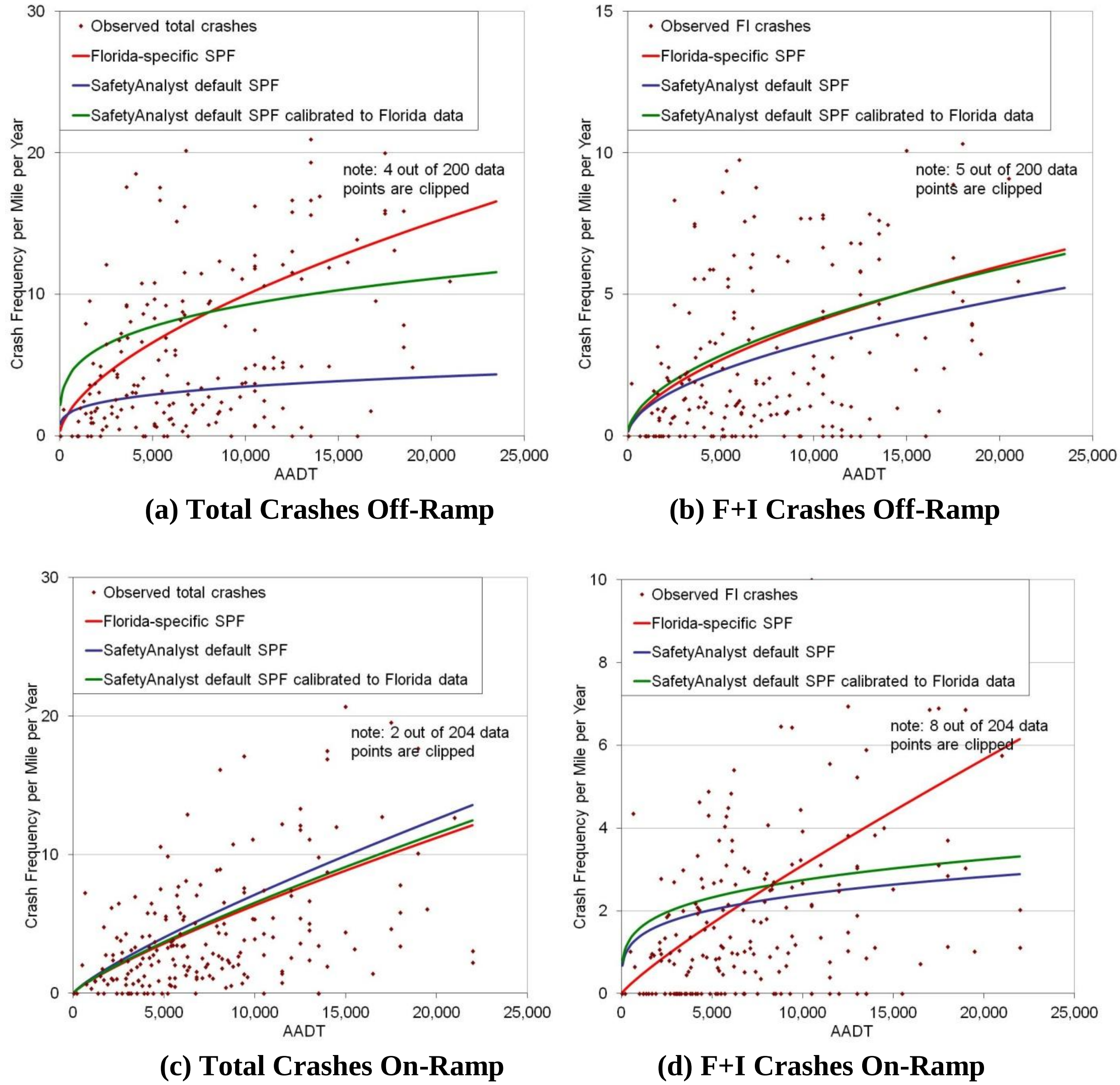


Figure 2-26: SPFs for Urban Partial Cloverleaf (Parclo Loop) Ramps

2.7 Summary

Florida-specific SPFs for segments were developed using 2008 RCI data and crash and traffic data from 2007-2010 for both total and F+I crashes. As per the predefined subtypes used in *SafetyAnalyst*, segments were divided into 17 site subtypes based on area type, functional classification, and number of lanes. Florida-specific SPFs were developed for all the 17 predefined segment subtypes using the procedure similar to the development of national default SPFs.

Compared to segments, the data requirements to generate intersection SPFs are intense. *SafetyAnalyst* divides intersections into 12 subtypes. One of the required variables, traffic control type (more precisely, type of signal phasing for signalized intersections and type of stop control or yield control for unsignalized intersections) is not in the required detail in the RCI database. Therefore, SPFs were developed for only four types of signalized intersections (rural and urban, three-leg and four-leg signalized intersections). RCI data from 2008 and crash and traffic data from 2007-2010 were used to develop Florida-specific SPFs. At this point, analysis of unsignalized intersections is not possible due to the lack of detailed data on traffic control type.

SafetyAnalyst classifies ramps into 16 subtypes based on ramp configuration, ramp type, and area type. This classification could not be used to generate Florida-specific SPFs as Florida uses different ramp classifications. Therefore, SPFs for Florida-specific ramp classifications were generated using 2008 RCI data and three years of crash data and traffic data (2008-2010).

For segments, signalized intersections, and ramps, Florida-specific SPFs were compared to the national default SPFs calibrated to Florida data using Freeman-Tukey R^2 statistic and overdispersion parameter.

CHAPTER 3
ACQUISITION OF LOCAL AVERAGE ANNUAL DAILY TRAFFIC DATA

Average annual daily traffic (AADT) is the average 24-hour traffic volume at a roadway location over a full year. AADT is required in *SafetyAnalyst* and to calculate crash rates, which are usually calculated as the number of crashes per million vehicle miles (MVM) for roadway segments or the number of crashes per million entering vehicles for intersections. AADT can be acquired either by collecting traffic counts in the field or through application of some estimation method. This chapter addresses both of these approaches. It first summarizes the availability of traffic count data for local roads from counties in Florida and then presents a new AADT estimation method based on travel demand modeling approach. A detailed review of the existing methods for AADT estimation is also included.

3.1 AADT Data Collection Methods

The most accurate method for obtaining the AADT of a roadway segment is to install an Automatic Traffic Recorder (ATR) to continuously count the total volumes throughout the entire year. However, the installation and maintenance of permanent counters is expensive, so the number of permanent counters is limited. For example, there are only a total of about 300 permanent counters installed along state roads in Florida. Therefore, it is economically infeasible to extensively apply this method of AADT estimation.

An alternative approach to estimating AADT is to use portable counts, also called short-term, seasonal, or coverage counts, with different types of portable devices such as pneumatic road tubes and microwave radar sensors. The short-term volumes, usually collected for one to three days, are referred to as the Average Daily Traffic (ADT), which is the average daily volume over the number days the data were collected. The AADT is then estimated by applying adjustment factors to ADT, as follows:

$$AADT = ADT \times AF \times SF \times GF \tag{3-1}$$

where,

AF = the axle correction factor,
SF = the seasonal adjustment factor, and.
GF = the annual growth factor.

FDOT currently uses this method to estimate AADT on all of its state roads. As noted in Chapter 1, FDOT planned to deploy *SafetyAnalyst* to enhance the safety improvement programs of both state and local roads in Florida. In other words, AADT data are needed not only for state roads, but also for local roads. The next section summarizes findings from an effort to determine the extent of AADT data availability for local roads from local agencies.

3.2 Availability of Local AADT Data

Table 3-1 lists the 67 counties of Florida by region. Since there is no standard program to collect or publish data, the local AADT acquisition has been done by contacting each county.

Information on traffic data was obtained either through an internet search or by contacting county offices individually. Table 3-2 gives the list of counties, their corresponding departments that had responded along with their mode of response (i.e., through email or phone). Table 3-3 gives the statistics of counties in Florida that were contacted for information on traffic data. Figures 3-1 and 3-2 display traffic data availability by county and thematic map of number of traffic count stations, respectively.

Table 3-1: Florida Counties by Region

North West	North Central	North East	Central	Central West	Central East	South West	South East
Bay	Alachua	Baker	Hardee	Citrus	Brevard	Charlotte	Broward
Calhoun	Bradford	Clay	Highlands	Desoto	Indian River	Collier	Martin
Escambia	Columbia	Duval	Lake	Hernando	Okeechobee	Glades	Miami-
Franklin	Dixie	Flagler	Marion	Hillsborough	St. Lucie	Hendry	Dade
Gulf	Gadsden	Nassau	Orange	Manatee	Volusia	Lee	Monroe
Holmes	Gilchrist	Putnam	Osceola	Pasco			Palm
Jackson	Hamilton	St Johns	Polk	Pinellas			Beach
Liberty	Jefferson		Seminole	Sarasota			
Okaloosa	Lafayette		Sumter				
Santa Rosa	Leon						
Walton	Levy						
Washington	Madison						
	Suwannee						
	Taylor						
	Union						
	Wakulla						

Table 3-2: List of Counties and their Corresponding Departments that Responded

County	Department	Through Email/Phone
Alachua	Engineering	Email
DeSoto	Transportation Director	Email
Gadsden	Planning	Email
Hamilton	Planning, Zoning, & Land Use	Email
Hamilton	Roadway	Phone
Highlands	Traffic Operations	Email
Highlands	Engineering	Email
Leon	Engineering	Email
Martin	Engineering	Email
Miami-Dade	MPO Transportation	Email
Okaloosa	Public Works	Email
Okeechobee	Engineering	Phone
Santa Rosa	Planning	Email
Sarasota	Planning	Email
Sumter	MPO Transportation	Email
Sumter	Planning & Development	Email
Taylor	Engineering	Email
Wakulla	Planning & Zoning	Email
Wakulla	Public Works	Phone
Wakulla	Planning (Transportation Planning Agency)	Phone

Table 3-3: Descriptive Statistics of Counties that were Contacted for Information

	Number of Counties
Counties with no contact information	5
Counties that have replied and indicated that they do have any traffic data	10
Counties that have not responded	10
Counties from which data are obtained	42
Total	**67**

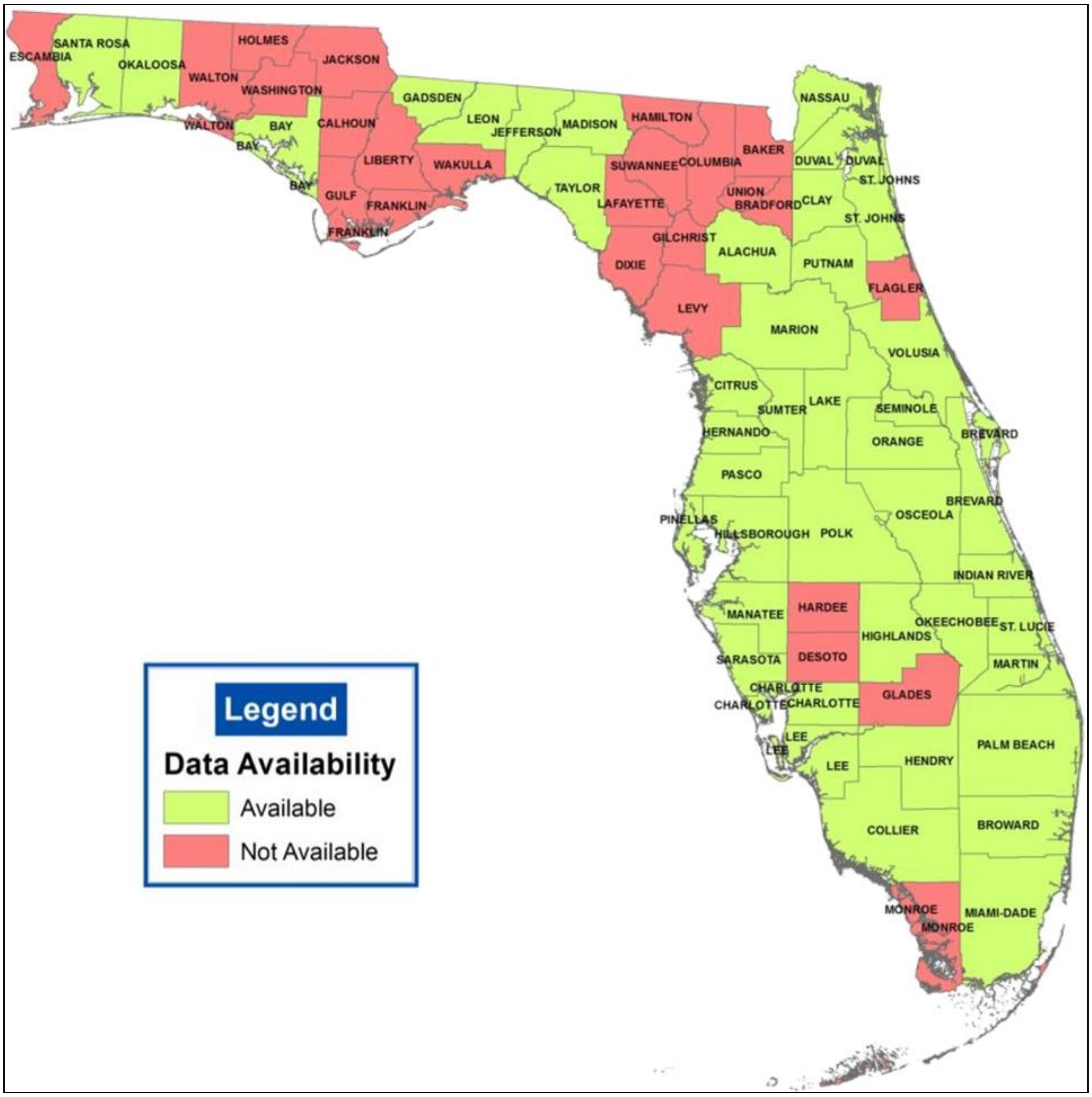


Figure 3-1: Traffic Data Availability by County in Florida

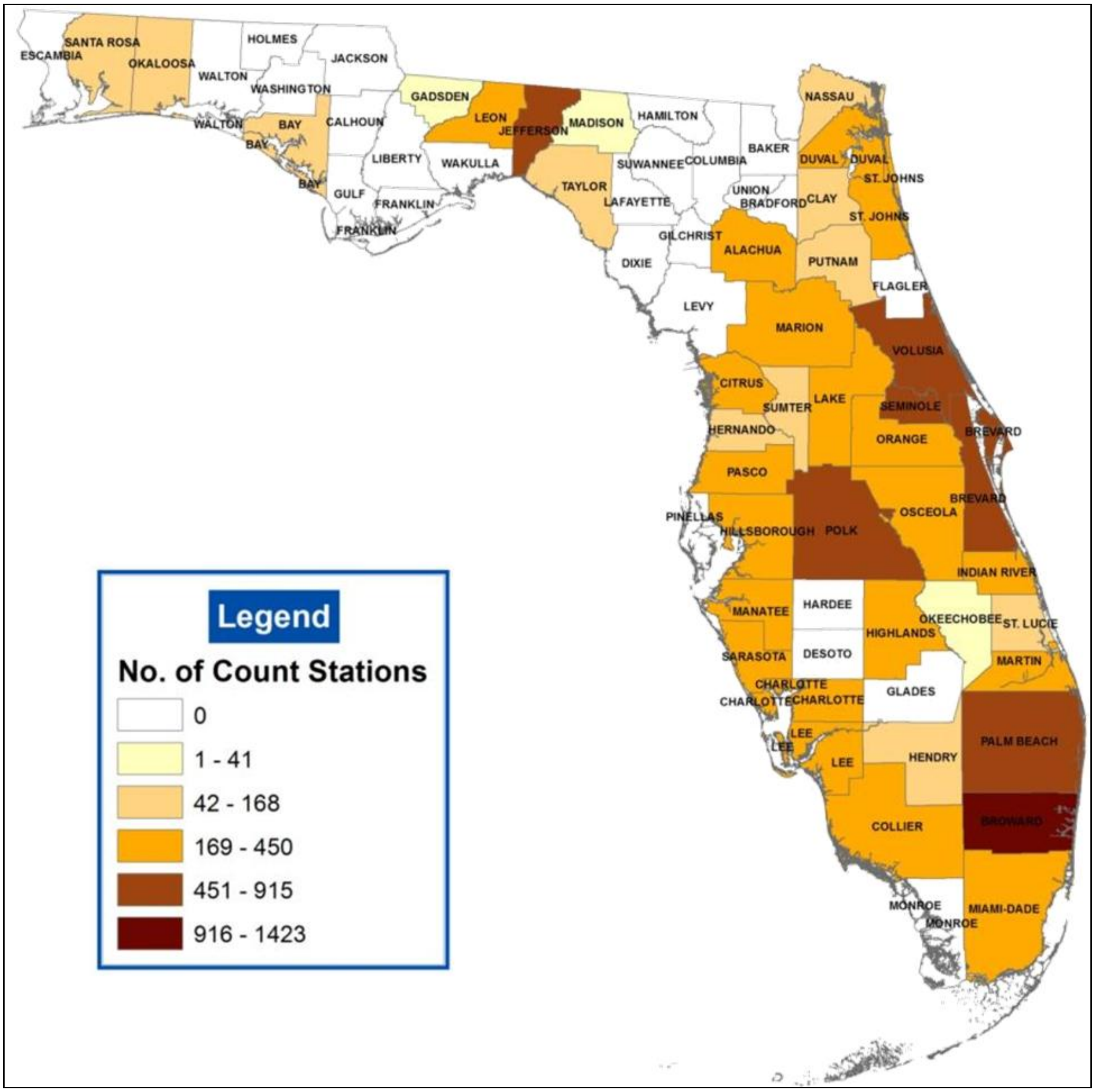


Figure 3-2: Thematic Map of Florida by Number of Traffic Count Stations

The following counties indicated that they do not have traffic data: Columbia, DeSoto, Flagler, Glades, Gulf, Hamilton, Holmes, Lafayette, Wakulla, and Washington.

The following counties have not responded: Bradford, Dixie, Escambia, Franklin, Gilchrist, Hardee, Jackson, Levy, Monroe, and Suwannee.

Appendix A gives contact information of the twelve counties that provided information through e-mail. Links to the thirty counties that provided their information on their respective websites are also provided.

Of the 67 counties in Florida, traffic data were obtained from 42 counties. The following sections give a description of the type of data available with each county.

3.2.1 Summary of Available Traffic Data by County

Alachua County

The Public Works Department has an Excel file containing ADT counts from 2005 to 2009 for 225 count stations. The Excel file has data on *Segment Number, Count Stations, Location, Road Name, County Road Designation, Cross Street*, and *Yearly ADT Counts*.

Bay County

Bay County has AADT count data in the PDF format. The Bay County Planning Department updates the *Bay County Concurrency Management System – County Roads* spreadsheet on a bi-weekly basis on the Bay County website. The spreadsheet has information on *Road, County/City Road and Segment, Road Segment ID, Function Class, Facility Type, Number of Signals, Segment Length, Mile, LOS Area, LOS/Maximum Volume, Count Station Number, 2009 AADT, Average AADT, Current LOS, Available Capacity, Adopted LOS AADT (1%, 5% and 110% capacity), Trips Added to AADT, New AADT (for 2010), New LOS (for 2010),* and *De Minimus Impact Allowed.* The PDF file contains other tables that summarize similar information for federal roads within the county and also includes tables with *D factor, K factor,* and *Peak Hour Volumes* for both county and federal roads.

Brevard County

Brevard County Space Coast Transportation Planning Organization (TPO) publishes *Brevard Traffic Count* report each year. The report is a summary of historical counts. The report summarizes data from 665 count stations on 18 state and 109 county roads. The data, collected on weekdays in 48-hour cycles, were then adjusted using FDOT's seasonal adjustment factors for each roadway segment to calculate the AADT.

Brevard's TPO uses a spreadsheet to compare the current AADT with the data from previous years. The TPO also uses an automated internet system called *Transportation Management System* that provides traffic counts data and traffic movement counts. The data can be retrieved either by searching the map or by entering roadway information. Figure 3-3 shows a screenshot of the Transportation Management System.

Broward County

Broward Metropolitan Planning Organization (MPO) has developed *The Urban Traffic Count Program* to provide AADT and turning movement counts for signalized intersections. The program includes both annual reports and maps. The maps provide a visual representation of the location and AADT of each station within the county and the report summarizes the AADT and peak hour traffic volumes. The Broward MPO also produces the *Quarterly 24-Hour Traffic Volumes* table which includes data from 1,423 stations. The columns in the table include *ID, Location, Direction 1, Direction 2, Date, 2009 AADT,* and *AADT Flag*. The flag explains how the data were obtained (i.e., computed or manually estimated).

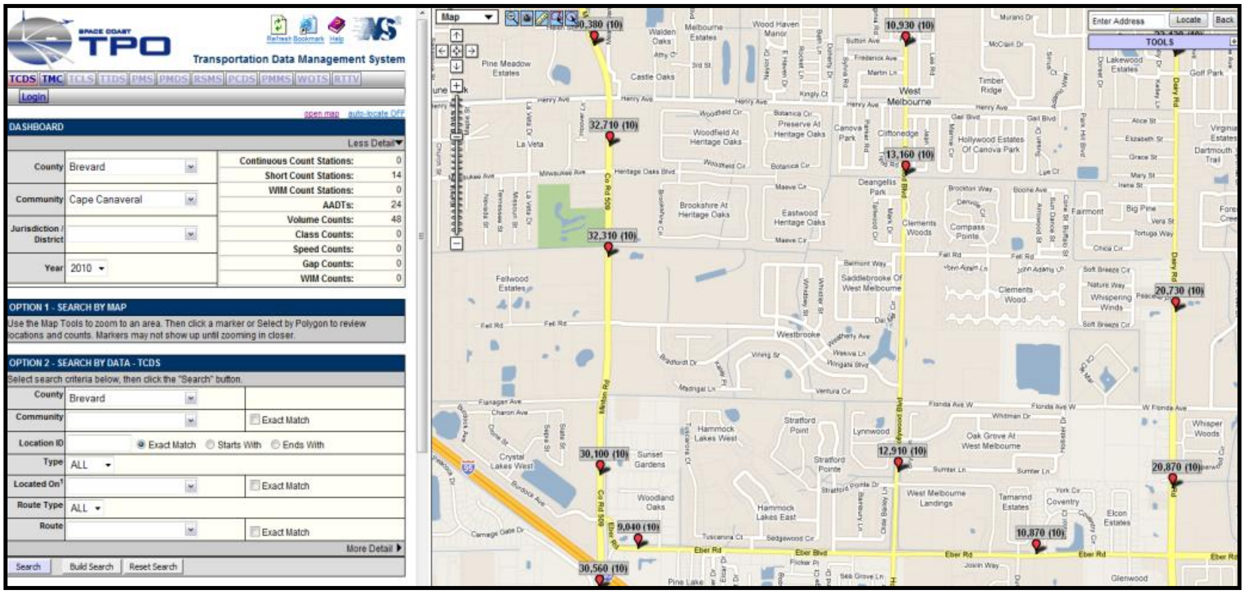


Figure 3-3: Transportation Management System of Brevard County

Charlotte County

Charlotte County's Public Works Department conducts studies on regular basis. The Department collects traffic counts on 299 stations and then summarizes them in the *Charlotte County Transportation Engineering Section 24-Hour Machine Traffic Counts* table with the following columns: *Station Number*, *Date*, *Location*, *24-Hour Volume*, and *24-Hour Adjusted Volume* (AADT).

Citrus County

Citrus County's Land Development Division prepares summary reports for 333 count stations. The division uses weekday 48-hour traffic counts data provided by the Road Maintenance Division. The reports are uploaded to the Board of County Commissioners website. The Department summarizes data in *2009 Average Daily Traffic and Truck Percentages* table with the following columns: *Station*, *Roadway*, *2009 Average AADT*, *First Cycle 2009*, *Second Cycle 2009*, *Date*, *ADT*, *% Light Trucks*, and *% Heavy Truck*.

Clay County

North Florida Transportation Planning Organization collects weekday 24-hour traffic volume count data and adjusts using FDOT seasonal factors to provide AADT data. The data are presented in a PDF file. The *Clay County Local Traffic Counts* table summarizes data from 72 count stations in the following columns: *Count Stations*, *Roadway*, *Location Description*, *Yearly AADT*, and *% Difference in Traffic in the Last Two Years*.

Collier County

Collier County's Traffic Operations Department develops an annual report summarizing traffic counts (i.e., raw data) obtained from 198 count stations. Of the 198 stations, 149 are located on heavily traveled roads and the counts are taken quarterly. Traffic counts are collected semi-annually (in and out of season) at 25 stations, and counts are collected annually on the remaining 24 stations. The Department also provides quarterly reports containing raw data from regular count stations during the fiscal year.

Duval County

North Florida Transportation Planning Organization collects weekday 24-hour traffic volume count data, and adjusts using FDOT seasonal factors to provide AADT data. The data are presented in a PDF file. The *Duval County Local Traffic Counts* table summarizes data from 364 count stations in the following columns: *Count Stations, Roadway, Location Description*, *Yearly AADT,* and *% Difference in Traffic in the Last Two Years*.

Gadsden County

Gadsden County's Planning Department does not collect traffic data. The county has a sheet of a project that shows the AADT count summary for the year 2008 on 41 count stations summarizing information of eleven county roads and six state roads in the following columns: *Road Name, AADT/LOS,* and *Peak Hour- Peak Direction/LOS*.

Hendry County

In 2009, Hendry County's Engineering Department published a report for county roads using data from 2006. The report provides average data taken for 48 consecutive hours and adjusted with FDOT seasonal factors to provide AADT data. The report includes a set of maps that illustrate the location of each count station and a summary table of the data collected from 65 count stations. The table includes the following columns: *Street, Location, Station #,* and *Yearly AADT for 2002-2006*.

Hernando County

Hernando County's Planning Department has developed a program to collect traffic data on county roads. With the help of Hernando County's Public Works Department, a report is being published every alternate year, with the latest summary report from 2010. The data from 103 stations are summarized in an Excel spreadsheet. The *Hernando County 2010 - Traffic Counts* table includes the following columns: *Station, Facility Name, From, To, Average Weekday Traffic Volume, Peak Hour Volume, v/c Ratio, Capacity,* and *Count Year.*

Highlands County

Highlands County's Traffic Operation Department develops an annual summary table with data from 207 count stations. The AADT county data is provided on an Excel spreadsheet with the following columns: *ID Number, Road Name, Location, AADT,* and *Peak Hour.*

Hillsborough County

Hillsborough County's Development Services Department has developed a LOS report for 2011 summarizing the AADT data from 310 count stations. Even though the main focus of the report is the level of service (LOS), AADT data can be extracted from the summary table. In addition, Hillsborough County's Planning and Growth Management Department develops a report exclusively for the countywide traffic data collection based on the data from 125 count stations. The report provides a summary table with the following columns: C*ount Stations, Roadway, Location, 3-Day Average, Peak Hour Factor, and Directional Factor*.

Indian River County

Indian River County's Traffic Engineering Department maintains an annual summary table of 258 count stations. The table is provided in a PDF file and contains Historical Data and 2010 Data. Data on *Link, On-Street, From-Street, To-Street, 2007 AADT, 2008 AADT and 2009 AADT* are stored under Historical Data. C*ount Date, ADT, N/E, S/W, and 2010 AADT* are stored under 2010 Data.

Jefferson County

Jefferson County's Highways and Transportation Department has a report developed using 2006 data. The report summarizes traffic data (AADT, 24-hour, and annual weekday traffic) from 572 count stations. Data on *Roadway Name, Jurisdiction, Location, Year, Count,* and *Type* are collected. This report in particular consists of traffic data for 2000-2005 along 75 roadways.

Lake County

The Public Works Engineering Division has an AADT report summarizing count data from 285 count stations for 2006-2010. Information is collected on *Map Station, Road Name, Location, AADT, and Adjusted PM Peak Hour Volume.*

Lee County

Lee County's Public Works Department prepares an annual report summarizing data from 391 count stations on both state and county roads. It is to be noted that, of the 391 stations, only 60 are permanent count stations.

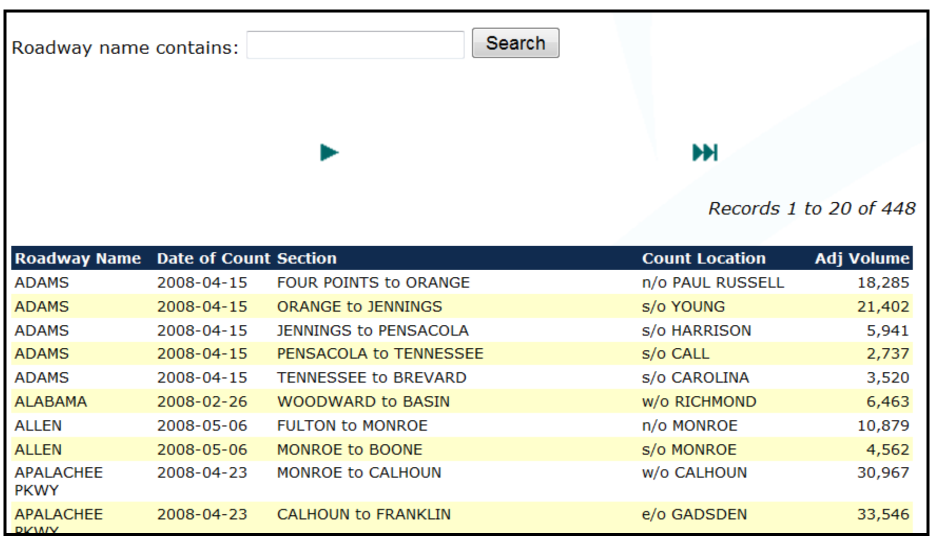
Leon County

Leon County's Public Works Department has an ongoing program to collect traffic data from 214 count stations (on county maintained roads), of which 165 are on county roads and 49 are on county roads that intersect state roads. The data were obtained by correspondence and provided in Excel format. The spreadsheet summarizes traffic data and includes the following columns: *Street OW/LO* (it defines whether the count station is on county or federal road), *Date of Count, Count Stations, Roadway, Section, Existing Volume* (raw data), and *Adjusted Volume* (AADT).

Leon County has only two cities, City of Tallahassee and City of Woodville. The Excel spreadsheet summarizes the data for the whole county. However, the City of Tallahassee posts a summary of the data from count stations pertaining only to its city. The data can be accessed through the City of Tallahassee website (talgov.com). The traffic information of the City of Tallahassee is summarized in an automated system where data could either be spatially visualized or downloaded in a PDF format. Figure 3-4 shows a screen shot of the automated system of Leon County. Within this system, data from 448 count stations (on city maintained roads) is summarized in the following columns: *Roadway Name, Date of Count, Section, Count Location,* and *Adjusted Volume (AADT).*

Madison County

Madison County's Public Works Department has data from 14 count stations in individual PDF files. The data varies from 24-hour counts period to 96-hour counts period. However, all the files provide a summary including the following information: *ID, Street Name, City, Begin Date* (when the count was taken), *End Date* (when the count was taken), *Total Number of Hours Recorded, Raw Data,* and *AADT Count.*


Roadway name contains: Search

Records 1 to 20 of 448

Roadway Name	Date of Count	Section	Count Location	Adj Volume
ADAMS	2008-04-15	FOUR POINTS to ORANGE	n/o PAUL RUSSELL	18,285
ADAMS	2008-04-15	ORANGE to JENNINGS	s/o YOUNG	21,402
ADAMS	2008-04-15	JENNINGS to PENSACOLA	s/o HARRISON	5,941
ADAMS	2008-04-15	PENSACOLA to TENNESSEE	s/o CALL	2,737
ADAMS	2008-04-15	TENNESSEE to BREVARD	s/o CAROLINA	3,520
ALABAMA	2008-02-26	WOODWARD to BASIN	w/o RICHMOND	6,463
ALLEN	2008-05-06	FULTON to MONROE	n/o MONROE	10,879
ALLEN	2008-05-06	MONROE to BOONE	s/o MONROE	4,562
APALACHEE PKWY	2008-04-23	MONROE to CALHOUN	w/o CALHOUN	30,967
APALACHEE PKWY	2008-04-23	CALHOUN to FRANKLIN	e/o GADSDEN	33,546

Figure 3-4: Automated System of Leon County

Manatee County

For over thirty-five years, Manatee County's Public Works Department has a program to collect traffic data annually from 293 count stations. The traffic volume data is computed by taking 24-

hour bidirectional count and adjusting it with seasonal factors provided by the FDOT. The data are also available at mymanatee.org website under the Public Work section in PDF format with the following columns: *Station, Route Name, Direction, Distance, Cross Route Name*, and *AADT Counts* for the years 1997-2010. The downloadable PDF document has links to different location maps for each of the count stations to provide a better understanding of the location of each count station.

Marion County

Ocala/Marion County TPO publishes a report in the summer of every year. The report contains information collected by the City of Ocala (OCA), Marion County (MC), and the Florida Department of Transportation (FDOT). It is noted that the data collection methods vary by count stations. For monthly counts, a series of 24-hour counts are taken on a Tuesday, Wednesday, or Thursday at the same location once a month for a year. For annual three-day counts, the average of three 24-hour counts is taken. For one day counts, a single 24-hour count is taken Monday through Thursday.

The TPO divides the county into ten subareas and has maps for a better understanding of the 406 count stations' locations. The report also provides a summary table per subarea containing the following information: *Road Segment/Map #, Location, Source* (OCA, MC or FDOT), *Count Type* (1, 2 or 3), *ADT* for years 2005-2009, and *5-Year Annual Growth Rate*.

Martin County

Martin County's Traffic Division posts a *Roadway LOS Inventory Report* every year. This report is available in PDF format and contains AADT data for 224 count stations. *Martin County 2010 Roadway Level of Service Inventory Report* contains information on *Road Name, From, To,* and *AADT Counts* for years 2006-2010.

Miami-Dade County

Miami-Dade County's MPO has an Excel spreadsheet with a summary of 378 count stations with information on *Station, Location, PHF* (peak hour factor), *AADT, K factor,* and *D factor*. The MPO also has a map showing the count stations superimposed on the county's roadway network.

Nassau County

North Florida Transportation Planning Organization collects weekday 24-hour traffic volume count data, and adjusts using FDOT seasonal factors to provide AADT data. The data are presented in a PDF file. The *Nassau County Local Traffic Counts* table summarizes data from 64 count stations in the following columns: *Count Stations, Roadway, Location Description, Yearly AADT (for 2000-2008)*, and *% Difference in Traffic in the Last Two Years*.

Okaloosa County

Okaloosa County's Public Works Department has an Excel spreadsheet with data from 55 count stations. The table includes information on *Station Number*, *Location*, *Count Date*, and *Two-Way ADT*. It is to be noted that the data provided by the Department are raw counts and no correction factors are applied to the counts.

Okeechobee County

Okeechobee County's Engineering Department has a report developed in 2008 which compiled traffic data from 40 count stations. Data from 48-hour counts were collected from each station and summarized in non-peak and peak season tables, and AADT is calculated using peak seasonal factors and seasonal factors from FDOT. The report also offers turning movement counts and a summary of the PM peak hour volumes for 20 intersections within the county.

Orange County

Orange County's Traffic Engineering Division has a program to collect traffic data annually on 384 count stations. The Division collects weekday 24-hour traffic volume count data, and adjusts using FDOT seasonal factors to provide AADT data. The data are summarized in a table in the PDF format. Significant columns in the table are: *Count Station ID, Roadway, Counter Location,* and *2010 AADT*. More information such as *K factor, D factor, Peak Hour Volumes,* and *Posted Speed Limit* are also available in the summary table.

Osceola County

Osceola County's Transportation Department has developed the *2007 Traffic Count Report* summarizing historical ADT count for the state, county, and city maintained roads. The report is based on 222 count stations on county roads alone. The data are categorized into the following five areas: Far West County, Poinciana/Campbell City, Kissimmee, Buenaventura Lakes/Neptune, and St Cloud and East area. The tables by each area summarize information on *Station Number*, *Count Location,* and *Historical ADT* (24-hour bidirectional vehicular volumes) counts for 2000-2007. Information such as *Peak Hour Volume, D factor,* and *K factor* are also included in the report.

Palm Beach County

Palm Beach County's MPO provides a variety of historical traffic data in its website (under the traffic counts section). The most recent publication is *2004: Traffic Count Book with Included Maps*. The document is a 2004 summary report of data from 915 count stations with the following information: *Station, Street Name, Counter Location, Lanes, Roadway, 1st Quarter (collected and adjusted data), 3rd Quarter (collected and adjusted data),* and *Average*. The report also includes maps of the different Palm Beach areas with the 2004 ADT counts.

There is also a *Palm Beach County Traffic Division Historic Growth Table* for the year 2010. The table presents data from the 941 count stations and the traffic data are summarized in the following columns: *Station, Road, From, To, Lanes, Daily Traffic Volumes* (for 2005-2009), *2010 Daily Volume, 2010 AM Peak Hour,* and *2010 PM Peak Hour*.

Pasco County

Pasco County's MPO posts the traffic data report from 346 count stations on its website. The data provided is the 24-hour count average at each station. Directional peak hour volume as well as 85% speed and percent of trucks are also available in the summary report. Additionally, the website also provides Traffic Count Map and a PDF file that shows the most recent ADT data plotted in the corresponding station within the county's roadway network.

Pinellas County

Pinellas County's MPO develops the *Average Annual Daily Traffic Counts in Pinellas County (AADT) Map* presenting count stations and their corresponding counts on the county's roadway network. The data provided is adjusted using a seasonal adjustment factors to provide AADT.

Polk County

Polk County's TPO provides traffic data from 657 count stations in the GIS format. The latest files can be downloaded from the TPO's website (polktop.com) under the *GIS and Maps* section. The section also has a table that summarizes the data in the PDF format. Count data are organized by *Station Number, Description* (location of the station), and *AADT Counts* (from 1986-2009).

Putnam County

Putnam County's Planning and Development Division provides a comprehensive report in the PDF format for the years 2010-2025. The Division provides a table and a map that summarizes the traffic data (AADT) from 56 count stations for 2008 and 2009.

Santa Rosa County

Santa Rosa County's Planning Department develops an *Annual Road Segment Report*. The latest report is for the 2009 traffic data and can be downloaded from the county's website (under the *Development Services* section). The report contains data from 73 count stations. The traffic data are summarized in 12 columns; the most relevant for this project are *Type* (AA for AADT and PH for peak hour), *Description* (road name), *Start, End,* and *Existing Traffic* (AADT).

Sarasota County

Sarasota County's MPO collects traffic data from the county and state roads within the county and creates a *Generalized Level of Service Analysis Summary*. The data from 450 count stations are summarized in the following columns: *ID#, Roadway Name, Limits* and within the *Existing Traffic Conditions, Counts Adjusted to 2009 AADT*.

Seminole County

Seminole County collects data from approximately 480 count stations annually between January and March. Data are typically collected on a weekday for a 24-hour period. The data are available on the county's website in two formats: PDF and automated system. The PDF lists all count stations' locations and their historical ADT data from 1986-2010. The Department's *Public Works* section hosts the automated system that shows all the available traffic data spatially. Figure 3-5 shows a screenshot of the automated system of Seminole County.

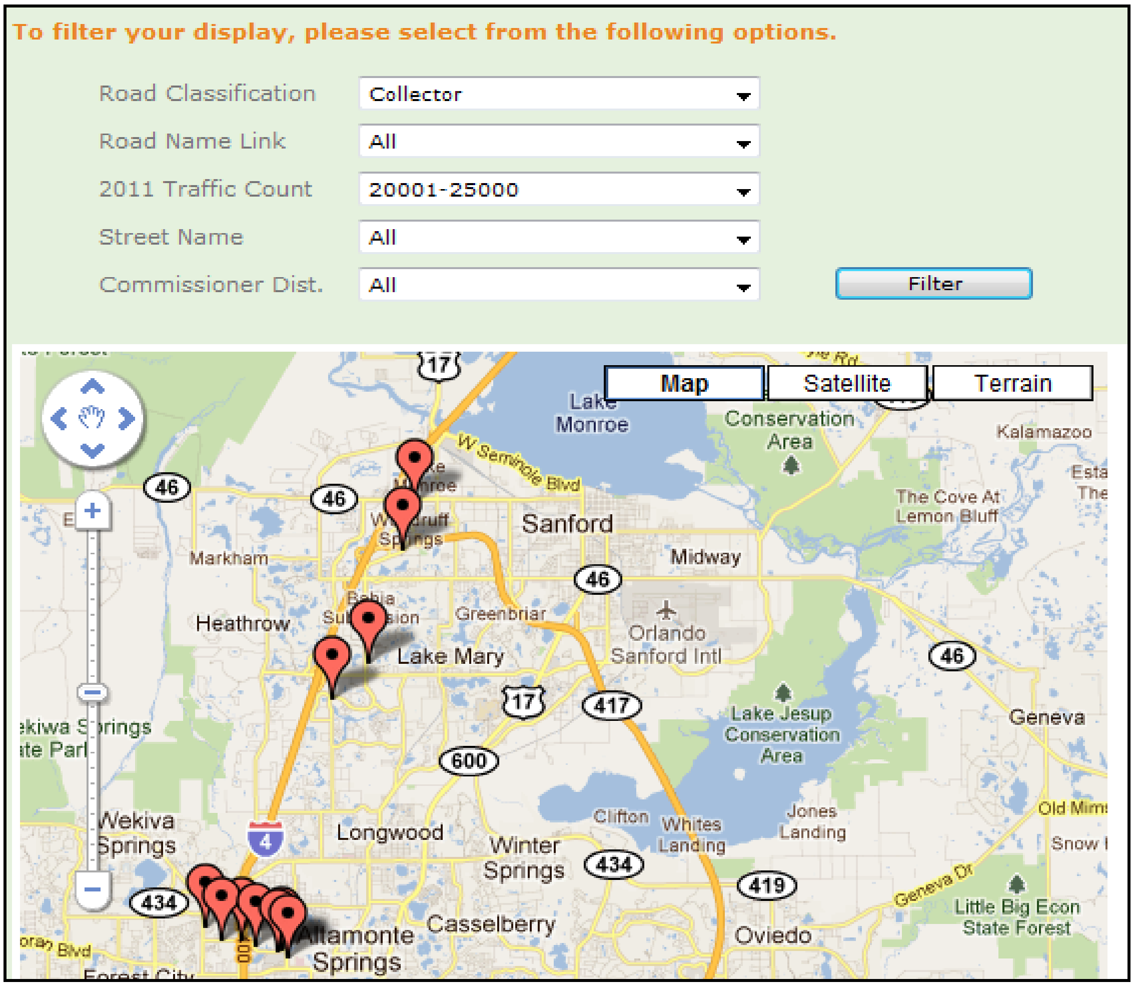


Figure 3-5: Seminole County Automated System

St Johns County

North Florida Transportation Planning Organization collects weekday 24-hour traffic volume count data and adjusts using FDOT seasonal factors to provide AADT data. The data are presented in a PDF file. The *St Johns County Local Traffic Counts Table* summarizes data from 203 count stations in the following columns: *Count Stations, Roadway, Location Description, Yearly AADT* (2000-2008), and *% Difference in Traffic in the Last Two Years*.

St. Lucie County

St. Lucie County's TPO collects traffic count data from 121 count stations. The data are available in the TPO's website in the PDF format. The data are summarized in the following columns: *Count Station #, Roadway Name, Location, Count Date, ADT,* and *Peak Hour Values*.

Sumter County

Sumter County's MPO maintains a record of 166 count stations. The MPO produces annually the *Sumter County Annual Traffic Counts Volumes Summary Table*. The traffic data are summarized in the following columns: *Station ID, Location, Start Date,* and *Duration* (24-hour, 48-hour or 72-hour counts). The summary table provides historical ADT data for the years 2007-2011. Information related to AM and PM peak hour volumes is also available.

Taylor County

Taylor County's Engineering Department provides a spreadsheet of the summary of data collected on 92 count stations along with 7-day average counts. The Department also provides the available traffic count sheets for different county roads.

Volusia County

Volusia County's Traffic Operations Department updates the *Volusia County Average Annual Daily Traffic & Historical Counts Table* every year. The county has 2010 data from 525 count stations summarized in a table that contains information of the count stations' location, facility type, and historical AADT data from 2001 to 2010.

As mentioned earlier, out of the 67 counties, data from 42 counties was successfully obtained. Tables 3-4 and 3-5 summarize the obtained data.

Table 3-4: AADT Data Summary by Data Type, Format, and Number of Count Stations

County	Data Type		Data Format				Count Stations	
	AADT	ADT	PDF	Excel	GIS	Map	No. of County Roads Stations (only)	No. of Stations (SR and County)
Alachua		1		1			225	
Bay	1		1				76	
Brevard	1		1					665
Broward	1	1	1	1	1			
Charlotte	1		1				299	
Citrus		1	1					333
Clay	1		1				72	
Collier		1	1					198
Duval	1		1				364	
Gadsden	1					1		41
Hendry	1		1				65	
Hernando		1		1			103	
Highlands	1		1				207	
Hillsborou	1	1	1				310	
Indian	1	1	1					258
Jefferson	1		1					572
Lake	1		1				285	
Lee	1							391
Leon	1			1				214
Madison	1		1				14	
Manatee	1		1				293	
Marion		1	1					406
Martin	1		1					224
Miami-	1			1			378	
Nassau	1		1				64	
Okaloosa	1	1		1			55	
Okeechobe	1		1					40
Orange	1		1				384	
Osceola		1	1				223	
Palm		1	1					915
Pasco		1	1				346	
Pinellas	1					1		
Polk	1		1		1		657	
Putnam	1					1		56
Santa Rosa	1		1					73
Sarasota	1		1					450
Seminole		1	1					480
St Johns	1		1				203	
St.Lucie		1	1				121	
Sumter		1	1				166	
Taylor		1		1			92	
Volusia	1		1				525	
Total	**29**	**16**	**32**	**7**	**2**	**3**	**5,527**	**5,316**

Table 3-5: AADT Data Summary by Department Providing the Data

County	Department Providing the Data								
	Public Work s	**Plannin g Dept**	**TP O**	**MP O**	**Develop- ment Division**	**Traffic Operatio -ns Dept**	**Engg. Dept**	**Highways & Transpo- rtation**	**Transpo- rtation Dept**
Alachua	1								
Bay		1							
Brevard			1						
Broward				1					
Charlotte	1								
Citrus					1				
Clay				1					
Collier						1			
Duval				1					
Gadsden		1							
Hen dry							1		
Hernando				1					
Highlands						1			
Hillsborough		1			1				
Indian River							1		
Jefferson								1	
Lake	1								
Lee	1								
Leon	1								
Madison	1								
Manatee	1								
Marion			1						
Martin						1			
Miami-Dade				1					
Nassau				1					
Okaloosa	1								
Okeechobee							1		
Orange							1		
Osceola									1
Palm Beach				1					
Pasco				1					
Pinellas				1					
Polk			1						
Putnam		1							
Santa Rosa		1							
Sarasota				1					
Seminole	1								
St johns				1					
St. Lucie			1						
Sumter				1					
Taylor							1		
Volusia						1			
Total	**9**	**5**	**4**	**12**	**2**	**4**	**5**	**1**	**1**

3.3 Existing Studies on AADT Estimation Methods

It can be concluded from the survey of local agencies that the AADT data for local roads for statewide *SafetyAnalyst* application are far from sufficient in both quantity and quality. A method to estimate AADTs for local roads is thus needed if *SafetyAnalyst* is to be deployed by local agencies. A number of different approaches for AADT estimation can be found in the literature. They include:

1. Traditional Factor Approach
2. Regression Modeling
3. Travel Demanding Modeling
4. Image Processing
5. Machine Learning
6. URS Method

These approaches and the related literature are summarized below.

3.3.1 Traditional Factor Approach

To estimate AADT on road segments with short-term counts, the traditional factor approach uses adjustment factors, which are calibrated from continuous Automatic Traffic Recorder (ATR) data, to convert the short-duration volume data collected (usually over a period of 48 hours) from the short-term counts. The effectiveness of this approach is based on the fact that it accounts for variations in traffic over different time scales such as time of day, day of week, and season (month of the year). It has been widely applied throughout the U.S., and is recommended by the guidelines of AASHTO (1992) and the Traffic Monitoring Guide (TMG) of FHWA (2001).

The AADT estimation procedure using the traditional factor approach can be divided into two steps. The first step is to calculate the adjustment factors using the continuous traffic data recorded on the ATR sites. The second step is to apply the adjustment factors calibrated to estimate AADT values for road segments with short-term counts. The commonly used adjustment factors include axle correction factors, seasonal adjustment factors, and annual growth factors. To estimate AADT accurately, the appropriate calculations of these factors are critical.

To obtain more accurate adjustment factors, factor groups can be created by grouping the short-term sites and associated ATR sites. In this way, the average adjustment factors for each group can be determined. Factor groups are usually divided according to the functional classification, geographical location, and the judgment of analysts. A report prepared by Cambridge Systematics, Inc. (1994) recommended that the number of ATR sites in each group should be between five and eight. Roess et al. (2004) pointed out that groups for daily factors and groups for seasonal factors do not have to be the same, although it is convenient if they match. A detailed discussion about the methodologies to create factor groups can be found in TMG (FHWA, 2001).

The axle correction factors are used to convert the number of axles to the number of vehicles. This correction is necessary only when the short-term counts measure axle impulses with a single road tube. To calculate axle correction factors, the data from the vehicle classification counters for the same days as the short-term traffic count are usually used. At each permanent counter site of a factor group, vehicle classification counters can detect the number of the vehicles in each classification. The total number of axles for this site can be calculated by summing up the product of the number of axles and number of vehicles for each classification. Dividing this figure by its total number of vehicles will get the average number of axles per vehicle for the site, which is summed up for all sites in the factor group and divided by the number of counters. The result is the group mean axles per vehicle, and its inverse is the axle correction factor for the group. The calculations can be performed using the following formula:

$$AF_g = \left[\frac{\sum_g \frac{\sum_c (A_c \times V_c)}{\sum_c V_c}}{N_g} \right]^{-1} \tag{3-2}$$

where,

AF_g	=	the axle correction factor for factor group g,
A_c	=	the number of axles for vehicle class c at a permanent count site,
V_c	=	the number of vehicles for vehicle class c at a permanent count site, and
N_g	=	the number of permanent sites in factor group g.

The seasonal adjustment factors are used for the day-of-week and monthly adjustments. An example to show how the seasonal factors are calculated is given as follows:

$$SF_{ijk} = \frac{AADT_k}{MADT_{ijk}} \tag{3-3}$$

where,

SFi_{jk}	=	the seasonal factor for the day-of-week j in month i at ATR site k,
$AADT_k$	=	the AADT of ATR site k, and
$MADT_{ijk}$	=	the monthly average day of the week traffic for month i and day-of-week j at ATR site k.

Two basic steps are involved in computing the seasonal adjustment factors: computing the numerator, which is AADT, and the denominator, which depends on the procedure used. The numerator, AADT, can be calculated with the continuous traffic data recorded by the ATR sites. There are two basic methods to calculate AADT. One is the simple average daily traffic of all days in a year, and the other is called the average of averages method, which was presented in AASHTO (1992). This method first calculates the seven values of monthly average day-of-week (MADW) traffic for each month. The results in 84 MADW values are then grouped by day-of-week and averaged across the twelve months to yield seven values of annual average days of the week (AADW) for the year. The last step is to calculate the arithmetic mean of the seven AADW values, which can be used as the estimation of AADT. Both Cambridge Systematics (1994) and TMG (FHWA, 2001) recommended this AASHTO method because it can provide a more accurate estimation than the simple average method for such cases as when some data are missing from a specified year at a given site.

The denominator of calculating seasonal adjustment factors depends on the temporal grouping procedures used. These procedures can be based on day-of-week, month, combined weekdays, or combination of day-of-week and month, etc. Cambridge Systematics, Inc. (1994) compared seven of these procedures and concluded that a number of different factoring techniques can result in reasonably similar levels of AADT estimating accuracy as long as the procedure accounts for all types of variation present in the data. TMG (FHWA, 2001) recommended a procedure named "combined month and day-of-week factors," which is also called "eight-four factors," if all seven days of the week (i.e., including Saturday and Sunday) are involved for each month.

The annual growth factors are needed when the historical traffic data are used to estimate AADT, since agencies rarely conduct traffic counts every year. The factors are usually the ratio of the AADT estimates of the current year to the preceding year. The sites from which these AADT estimates can be obtained are either ATR sites or short-term sites. While the ATR sites clearly provide better estimates of AADT, short-term sites provide a larger sample of sites, which means that more region-specific growth factors can be developed. Furthermore, the errors caused by short-term sites tend to be self-correcting over time (Cambridge Systematics, Inc., 1994).

After the necessary adjustment factors are calculated for a factor group, they can be used to estimate the AADT values for the road segments with short-term sites in the same group by simply multiplying short-term counts by the factors. In general, it can be represented with the following formula:

$$AADT_{gi} = ADT_{gi} \times AF_i \times SF_g \times GF_g \tag{3-4}$$

where,

$AADT_{gi}$	=	the annual average daily traffic at location *i* of factor group *g*,
ADT_{gi}	=	the average daily (vehicle/axle) traffic at location *i* of factor group *g*,
AF_i	=	the applicable axle correction factor for location *i* (if needed),
SF_g	=	the applicable seasonal adjustment factor for group *g*, and
GF_g	=	the applicable annual growth factor for group *g* (if needed).

The traditional factor approach to estimating AADT has been applied throughout the U.S. Even though AASHTO (1994) and TMG (FHWA, 2001) have provided guidelines for this approach, different states have adopted slightly different procedures according to their individual circumstances. However, the basic principles of the approach are the same as those presented herein.

3.3.2 Regression Approach

Regression analysis is a popular statistical tool to model and analyze the relationship between a dependent variable and one or more independent variables. Cook and Weisberg (1999) define regression analysis as a means to understand "as far as possible with the available data how the conditional distribution of the response y varies across subpopulations determined by the possible values of the predictor or predictors." Hence, regression analysis is widely used for the purposes of description, prediction, and inference. More specifically, it is used to describe the distribution of a variable under a number of different conditions, predict the distribution of a variable in the future, and make inferences from a sample to a population. A number of techniques for carrying out regression analysis have been developed. Familiar methods such as linear regression and ordinary least squares regression are parametric, in that the regression function is defined in terms of a finite number of unknown parameters that are estimated from the data. Conversely, nonparametric regression refers to techniques that allow the regression function to lie in a specified set of functions, which may be infinite-dimensional. Berk (2004) provides more detailed descriptions regarding regression analysis.

Regression analysis has been applied in several studies to estimate AADTs. At the state level, Deacon et al. (1987) produced a two-step modeling process to forecast highway volumes on the state highway systems in Kentucky. Shon (1989) produced multiple regression models to estimate AADT according to the functional classification of the highways in Alabama. Different socio-economic characteristics were used as predictors for different functional classifications. State vehicle registrations and gasoline prices were used as predictors for principal arterials and interstate highways, year and county vehicle registrations were used for minor arterials, and year and gasoline prices were used for major collector roadways.

Cheng (1992) developed a regression model to estimate AADT on highway systems in Minnesota. Initially, independent variables were chosen from the road-log (RLG) database to be used as potential predictors. These included Route System (state roads or local roads), City Population, County Population, Location (urban or rural), Functional Classification (six functional classes for rural and eight for urban roads, respectively), Intersection Category, Special Road Section, Federal-Aid System (if the road section receives federal aid), Access Control (uncontrolled, partially controlled, or fully controlled), Number of Through Lanes (in both directions), Type of Truck-Route (eight truck-route classifications), Road Width (in feet, including sidewalks), and Surface Type (twenty-four categories). After analyzing each variable, some variables were dropped because they were either not useful or added significant complexity to the model. Ultimately, the number of the predictors was reduced to four: Route System, County Population, Number of Through Lanes, and Location. It was found that Number of Through Lanes and AADT have a curvilinear relationship. The formula of the regression function is given as follows:

$$AADT = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2 + \beta_4 X_3 + \beta_5 X_4 + \beta_6 X_2^{\ 2} \quad (3\text{-}5)$$

where,

X_1 = county population size,
X_2 = total number of through lanes in both directions,
X_3 = route system (state/non-state code), and
X_4 = location (rural/urban code).

Mohamad et al. (1998) conducted a study to develop a linear regression model to estimate AADT on roadways in Indiana. Nine independent variables were initially considered: County

Population, County Household, County Vehicle Registration, County Employment, County Per Capita Income, County Mileage, Location, Presence of Interstate Highway, and Accessibility (to the freeway for each road). After using the stepwise regression method to determine the independent variables which should be included in the model, four of them were chosen: Location, Accessibility, County Population, and County Mileage. The formula for the final AADT prediction model is given as follows:

$$Log(AADT) = 4.82 + 0.82X_1 + 0.84X_2 + 0.24Log(X_5) - 0.46Log(X_4) \tag{3-6}$$

where,

X_1 = location (1 = urban; 0 = rural),
X_2 = accessibility (1 = easy access or close to the state highway; 0 = otherwise),
X_3 = county population, and
X_4 = total arterial mileage of county.

Xia et al. (1999) developed a regression model to estimate AADT for local roads in Broward County of Florida. The predictors used included number of lanes, area type, auto ownership, functional classification, presence of non-sate roads nearby, and service employment. The adjusted R^2 value was 0.5961, and prediction errors ranged from 1.31% to 57%. This model was later modified by Shen et al. (1999) by removing the service employment variable. The adjusted R^2 value was improved to 0.6069, with prediction errors ranging between 0.57% and 61.99%. Continuous efforts were made by Zhao and Chung (1999) based on the previous study. In this study, a larger data set was used, the old state roadway function classification system was replaced with the new federal functional classification system, and a more extensive analysis of land use and accessibility variables was performed. Four models using different variables were developed, compared, and discussed. The best model used five predictors: Number of Lanes, Functional Classification, Accessibility to Regional Employment, Direct Access (from a count station to expressway access points), and Employment in a Variable-sized Buffer surrounding a Count Station. This model has an adjustment R^2 value of 0.8180, and its Mean Squared Error (MSE) was 50.00.

The most relevant study regarding this topic was conducted by Lu et al. (2007). In the study, the authors developed a procedure to estimate AADT on all roads in Florida. The road segments were divided into three different types based on the number of traffic counts available at each street. The Type I streets include all freeways and major state highways where each road has at least one traffic count in each county. Minor state and county highways and local streets consist of the Type II streets. The Type III streets include vehicle trails, freeway ramps, cul-de-sac, traffic circles, serve drivers, driveways, roads in parking area, and alleys. The linear regression models were developed to estimate the AADT values on Type II roads, which account for about 80% to 85% of the total streets. The authors also divided the counties in Florida into three groups based on the population in each county: rural area group (counties with population less than 100,000), small-medium urban area group (counties with population between 100,000 and 400,000), and large metropolitan area group (counties with population greater than 400,000). To estimate the AADT values on Type II streets, two distinct regression models, the state/county highway model and local street model, were created and applied to each county group, for a total of six complete regression models. Stepwise regression method was then used to select the variables for each model. The adjusted R^2 values and the Mean Absolute Percentage Error

(MAPE) values were subsequently calculated. The final equations of the six prediction models with the adjusted R^2 and MAPE values are given as follows:

- Large Metropolitan Area, State/County Highway Model

$$AADT = -848.8 + 13.541 \times VEHICLE + 1273.347 \times DIVIDED + 2983.442 \times COMMERCIAL + 6259.677 \times LOCATION - 8.845 \times LABORFORCE - 2839.185 \times AGRCULTRUE + 421.252 \times NUMBEROFLANE + 1311.231 \times INSTITUTIONAL + 129.069 \times INCOME + 796.601 \times 0.5MILE - 782.648 \times RESIDENTIAL - 587.47 \times SEMIPUBLIC$$

$$R^2_{adj} = 0.186 \quad MAPE = 46.81\%$$

- Large Metropolitan Area, Local Street Model

$$AADT = -2738.443 + 3.806 \times MUNICIPALITIES + 1349.659 \times DIVIDED - 452.459 \times RESIDENTIAL - 567.182 \times 1.5MILE + 2745.195 \times LOCATION + 259.492 \times NUMBEROFLANE + 1040.226 \times SEMIPUBLIC + 769.194 \times COMMERCIAL - 19.545 \times LABORFORCE + 17.369 \times POPULATION - 4.345 \times VEHICLE$$

$$R^2_{adj} = 0.242 \quad MAPE = 159.49\%$$

- Small-medium Urban Area, State/County Highway Model

$$AADT = 770.374 + 5566.145 \times LOCATION + 122.079 \times LABORFORCE + 2760.767 \times COMMERCIAL + 960.82 \times NUMBEROFLANE + 27.673 \times VEHICLE - 70.869 \times POPULATION + 0.994 \times SALES - 13.311 \times MUNICIPALITIES + 952.963 \times 1.5MILE - 431.282 \times RESIDENTIAL + 765.103 \times SEMIPUBLIC - 0.43 \times MILEAGE + 1072.666 \times INDUSTRIAL$$

$$R^2_{adj} = 0.259 \quad MAPE = 65.01\%$$

- Small-medium Urban Area, Local Street Model

$$AADT = 1533.94 + 2482.69 \times DIVIDED - 679.405 \times RESIDENTIAL + 2107.874 \times 1.5MILE + 2707.119 \times LOCATION + 18.468 \times VEHICLE - 14.468 \times POPULATION + 0.9437 \times MUNICIPALITIES + 3320.091 \times INDUSTRIAL + 1491.556 \times COMMERCIAL + 1464.231 \times INSTITUTIONAL + 2011.814 \times RECREATION$$

$$R^2_{adj} = 0.166 \quad MAPE = 65.35\%$$

- Rural Area, State/County Highway Model

$$AADT = 3015.747 + 3878.551 \times LOCATION + 17.722 \times VEHICLE + 57.072 \times MUNICIPALITIES - 1656.733 \times AGRICULTURE + 22.293 \times LABORFORCE - 1.931 \times SALES - 3312.919 \times RECREATION - 2324.493 \times INDUSTRIAL + 33.239 \times POPULATION - 748.708 \times RESIDENTIAL$$

$$R_{adj}^2 = 0.378 \quad MAPE = 31.99\%$$

- Rural Area, Local Street Model

$$AADT = 1225.505 + 62.168 \times POPULATION + 1458.501 \times LOCATION - 1445.085 \times AGRICULTURE - 1017.873 \times RESIDENTIAL$$

$$R_{adj}^2 = 0.418 \quad MAPE = 46.79\%$$

The definitions of the independent variables used in the equations above are listed as follows:

- Socio-economic Variables
  - POPULATION: population in thousands;
  - MILEAGE: total mileage of highways in a county;
  - VEHICLE: total number of registered vehicles in thousands;
  - INCOME: the per capita income in thousands;
  - SALES: yearly retail sales in millions;
  - MUNICIPALITIES: population within incorporated area in millions; and
  - LABORFORCE: labor force within one county in thousands.

- Road Characteristics Variables
  - DIVIDED: if the roadway is divided, is 1; otherwise, 0;
  - NUMBEROFLANE: number of lanes in both directions;
  - LOCATION: if the location is urban, is 1; otherwise, 0;
  - 0.5MILE: if a road is within 0.5 miles from freeway, is 1; otherwise, 0;
  - 1.0MILE: if a road is within 1 mile from freeway, is 1; otherwise, 0;
  - 1.5MILE: if a road is within 1.5 miles from freeway, is 1; otherwise, 0;
  - SEMIPUBLIC: if land use type is Public-Semipublic, is 1; otherwise, 0;
  - COMMERCIAL: if land use type is Commercial, is 1; otherwise, 0;
  - AGRICULTURE: if land use type is Agriculture, is 1; otherwise, 0;
  - INSTITUTIONAL: if land use type is Institutional, is 1; otherwise, 0;
  - RESIDENTIAL: if land use type is Residential, is 1; otherwise, 0;
  - RECREATION: if land use type is Recreation, is 1; otherwise, 0; and
  - INDUSTRIAL: if land use type is Industrial, is 1; otherwise, 0.

While all the applications of regression analysis given above used the traditional Ordinary Least Squares Regression (OLS-regression), Park (2004) applied Geographically Weighted Regression (GWR) to estimate AADT for highways in Broward County of Florida. Differing from OLS-regression, in which the model estimates the global parameters for the entire study area, GWR considers the influence of correlations among the variables over space, and estimates different parameters for different locations by weighting the observations inversely to their distance from the location where the AADT is estimated. Six independent variables were selected from 67 variables to develop the model: Number of Lanes, Speed, Regional Accessibility, Direct Access to Expressways, Density of Roadway Length, and Density of Seasonal Household. A comparison with the OLS-regression model was also done, and it was concluded that the GWR approach exhibited better performance.

3.3.3 Travel Demand Modeling Approach

Travel demand modeling utilizes mathematical models to simulate "real world" transportation system and human travel behaviors. Traditionally, the "four-step process" has been used for travel demand analysis and, as its name implies, is composed of four steps: trip generation, trip distribution, mode choice, and trip assignment. The first step, trip generation, calculates the number of trips generated in each Traffic Analysis Zone (TAZ), which is the unit of geography commonly used in travel demand modeling. In the second step, trip distribution, the distribution of trips among the origin and destination zones is determined. The third step, mode choice, splits the trips between the origin and destination zones according to different modes of travel. Finally, trip assignment allocates the trips to routes by each travel mode.

Little research has been done in terms of applying the travel demand modeling approach to AADT estimations. Zhong and Hanson (2009) utilized traffic demand models to estimate AADT on low-class roads for two regions in the province of New Brunswick, Canada. Modifying the traditional four-step process, the authors omitted the mode choice step from their procedure. The Quick Response Method (QRM) (Sosslau et al., 1978) was also adopted for the trip generation step, and the traditional gravity model used for the trip distribution step. The final step, trip assignment, was implemented by using the STOCH method, which was first proposed by Sheffi (1985). The empirical results show that the average estimation errors can be limited to less than 40%, which is comparable to the results of other AADT estimating approaches.

While their research showed that this method has the potential to improve AADT estimation, due to the resolution limitations of the available census data, their method was applied at the dissemination areas (DAs) level. DA is the smallest census unit in Canada. A DA is a small, relatively stable geographic unit composed of one or more neighboring dissemination blocks, with a population of 400 to 700 persons. Further research is needed to estimate the performance of this method as applied to smaller areas such as parcels level researched in this dissertation.

3.3.4 Image-Based Approach

Estimating AADT with image-based data has been possible with the collection of high-resolution satellite images, aerial photos, and LiDAR (Light Detection and Ranging) data by transportation agencies for planning and analysis purposes. McCord et al. (1995a and 1995b) analyzed the feasibility of this approach and proved that 1-m resolution is necessary to count and classify cars and trucks with accuracy greater than 90%.

McCord et al. (2003) proposed the methodology of image-based AADT estimation and also compared this with the traditional ground-based factor method. To produce the AADT estimation on a road segment, the vehicle density is first obtained from the image and converted to a short-duration volume. The short-duration volume is then expanded to an hourly volume, daily volume, and finally, AADT, by multiplying by expansion factors. A comparison with the traditional ground-based factor approach indicated a small difference between the results of the two methods, which might imply that image-based estimation can augment traditional ground-based estimation and, therefore, that the combination of the two could lead to more accurate estimation. This combination of image-based and ground-based estimations was implemented in Jiang et al. (2006). For ground-based data, they estimated AADTs for the current year by using seasonal factors and growth factors on coverage counts data in earlier years. For image data, they applied the method proposed in McCord et al. (2003) to estimate AADTs for road segments with a single, more recent image. The two AADT estimation results were then integrated by using a linear weighted combination according to their variances. An empirical study was conducted to simulate weighted estimation of AADTs on 122 Florida highway segments between 1994 and 2003, with the results showing that the accuracy of AADT estimation was markedly improved.

Jiang et al. (2007) verified the numerical results of Jiang et al. (2006) with a study of 12 aerial photos taken by Ohio DOT in 2005 for Ohio road segments equipped with ATRs. They compared both the combined estimation and traditional coverage count estimate to the "true" AADT determined by the ATRs data. The results showed that the combined estimation produced a lower average relative error, a higher proportion of estimates with relative error less than 0.10, and better estimates overall more than 50% of the time.

Another approach using image-based data to estimate AADT was researched by Jiang (2005). In this study, a Bayesian approach is used to combine the traditional ground-based data and the traffic data extracted from the images. A three-stage model was then developed to simulate the prior distribution of AADT and the probability distribution of short-tem traffic counts conditional on AADT. This numerical investigation shows the benefits of image-based data in terms of improving the accuracy of AADT estimation.

3.3.5 Machine Learning Approaches

Mitchell (1997) defines machine learning as a computer program "to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E." The learning system utilizes certain learning algorithms to derive a description of a given concept based on a set of concept examples and background knowledge (Michalski et al., 1998). A number of machine learning algorithms have been used to perform the task of AADT estimation or provide helpful assistance to certain aspects of the task. This section reviews three typical approaches: the artificial neural network, k-nearest neighbor, and support vector regression machine.

3.3.5.1 Artificial Neural Network Approach

An Artificial Neural Network (ANN) is a computational model that is inspired by the structural/functional aspects of biological neural networks. It is an emulation of biological neural networks, and consists of simple artificial neurons connected by directed weighted connections. It may be thought of as simplified models of the networks of neurons that occur naturally in the animal brain (Gurney, 2009). The structure of an ANN is changed based on external or internal information that goes through the network during the training phase. Modern ANNs are non-linear statistical data modeling tools, and a well-trained ANN is usually used to model complex relationships between the inputs and the outputs of the network or to find patterns in the data.

Figure 3-6 shows an example of a simple feedforward neural network from Wikibooks (2011). In this common type of ANN, there are three layers of units: the input layer, the hidden layer, and the output layer. The input layer is connected to the hidden layer directly, and the hidden layer is connected to the output layer directly. There is a weight value assigned to a connection between each pair of connected units, and the weight value can be adjusted during the learning phase. The activity of the input units represents the raw information that is fed into the neural network. The behavior of each hidden unit is determined by the activities of the input units and the weight values of the connections between the input and the hidden units. The activity of the output units depends on the activity of the hidden units and the weight values of the connections between the hidden units and the output units. “Feedforward” means the signals are allowed to travel one way only: from the input layer to the output layer. Feedforward network is simple and straight forward, since there are no loops in the network. On the contrary, more complex feedback networks can have signals travelling in both directions, and they are more powerful and can be extremely complicated, because feedbacks (loops) are allowed in the network.

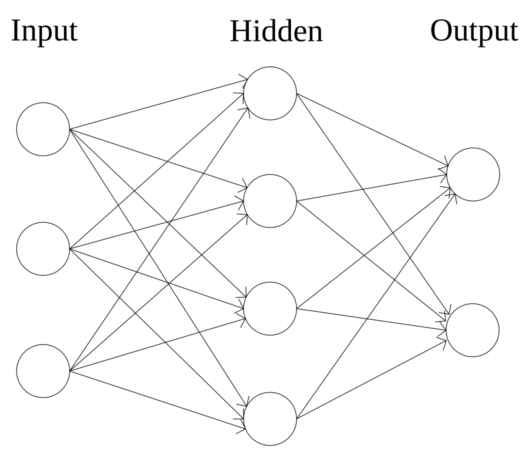


Figure 3-6: Example of a Simple Feedforward Neural Network

ANN is a type of non-linear processing system that is ideally suited for a wide range of tasks, especially tasks in which there is no existing algorithm for task completion (Wikibooks, 2011). When the system is set running, the activation levels of the input units are affixed to the desired values. After this, the activation is propagated, at each time step, along the directed weighted connections to other units. The activations of non-input neurons are computed using each neuron's activation function. The system might either settle into a stable state after a number of time steps, or in the case of a feedforward network, the activation might flow through to output units.

ANN can be trained to solve certain problems using a teaching method and sample data. In this way, identically constructed ANN can be used to perform various tasks depending on the training received. With proper training, ANN is capable of generalization, or the ability to recognize similarities among different input patterns, especially patterns that have been corrupted by noise. Detailed information about the theoretical foundations of ANN can be found in Anthony and Bartlett (1999).

ANN has been extensively applied to transportation research since the 1990s. Dougherty (1995) summarized the findings of research papers regarding the application of ANN to transportation. The subject areas with the most ANN application include driver behavior/autonomous vehicles, parameter estimation, pavement maintenance, vehicle detection/classification, traffic pattern analysis, traffic forecasting, etc. More applications of ANN in transportation can also be found in Himanen et al. (1998).

As an important aspect of transportation research, an ANN approach to AADT estimation has also been explored. Sharma et al. (1999) compared the ANN approach to the traditional factor approach with 48-hour short-term counts data for estimating AADT. A multilayered, feed-forward, and back-propagation neural network with supervised learning was designed to achieve this purpose. It was found that for a single 48-hour count, if ATR sites are grouped appropriately and the coverage counts are assigned to the ATR groups correctly, then the estimation errors of the traditional factor approach can be lower than that of the ANN approach. However, this investigation also indicated that, there was unfortunately little guidance on how to achieve a high enough ATR site grouping and accuracy of sample counts assignment to obtain reliable AADT estimates. It was also found that the accuracy of the ANN approach is comparable to the traditional factor approach when it is applied to two or more 48-hour counts taken during different months. Since the advantage of the ANN approach is that the groups of ATR sites and assignment of sample short-term counts are not required, the research recommends the ANN approach as a better choice.

While Sharma et al. (1999) focused on interstate and other high-volume roads, Sharma et al. (2000, 2001) applied the ANN approach to low-volume rural roads. In addition to some findings that verified those of Sharma et al. (1999), it also found that the 48-hour count duration is likely to produce much better estimation than the 24-hour count duration. Furthermore, 72-hour count duration may not necessarily offer an advantage.

Lam and Xu (2000) implemented a multi-layer feed-forward neural network with back-propagation algorithm to estimate AADT and determine the most appropriate length of counts. The case study was carried out by analyzing data on 13 trunk roads and primary roads in Hong Kong, and the results showed that the neural network approach performed consistently better than the regression analysis approach in estimating AADT.

3.3.5.2 K-Nearest Neighbor Approach

The K-nearest neighbor algorithm (K-NN) is a data mining method for classification, although it can also be used for estimation and prediction. K-NN is among the simplest of all machine learning algorithms and is a type of instance-based learning in which the training data set is stored, thereby allowing a new unclassified record to be classified by comparing it to the most similar records in the training set (Larose, 2005). The similarity is measured by the distance between the records, with the new record assigned to the class most common among its K-nearest neighbors.

There is no obvious best solution to choose the value of K. As mentioned by Larose (2005), a K with a value that is too small may cause overfitting, while a K with a value that is too large tends to overlook locally interesting behavior. Thus, it is typically a small (but not too small) positive integer. If K = 1, then the object is simply assigned to the class of its nearest neighbor.

Since the K-NN algorithm is used mostly for classification, it can be utilized to assign short-term count sites to different ATR factor groups. Li and Fricker (2008) proposed a K-NN algorithm combined with GIS technology to carry out roadway classification. The attributes of a roadway count that are helpful for the classification were chosen, which include geographic spatial location, roadway link characteristics (Functional Class, Number of Lanes, and Posted Speed), and land use characteristics in the area surrounding the ATR. Various values of K from 5 to 9 were then tried and compared, using data from 56 ATRs on the Indiana roadway network for 2004. They also compared the K-NN method with the traditional twenty-four and eighty-four factor approaches, which use each functional class as a factor group. The results showed that K-NN can produce better AADT estimates.

3.3.5.3 Support Vector Regression Machines Approach

Support vector machines (SVM) are a set of supervised learning methods. A support vector machine constructs a hyperplane or set of hyperplanes in a high or infinite dimensional space, which can be used for classification, regression, or other tasks. Support vector machines represent an extension to nonlinear models of the generalized portrait algorithm developed by Vladimir Vapnik. The SVM algorithm is based on the statistical learning theory and the Vapnik-Chervonenkis (VC) theory introduced by Vladimir Vapnik and Alexey Chervonenkis. A detailed description of the SVM algorithm is given by Vapnik (1995).

Based on SVM theory, Support Vector Regression Machines (SVR) were proposed by Drucker et al. (1996). While SVR uses the same principles as the SVM for classification, it also sets a margin of tolerance, e, in approximation to SVM to predict the real number output, which has infinite possibilities and is very difficult to predict. SVR is the most common application form of SVMs. An overview of its basic ideas has been given in Smola and Schölkopf (1998).

SVR has been widely applied due to its remarkable characteristics. Castro-Neto et al. (2009) evaluated the performance of a modified version of SVR named SVR-DP (SVR with Data-dependent Parameters). This model was used in forecasting AADT one year into the future based on the historical AADT values, which differs from the common type of current-year AADT estimation based on external predictor variables. The technique was first introduced by Cherkassky and Ma (2004). By computing the SVR parameters based on the distribution of the incoming training data, it can alleviate the problem of excessive data requirements and the time-consuming computation of adequate SVR parameters, which are crucial to the quality of SVR models. Castro-Neto et al. (2009) used AADT values collected between 1985 and 2004 for both urban and rural roads in 25 counties in Tennessee. The SVR-DP approach was compared with two other popular methods, Holt Exponential Smoothing (Holt-ES) and Ordinary OLS-regression. The results show that SVR-DP outperformed both of these models, although the Holt-ES also presented good performance.

3.3.6 URS Method

FDOT contracted with URS Corporation to improve the AADT estimation. The URS method divides the street network in a Traffic Analysis Zone (TAZ) into N + 1 (from 0 to N) tiers according to the road levels. Tier 0 segments represent roads that have an official FDOT AADT or segments in the Turnpike State model. Tier 0 segments are the boundary segments of the TAZ zones developed for the Turnpike State Model. Tier 1-N segments are roads inside a TAZ zone, and each TAZ is analyzed separately as a unit. The segments with the same Roadway ID are called a route. The segments of a route that touches a tier 0 segment were assigned a tier value of 1. The segments of a route that touches a tier 1 route were assigned a tier value of 2. The process repeats until every route and segment within the TAZ is assigned a tier value.

The AADT of a tier 0 segment will be the official FDOT AADT, but if a segment did not receive an official FDOT AADT, the Turnpike State model volume is used as the AADT. To calculate the AADT for the non-state road segments in a TAZ, the routes are buffered and intersected with the parcel polygons and employment points to get the sum of housing units and employees associated with each route. The total number of housing units and employees within the TAZ can be summed. The total number of trips within the TAZ can be provided by the Turnpike State Model. The total number of trips divided by the total number of housing units and employees will generate a trip factor. Using this trip factor multiplied by the number of housing units and employees for each route, each route within the TAZ is assigned a volume. Starting from the highest tier routes, each route's volume is trickled down to the connected lower tier routes which are called the mother routes. If there are multiple mother routes, the volume is split evenly and accumulated to each of the mother routes. The AADT of a route is the trips for that route plus the accumulation of the trips from the higher tiered routes that are connected to the route.

3.3.7 Summary

For AADT estimations, the traditional factor approach uses the permanent count sites to calibrate the adjustment factors, the short-term count sites to collect the short-duration volume data, and coverts the short-duration volume to the estimated AADT with the adjustment factors. This method may be the most accurate AADT estimation method and has been widely applied for state roads. However, it is obvious that it is economically infeasible to maintain the permanent count sites on local roads and also infeasible to use the portable count sites to cover all the local roads.

The regression modeling method uses the statistical methodology and tools to analyze the relationship between AADT and socio-economic variables such as population and the road characteristic variables such as number of lanes. This method has been most widely researched, but the main problem with this method is that it cannot capture passer-by trips. In addition, it does not perform well when the relationship between the independent and the dependent variable is nonlinear.

Travel demand modeling technique has seldom been researched in terms of AADT estimation. Zhong and Hanson (2009) was the only research that has been reviewed. While their research showed that this method has the potential to improve AADT estimation for low-class roads, further research is needed to estimate the performance of this method as applied to smaller areas such as at parcel level.

The image processing method uses image-based data including the high-resolution satellite images, aerial photos, and LiDAR (Light Detection and Ranging) data to obtain vehicle density and then converts it to a short-duration volume which can be expanded to AADT by multiplying by expansion factors. The limitation of this method is that it is difficult to retrieve and estimate volume for local roads accurately, because the traffic on local roads is usually sparse and infrequent compared to major roads.

The machine learning methods such as ANN, K-nearest neighbor algorithm, and SVR have also been reviewed, but it was found that these methods usually try to improve the traditional factor approach but still need to deploy portable count sites to collect short-term traffic count data, which has been proven to be unpractical for local roads. In addition, none of these methods can provide satisfying estimation results for local roads.

Lastly, the method recently proposed by the URS Corporation for FDOT was also reviewed. The URS method divides the street network in a TAZ into multiple tiers according to the road levels, uses the parcels and employee data in the road segment buffers to estimate the initial trips, and assigns the trips to the created roadway tire structure by trickling down to the connected parent routes. The idea of this method is based on the similarity between the roadway system and the river system, and its process is trying to simulate the river system. Theoretically, this AADT estimation method should be suitable for local roads, because it uses the most detailed parcel and employee data, and collects trips from the lowest level roads. However, the performance of this method needs further evaluation, and therefore, is selected as one of the testing methods to compare with the method proposed in this project.

3.4 Parcel-level Travel Demand Analysis Model

The proposed parcel-level travel demand analysis model involves a series of mathematical models to simulate human travel behaviors. This model attempts to simulate choices that travelers may make in response to the given local streets system to access the major roads.

As shown in Figure 3-7, the proposed parcel-level travel demand analysis model involves four steps. Network modeling, parcel-level trip generation, parcel-level trip distribution, and parcel-level trip assignment will be performed separately, in sequence.

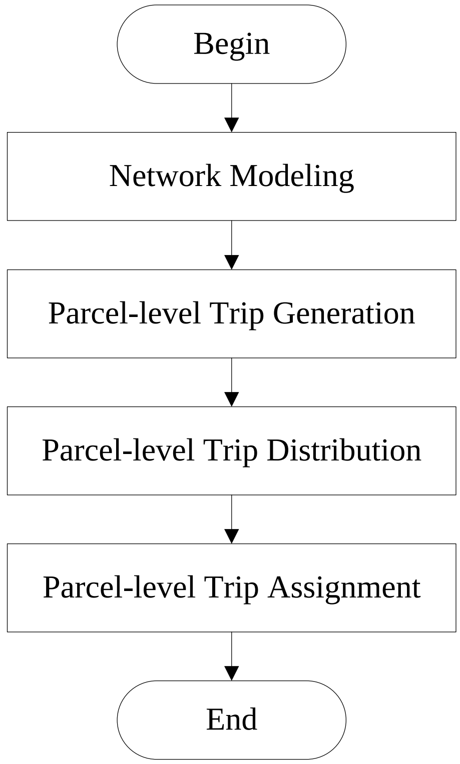


Figure 3-7: Flowchart of Parcel-level Travel Demand Analysis Model

The functionalities of each step involved in the parcel-level travel demand analysis model are listed as follows:

- *Network Modeling* defines the boundaries of the study area, prepare and preprocess the roadway network, parcel, and traffic counts data, and sets up the network representation of the roadway linked with parcels and traffic count sites.
- *Parcel-level Trip Generation* estimates the number of vehicle trips generated by each parcel in the study area. The estimation is calculated based on the land use type of each parcel and the respective ITE trip generation rate.
- *Parcel-level Trip Distribution* determines where the trips generated by each parcel will go. It determines the number of trips between a parcel and a traffic count site based on traffic count data (or AADT estimated from the count data) and the shortest travel time between them.
- *Parcel-level Trip Assignment* predicts the routes the travelers will take to approach the traffic count sites, resulting in the estimated AADTs of local roads in the study area.

From the above discussion, it can be seen that the principle of the proposed parcel-level travel demand analysis model is similar to that of the traditional four-step zone-level travel demand analysis approach as both methods attempt to simulate human travel behaviors. However, there are also significant differences between them. While the traditional model performs the travel demand analysis on an abridged roadway network with only major roads, the proposed model simulates the trips on the entire roadway network including the local roads. Another major difference is that there is no mode choice step in the parcel-level model, since the parcel-level trip generation step will generate only vehicle trips and exclude the transit trips, which are usually represented by walk trips inside a zone traveling between public transit facilities such as bus stops located on major roads. A third difference is that while the traditional four-step zone-level travel demand model distributes trips among TAZs, parcel-level model will distribute the trips between the parcels and their nearby traffic count locations.

3.4.1 Network Modeling

In network modeling step, the data preparation process is comprised of the following three sub-steps:

1. define the boundary of the study area;
2. prepare and preprocess the required data including roadway network, parcels, and count sites; and
3. link the parcels and the count sites to the unabridged roadway network.

As mentioned above, the boundary of the study area is commonly called the cordon line. When defining the cordon line, the same rules that apply for the traditional zone-level travel demand analysis approach can be followed. To establish the cordon line, political jurisdictions, census area boundaries, and natural boundaries may be taken into account, and it is generally defined such that it intersects with as fewer roads as possible.

After the boundary of the study area is defined, the required data are prepared and preprocessed. The data include the unabridged roadway network data, the detailed parcel data, and the traffic count sites data. If necessary, some preliminary processing on the input data is performed. For example, the traffic count site data can be divided into two groups based on the location of count site (if a count site is located on the major roads or the local roads) so that the major roads group will be used for AADT estimation, and the local roads group will be used for the evaluation of results.

Another important step in network modeling is to link parcels and traffic count sites to the unabridged network. Similar to the method adopted by zone-level travel demand analysis, some special nodes and links named parcel centroids and parcel centroid connectors, respectively, can be used to represent parcels and their points of access to the surrounding roadways.

3.4.2 Parcel-level Trip Generation

Parcel-level trip generation is the process used to estimate and quantify the number of trips each parcel will produce and attract. In this research, this step will be implemented by using both the parcel data from the Department of Revenue (DOR) and the trip generation rates and regression equations from the *Trip Generation Report* (8th edition, 2008), published by the Institute of Transportation Engineers (ITE).

The DOR parcel data describe the rights, interests, and value of properties and it defines the legal boundaries of land parcels in the deed to properties. Real estate tax parcels are typically graphic representations of the land ownership to support property taxing functions. Parcel data forms the basis for all land use and zoning decisions, and represents the location of residences, businesses, and public lands.

Parcels are the lowest geographical level land use. There are typically hundreds of parcels within a TAZ. The lowest level land use scale can provide more accurate and detailed geographical information to help conduct the microscopic transportation study such as AADT estimation for local roads in this research. Figure 3-8 illustrates an example that compares the extents of parcels and TAZs. In this figure, the thicker lines are the TAZ boundaries, and the thinner lines are the parcel boundaries.

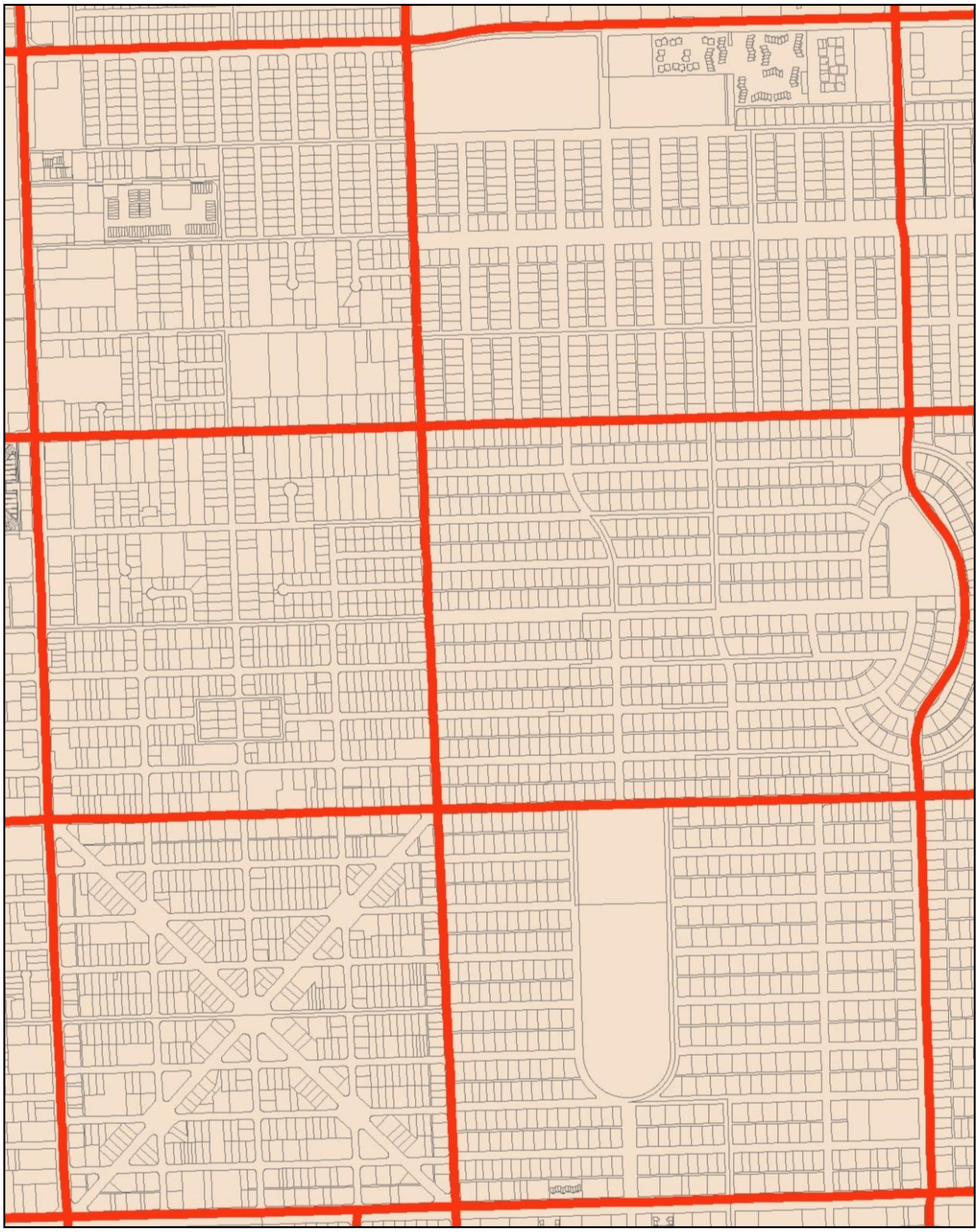


Figure 3-8: Comparison of Parcels and TAZs

The *ITE Trip Generation Report* is a multi-volume informational report which presents a summary of the trip generation data that have been voluntarily collected and submitted to ITE. The data used to compile this information report is based on more than 4,800 individual studies conducted in the United States and Canada since the 1960s. In the 8th edition of the report, trip generation rates and/or equations are provided for 10 main land use categories and 162 sub-categories. For a specific land use type, trip generation rates and regression equations (if available) are developed for daily traffic (average weekday, Saturday, and Sunday) and peak hour traffic (AM and PM peak hour for weekday, Saturday, and Sunday).

Figure 3-9 is an example of the statistical and descriptive information available for the majority of the land uses contained in the *Trip Generation Report*. Data plots provide the most fundamental display of the variance within the database. Other important information provided in the report include the land use name, land use code, average trip rate, range of rates, independent variable, number of studies, regression equation, R^2, etc. As shown in Figure 3-9, this report provides the weekday trip generation information for fast food restaurant with drive-through windows (with land use code 834) based on 1,000 square feet gross floor area, and its average trip rate is 632.125 trips per day.

It should be noted that great care should be taken when selecting the average trip rates and the regression equations to carry out the trip generation analysis. As shown in Figure 3-9, the text above the data plot warns that the data for this land use type should be used carefully because of the low R^2. Therefore, the descriptions and statistical information provided for each land use should be carefully reviewed.

Depending on the linear or logarithmic relationship between the independent variable and the dependent variable, there are two forms of regression equations used in the *Trip Generation Report*, which are listed as follows:

$$Linear: T = aX + b \tag{3-7}$$

$$Logarithmic: Ln(T) = aLn(X) + b \tag{3-8}$$

where,

T = number of vehicle trips generated by a parcel;
X = independent variable such as dwelling units, or gross floor area, etc.; and
a, b = parameters.

Guidelines are provided in the *Trip Generation Handbook* which provides suggestions on selecting among weighted average trip rates, regression equations, and data plots in estimating the trip generation characteristics of a specific land use. Many professionals calculate trip generation characteristics with both the average rate and the regression equation, and then use the one that provides the highest estimate of the number of the trips in the analysis. However, this is not suggested in the handbook.

FAST FOOD RESTAURANT WITH DRIVE-THROUGH WINDOW (834)

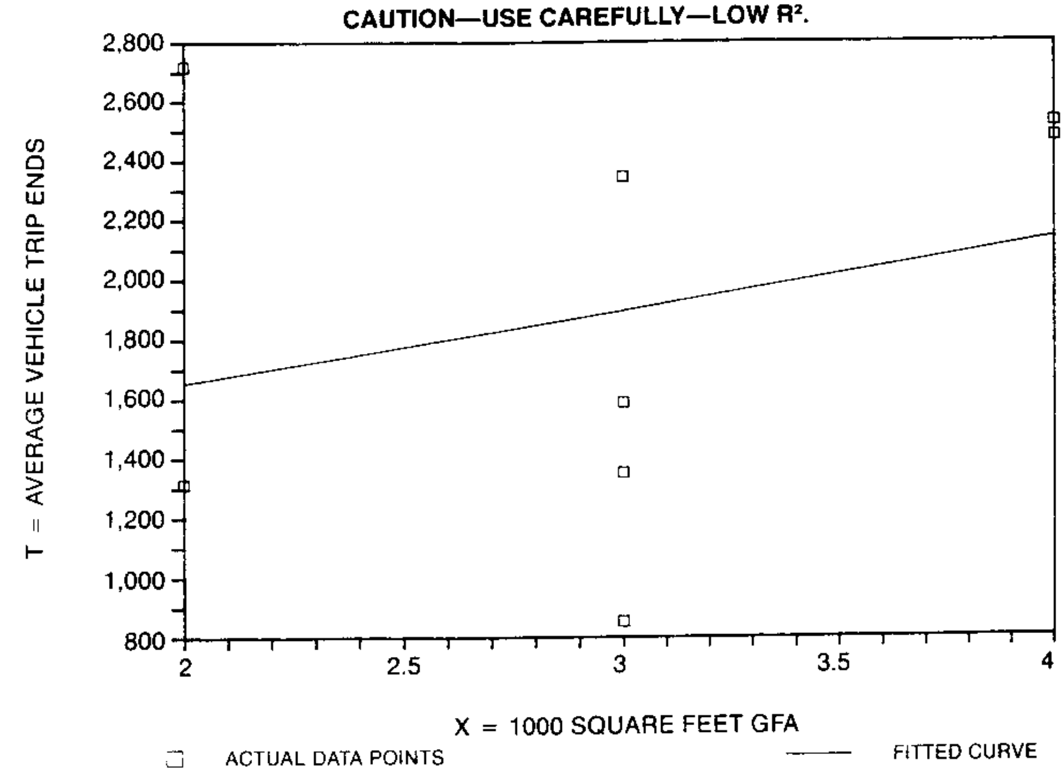
Average Vehicle Trip Ends vs: **1,000 SQUARE FEET GROSS FLOOR AREA**
On a: **WEEKDAY**

TRIP GENERATION RATES

Average Weekday Vehicle Trip Ends per 1,000 Square Feet Gross Floor Area				
Average Trip Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average 1,000 Square Feet GFA*
632.125	284.000–1359.500	*	8	3.0

DATA PLOT AND EQUATION

CAUTION—USE CAREFULLY—LOW R^2.



Fitted Curve Equation: $T = 242.75(X) + 1168.0$
$R^2 = 0.069$

DIRECTIONAL DISTRIBUTION: Not available.

Figure 3-9: Example of ITE Trip Generation Report

ITE's suggested guidelines on using the average rates or the regression equations and when local data should be collected are listed as follows:

- Use the regression equations when:
  - regression equation is provided,

- independent variable is within the range of data,
- data plot has at least 20 points,
- the R^2 is greater than or equal to 0.75,
- equation falls within data cluster in plot, and
- standard deviation > 110 percent of the average rate.

- Use the average rate when:
  - at least three data points are available (ITE encourages local data be collected when three to five data points are provided),
  - independent variable is within the range of data,
  - standard deviation is less than or equal to 110 percent of the average rate,
  - the R^2 is less than 0.75 or no regression equation provided, and
  - average rate fall within data cluster in plot.

- Collect local data when:
  - study site is not compatible with the ITE land use code definition,
  - only one or two data points are provided,
  - independent variable does not fall within the range of data, and
  - neither average rate line nor fitted curve falls within data cluster at size of development.

In this research, the guidelines listed above are followed to the extent possible. In the case that a regression equation is lacking or not suitable for trip generation calculation, the average trip generation rates provided by the report are used to calculate the parcel-level trips.

The *Trip Generation Report* also includes the peak hour traffic information, but in this research, only daily traffic trip generation rates and regression equations will be needed. Due to the different travel patterns among the weekday, Saturday, and Sunday, the number of trips for weekday, Saturday, and Sunday will be calculated separately through the use of either a regression equation or the average trip generation rate. The final estimated number of trips for a parcel is their average value, which can be calculated as follows:

$$T_{average} = \frac{T_{weekday} \times 5 + T_{Saturday} + T_{Sunday}}{7} \tag{3-9}$$

where,

$T_{average}$	=	the final estimated number of trips generated by a parcel,
$T_{weekday}$	=	average weekday trips generated by a parcel,
$T_{Saturday}$	=	Saturday trips generated by a parcel, and
T_{Sunday}	=	Sunday trips generated by a parcel.

While parcel-level trip generation can be performed for most of the land use types defined in the parcel database through the steps introduced above, some special types may require further steps with the use of various other demographic or land use databases.

The *ITE Trip Generation Report* has more detailed land use types, so some land use codes in the parcel database encompass several ITE land use types. Table 3-6 lists two such examples.

Table 3-6: Examples of Land Use Types Matching

Parcel Land Use Code	Parcel Land Use	ITE Land Use Code	ITE Land Use
072	Private School	534	Private School (K-8)
		536	Private School (K-12)
023	Financial Institutions	911	Walk-in Bank
		912	Drive-in Bank

In these cases, the ITE rates in the constituent land use type are averaged and weighted by an estimate of the relative presence of each category in the study area, which can be obtained from other demographic or land-use databases. The calculation can be expressed as follows:

$$T = \sum_{i=1}^{n} F_i(X) \times P_i \tag{3-10}$$

where,

T = number of vehicle trips generated by a parcel;
F_i = the ITE trip generation function (either regression equation or average trip rate, which can be regarded as a special linear regression without parameter b) for ITE land use type *i*;
X = independent variable such as dwelling units, or gross floor area, etc.; and
P_i = the percentage of the presence of ITE land use type *i* in the study area.

For most of the land use types, ITE trip generation rates are based on dwelling units or gross floor area, which are also the attributes of a parcel in the parcel database. Hence, for a majority of parcels, trip generation can be calculated directly by using the parcel data. However, when ITE rates are based on independent variables that are unavailable in the parcel data, the generated trips need to be adjusted by a factor (as shown in Equation 3-11). This factor is calculated as the ratio of mean values between the ITE independent variable and the parcel size attribute.

$$T = F(X \times R) \tag{3-11}$$

where,

T = number of vehicle trips generated by a parcel;
F = the ITE trip generation function (either regression equation or average trip rate, which can be regarded as a special linear regression without parameter b);
X = independent variable such as dwelling units, or gross floor area, etc.; and
R = the ratio of mean values between the ITE independent variable and the parcel size attribute.

3.4.3 Parcel-level Trip Distribution

Once the number of trips for each parcel has been generated, the next step is to distribute the trips to the nearby count sites; this is performed in the parcel-level trip distribution step.

While the traditional model distributes the trips generated by each TAZ to all the TAZs in the study area, the proposed model only distributes the trips generated by each parcel to the count sites on the major roads within a certain distribution range.

Similar to the zone-level trip distribution model, parcel-level trip distribution is also derived from Newton's law of gravity. It can be expressed as follows:

$$T_{ij} = \frac{\frac{A_j}{D_{ij}}}{\sum_{k=1}^{n} \frac{A_k}{D_{ik}}} \times T_i \tag{3-12}$$

where,

T_{ij} = daily vehicle trips between parcel i and traffic count site j,
T_i = total vehicle trips generated at parcel i,
A_j = AADT estimated from traffic count volume at traffic count site j,
D_{ik} = the shortest free flow travel time between parcel i and traffic count site k, and
n = number of the nearby traffic count sites within a distribution range.

From the formula above, it can be seen that parcel-level trip distribution is to distribute the trips between the parcels and the nearby traffic count sites within a distribution range in a manner that differs from zone-level trip distribution which distributes trips among all the zones. It assumes that the total number of vehicle trips between a parcel and a traffic count site is directly proportional to the trips generated by the parcel and the AADT value estimated from the traffic volume measured at the traffic count site, and is inversely proportional to the shortest free flow travel time between them.

In Figure 3-10 and Table 3-7, an example is given to illustrate the trip distribution calculation procedure. In Figure 3-10, a parcel is assumed to generate 200 trips per day, and the distribution range is the nearby major roads that surround the area. Within the distribution range, there are eight traffic count sites on the surrounding major roads, and their traffic count data (or AADTs estimated from the traffic count data) are shown in the figure. Table 3-7 lists the assumed free flow travel times from the parcel to the traffic count sites, the calculation procedure, and the calculated trips distributed to each traffic count site.

It should be noted that the process of parcel-level trip distribution introduced above only takes into consideration the case that there is only one centroid connector for each parcel. Theoretically, if a parcel has multiple centroid connectors, the parcel trips are suggested to be split, and the trip distribution for each connector will be the same as the process described above. However, the parcels with multiple accesses to the roads are usually the large scale land use for business or education, and these types of parcels are typically located adjacent to major roads. Therefore, it should not affect the performance of the model if only one centroid connector is created for each parcel, since this research is to estimate AADTs for local roads alone.

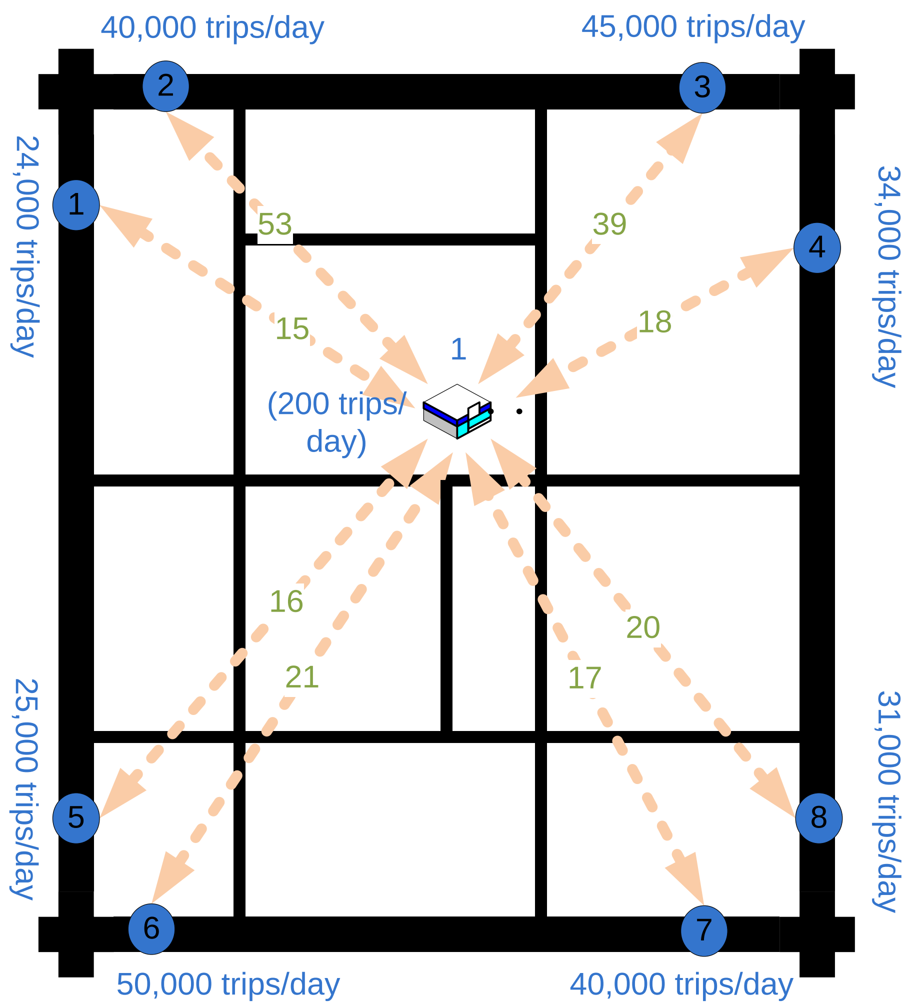


Figure 3-10: Example of Parcel-level Trip Distribution

Since the parcel-level trip distribution is to distribute trips between the parcels and the traffic count sites, there are some requirements for the count sites data. Firstly, there should be enough traffic count sites to evenly cover the major roads in the study area. In addition, enough traffic count data on local roads are also suggested to be collected, so that they can be used to evaluate the model. Secondly, if there are no estimated AADT values available, daily traffic count data can also be used. In either case, it is required that all the traffic count sites adopt the same kind of daily volume measurement to maintain consistency.

While a traditional zone-level trip distribution model usually includes the effects of multiple travel impedance factors, such as travel time, cost, etc., parcel-level trip distribution will only consider the shortest free flow travel time. This is expedient because travel time is the major factor that determines the trips on the local roads, and travelers will choose the fastest path to access major roads in order to arrive at their destinations as soon as possible.

Table 3-7: Example of Parcel-level Trip Distribution Calculations

i	j	T_i	A_j (Trips/Day)	D_{ij} (Seconds)	A_j / D_{ij}	T_{ij}
1	1	200	24,000	101	237.62	$\frac{237.62}{3081.63} \times 200 = 15$
1	2	200	40,000	49	816.33	$\frac{816.33}{3081.63} \times 200 = 53$
1	3	200	45,000	74	608.11	$\frac{608.11}{3081.63} \times 200 = 39$
1	4	200	34,000	123	276.42	$\frac{276.42}{3081.63} \times 200 = 18$
1	5	200	25,000	101	247.52	$\frac{247.52}{3081.63} \times 200 = 16$
1	6	200	50,000	153	326.80	$\frac{326.80}{3081.63} \times 200 = 21$
1	7	200	40,000	151	264.90	$\frac{264.90}{3081.63} \times 200 = 17$
1	8	200	31,000	102	303.92	$\frac{303.92}{3081.63} \times 200 = 20$
					$\sum_{j=1}^{n} \frac{A_j}{D_{ij}} = 3081.63$	**Total Trips** = 200

The free flow travel time will also be used to determine the distribution range. The trips generated by a parcel will be distributed to only the traffic count sites that can be reached within certain travel time, and the traffic count sites that are too far away from the parcel will not attract any trips, based on the fact that the trips on the local roads are mainly influenced by the nearby surrounding major roads. The distribution range is used to make sure that the trips of a parcel are distributed locally, and as a result, the trips will also be assigned locally in the following parcel-level trip assignment step.

3.4.4 Parcel-level Trip Assignment

Once the number of vehicle trips between the parcels and the nearby traffic count sites has been calculated by the parcel-level trip distribution step, the next step is to predict the routes that the travelers will take to approach these count sites.

Zone-level trip assignment commonly uses an all-or-nothing with capacity restraint method, also known as the equilibrium assignment method. It is implemented through an iterative procedure in which travel time for each link on the network is calculated at the end of each assignment and used as the input to the next computation of the minimum impedance routes. The iterative procedure continues until the model reaches equilibrium when further route changes will increase the travel time. This method is suitable for zone-level trip assignment because the trips among zones are usually assigned to the major roads where avoiding congestion to save travel time is the travelers' primary concern. In the case of parcel-level trip assignment, congestion seldom happens on local roads; as such, the simple all-or-nothing assignment method is adopted to assign trips, and only travel time is considered to affect the travelers' route selection. After the trips for all of the parcels have been assigned, the sum of the trips assigned to each road segment is its estimated AADT.

3.5 Model Development

A parcel-level travel demand analysis model was implemented to estimate AADT for local roads. The following two development tools were adopted to implement this model: ArcGIS from Esri and Cube from Citilabs.

ArcGIS is a software suite consisting of a set of Geographic Information System (GIS) software products developed by Esri. ArcGIS has been widely used for creating, analyzing, and managing geographic information in many applications. In this research, ArcGIS 10.0 was used to perform both data pre and post-processing.

Cube is a travel demand modeling software product marketed by Citilabs. It has been widely used for transportation planning to analyze and estimate the impacts of a wide range of infrastructure improvements and operating policies. In this research, Cube 5.1.3 was used to develop the four model steps. Cube Voyager is a module of the Cube software suite. It provides a script-base structure allowing the implementation of multiple model methodology including standard four-step model, discrete choice model, and activity-based model. It also provides a comprehensive library of functions for the modeling and analysis of passenger transportation systems. To implement the parcel-level travel demand model proposed in this research, Cube Voyager scripts were developed to customize the standard four-step model templates provided by Cube Voyager. Because the standard templates are designed for traditional zone-level travel demand modeling, it was necessary to customize them to simulate the parcel-level travel patterns with the zone-level implementation. A parcel defined in the proposed model can be treated as a small size Traffic Analysis Zone (TAZ) used in the traditional travel demand modeling.

Figure 3-11 shows the system components and the procedure used to estimate AADT. The procedure can be divided into the following sub-steps:

- ArcGIS is used to preprocess the input data for the model including the DOR parcel data, unabridged highway network data, and traffic count sites data.
- The preprocessed input data are imported into Cube, and the highway network is built from the unabridged roadway shape file.
- The built highway network is used by the network modeling step to calculate the free flow travel time skim matrix.
- The parcel-level trip generation step is performed by using the merged DOR parcel data and traffic count sites data as well as the trip generation rates and regression equations provided by the *ITE Trip Generation Report*.

- A parcel-level trip distribution gravity model is used to distribute the generated trips between the parcels and the nearby traffic count sites.
- The distributed trips are assigned to the network by using all-or-nothing assignment method in the parcel-level trip assignment step.
- The traffic volume data of the loaded network are exported, and ArcGIS is used again to calculate the final AADTs, which are then joined with the original roadway network to get the roadway network with AADTs.

The ArcGIS component was implemented with an ArcGIS application called ArcGIS ModelBuilder, which provides a visual programming environment allowing the user to graphically link geoprocessing tools into models. While the models built with ModelBuilder can be executed directly in ArcGIS, they can also be exported to scripting language such as Python. The Python scripts can be called with the Cube Voyager Pilot program, so theoretically all the steps of the ArcGIS part can be integrated into Cube to simplify the running of the entire model. However, because this part has called some geoprocessing tools that are supported only by ArcGIS 10.0, which is not compatible with the current version of Cube (5.1.3), integration of ArcGIS into Cube has not be implemented. Nevertheless, this incompatibility would not affect the results of the entire model.

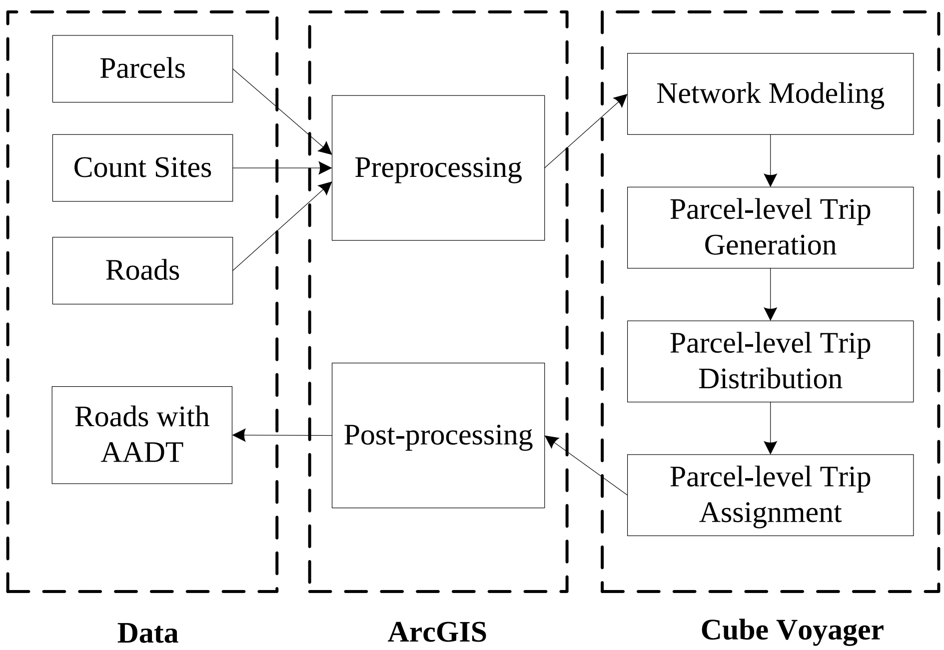


Figure 3-11: System Components and Procedure

Figure 3-12 shows the model steps and the input and output files for each steps implemented in Cube. It can be noted that the four model steps are integrated. When the model is run, the four steps are executed in sequence, and the output files of a previous step becomes the input files of a later step. If there were no compatibility problems as mentioned above, the ArcGIS part should have been combined with the Cube, and the steps shown in this Figure 3-12 would be all the steps involved in the entire model.

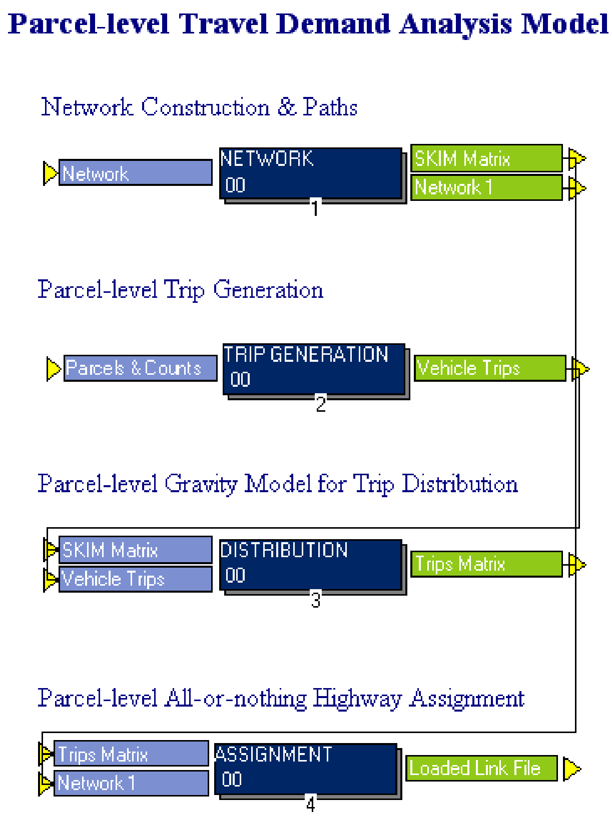


Figure 3-12: Model Steps in Cube

Table 3-8 summarizes the input and output files for each step. There are two input files for the Cube. One is the network file preprocessed by the ArcGIS, and the other is the DBF file for the merged parcels and traffic count sites shape file which is also generated by the ArcGIS. There is one output file generated by the Cube part, and it is the DBF link file with the traffic volume information exported from the loaded network assigned in the parcel-level trip assignment step. Among the steps, the output files of the preceding step may become the input files for the later step.

Table 3-8: Input and Output Files

Model Step	Input File	Output File
Network Modeling	Preprocessed Network File	Free Flow Time SKIM Matrix File
		Modified Network File
Parcel-level Trip Generation	Merged Parcels and Counts DBF File	Vehicle Trips DBF File
Parcel-level Trip Distribution	Free Flow Time SKIM Matrix File	Distributed Trips Matrix File
	Vehicle Trips DBF File	
Parcel-level Trip Assignment	Distributed Trips Matrix File	Link DBF File with Volume Exported from Loaded Network
	Modified Network File	

The following sections describe the steps in implementing the parcel-level travel demand model. Preprocessing of the input data with ArcGIS will be introduced in the Network Modeling step, and the calculation of the AADT values from the loaded network and the implementation of the evaluation with ArcGIS will be described under the Parcel-level Trip Assignment step.

3.5.1 Network Modeling

The implementation of the Network Modeling step includes the following four sub-steps:

a) Preprocess the input data in ArcGIS.
b) Build the Cube network file from the roadway shape file.
c) Create the centroid connectors in Cube.
d) Calculate the free flow time skims matrix in Cube.

The implementation of each of these steps is described in detail below.

3.5.1.1 Data Preprocessing

The preprocessing of the input data involved:

- divide the traffic count site point data into two groups, one for estimating AADT, and the other for evaluating the results;
- create buffer around traffic count site points for AADT estimation and merge them with the DOR parcel polygon data; and
- split roadway polylines at the parcels' access points.

Division of traffic count sites was based on the level of the road at which a traffic count site is located. Count sites on the major roads were used for AADT estimation, and those on the minor local roads were used for evaluating the results. This step is not required, but it is highly recommended if there are multiple traffic count sites located on the minor roads. This will not only help provide the required data for the results evaluation but also improve the accuracy of AADT estimation.

TAZ boundaries were used to locate traffic count sites on the major roads. Figure 3-13 shows the model used in ArcGIS to divide count sites into estimation and evaluation groups. As shown in Figure 3-13, the input data used were the TAZ polygon data and the traffic count site point data. The TAZ polygons were converted to the polylines, the TAZ boundaries, so that they can be processed by ArcGIS to create buffers on both sides of the TAZ boundaries. The traffic count sites located within the TAZ boundary buffers were erased first to retrieve those located on the local roads. The results were compared with the original traffic count sites, and differences were saved as the traffic count sites located within the TAZ boundary buffer and on the major roads. All the traffic count sites located on the major roads were used for AADT estimation, and the count sites located on local roads were used for result evaluation.

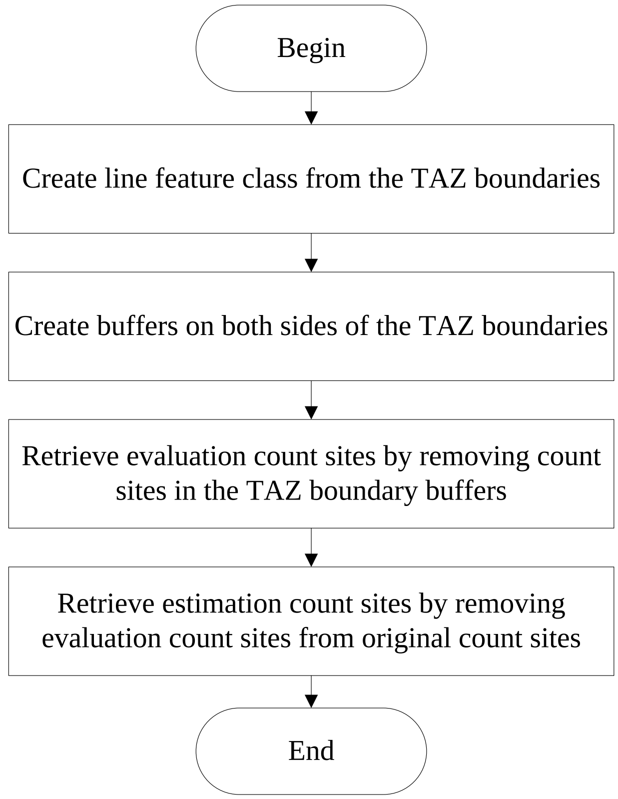


Figure 3-13: Dividing the Count Sites into Estimation and Evaluation Groups

The traffic count sites for AADT estimation had to be merged with the parcels, because the trips were to be distributed between them. The traffic count site points were first buffered so that they have the same feature types with the parcel data. It is to be noted that not all the parcels were used. Depending on their land use types, very few or no trips could be generated by some parcels such as vacant residential, rights-of-way streets, roads, canals, camps, rivers, lakes, etc. A total of 42 parcel land use types were considered to have very few or no trips, and therefore, were not used. After the traffic count sites and parcels were merged, a new field named "TAZ" was added, and its values range from one to the total number of merged parcels and count sites. This field is required because it ensures that the centroid connectors would be created successfully with Cube in the next step. Figure 3-14 shows this procedure.

It is also necessary to split the roadway polylines at the access points of the parcels so that the centroid connectors can be created correctly with Cube in the next step. Cube provides a functionality to automatically add centroid centers and centroid connectors, but the connectors can only be created between two nodes. This means that a centroid connector will always connect a centroid center node to its nearest intersection node. Figure 3-15 gives an example of a subarea with incorrectly created centroid connectors. In the figure, the gray lines represent the added centroid connectors connecting the parcels to the closest intersections.

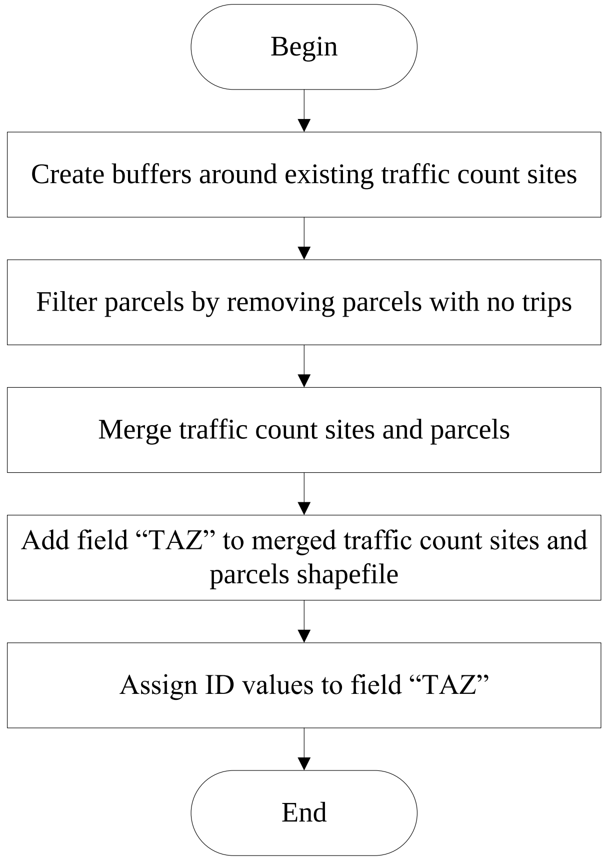


Figure 3-14: Merging the Parcels and the Traffic Count Sites

Figure 3-15: Centroid Connectors Incorrectly Connecting Parcels to Intersections

Connecting the parcels to the closest intersections will seriously reduce the accuracy of the AADT estimation. To prevent this from happening, the access points of the parcels on the roads can be estimated and inserted as nodes into the road segments, and the centroid connecters will then connect the centroid centers to the closest roads instead of the closest intersections. After the roadway polylines were split, three fields named "A", "B", and "FF_TIME" were added. The fields "A" and "B" were required for Cube to create the centroid connectors automatically and the field "FF_TIME" was used to store the Free Flow Time calculated in the next step. Figure 3-16 shows the procedure.

Preprocessing of the input data generated two shape files: the split roadway file and the merged parcels and count sites file. These generated files were later used to build the Cube network file and create the centroid connectors automatically on the network in the sub-steps that follow. The DBF file associated with the merged parcels and count sites shape file were later used as an input file to the parcel-level trip generation step.

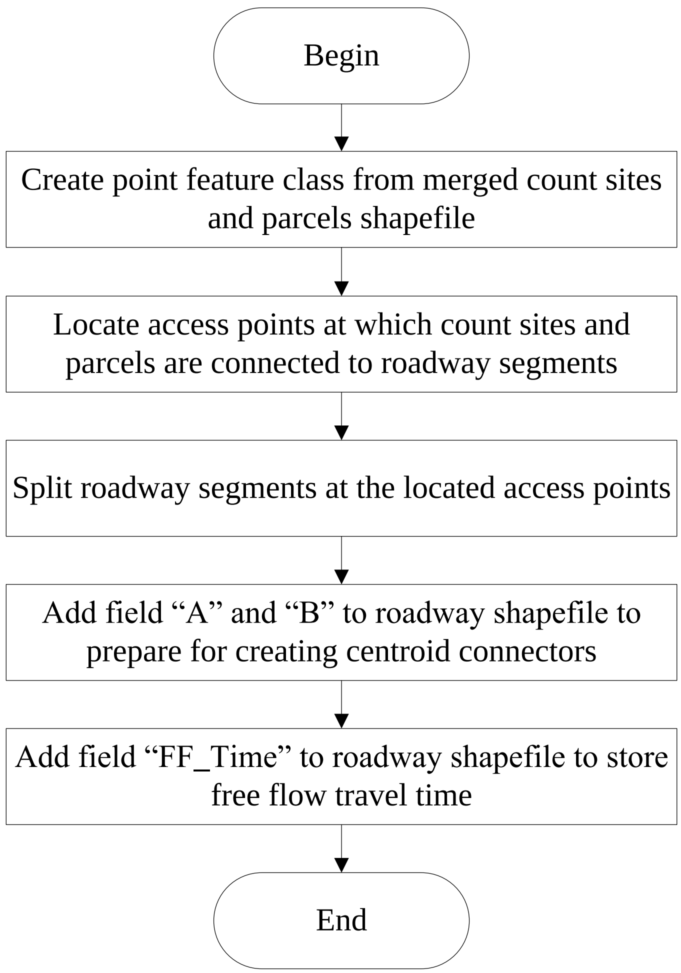


Figure 3-16: Splitting the Roadway Polylines at the Parcel Access Points

3.5.1.2 Cube Network File

In this research, the unabridged roadway network data are in the shape file format, but Cube models are based on the highway network file format which was defined by Citilabs. Therefore, the preprocessed roadway shape file has to be converted to the highway network file compatible with Cube. Cube Base provides the required functionality and interface to build a highway network file from either a shape file or a geodatabase's feature class. Figure 3-17 shows the dialog to build the Cube highway network from the line shape file or the line feature class.

In this dialog box, both the output binary network file and the input line shape file can be defined. The node fields A and B that were earlier added to the input line shape file can be chosen in this dialog box. If the input line shape file has a field to indicate one-way or two-way, it can be chosen; otherwise, two-way is always chosen since AADT is non-directional. If the input line shape file does not have an attribute for the road segment distance, the Add Distance Field option should be chosen so that the free flow time can later be calculated. The highest zone number is the number of the merged parcels and traffic count sites in the study area, and the "Starting New Node Number" should always be greater than the highest zone number and can be the highest zone number plus one. All other items can be based on the default values.

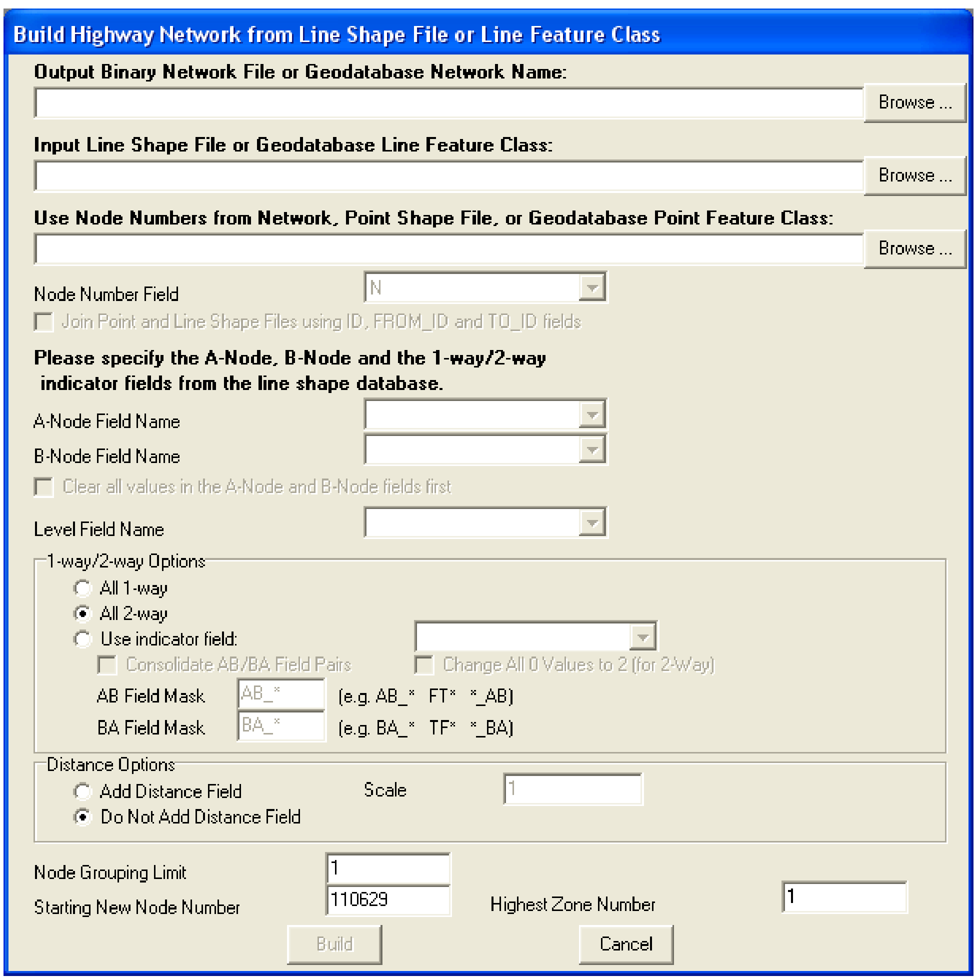


Figure 3-17: Build Highway Network from Line Shape File Dialog

The built highway network file was then compared with the original shape file to check if the build network was the same as the original roadway layout. This was needed because Cube might simplify some horizontal curves and convert them to straight lines. Figure 3-18 gives an example of this mismatching. Fortunately, Cube provides a functionality to fix this problem. It is implemented by overriding the original shape file and the built highway network as two layers and correcting the difference between the two layers on the built highway network layer. Figure 3-19 shows the Display True Link Shape dialog box. By using the interface provided by Cube, the built network can be fixed by taking the actual shape of the roadway in the shape file.

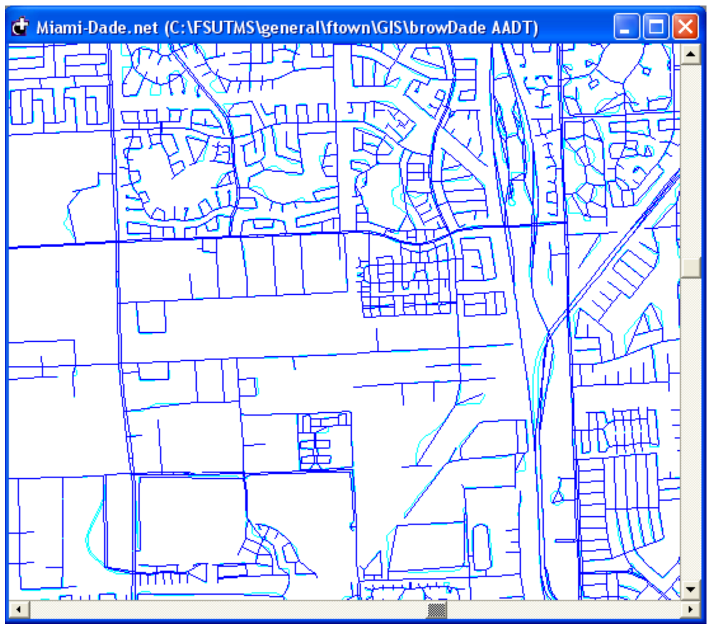


Figure 3-18: Mismatching of the Built Network with Original Shape File

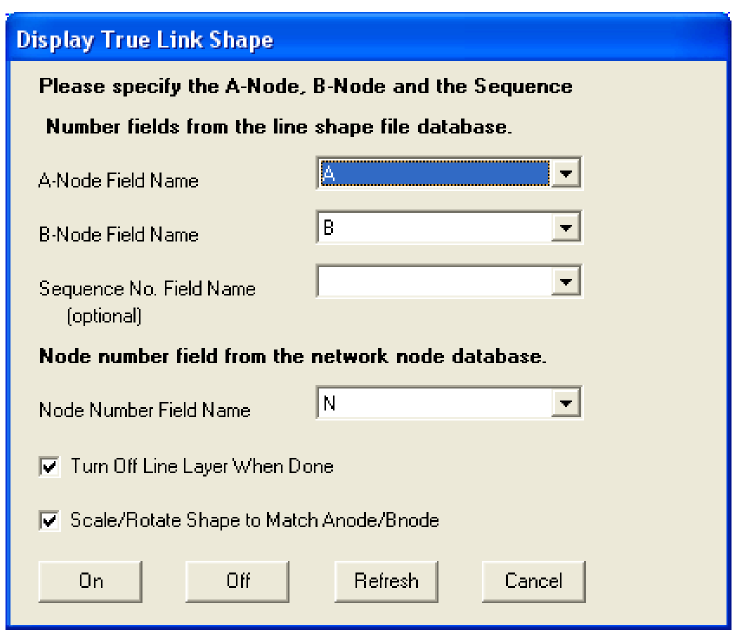


Figure 3-19: Display True Link Shape Dialog

The shape source data have now been converted to a highway network for use in modeling, and the next sub-step was to create the centroid centers and connectors for the highway network.

3.5.1.3 Centroid Centers and Connectors

Cube provides a functionality to automatically add centroid centers and centroid connectors. To automatically add the centroid centers and connectors, the highway network must be loaded into the highway network layer with the correct number of zones specified. The nodes inserted into the road segments in the data preprocessing step are also required. Figure 3-20 shows the Automatic Centroid Connectors Generation dialog box for the user to specify the parameters. The Maximum Number of Connectors to Generate option was set as one, and default values were used for other parameters. Figure 3-21 shows an example of a subarea with the added centroid connectors connecting the parcels and the closest roads. The green polygons represent the parcel boundaries; the blue lines represent the roadway; and the gray lines are the added centroid connectors.

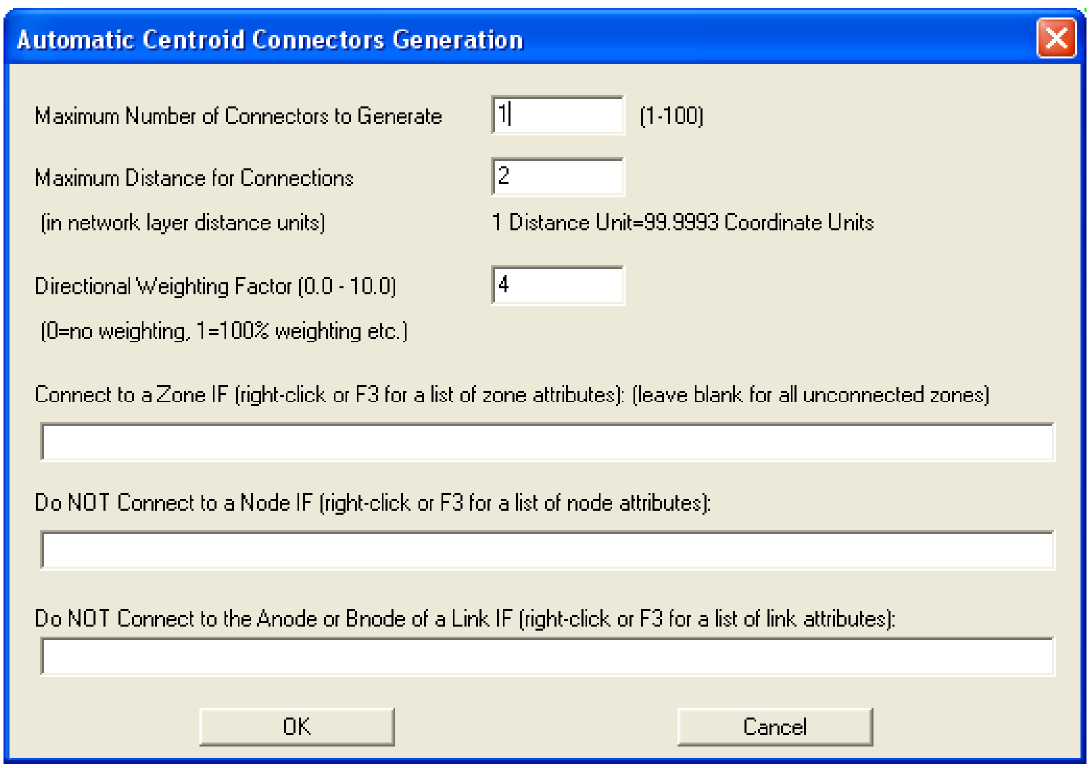


Figure 3-20: Automatic Centroid Connectors Generation Dialog

3.5.1.4. Free Flow Travel Time Skim Matrix

After building the Cube network file and correctly adding the centroid centers and connectors, the next step is to calculate the free flow time skim matrix, which contains the free flow travel times between each pair of parcels/count sites, although only the free flow travel times between the parcels and the count sites were used by the model. Figure 3-22 shows the components of this sub-step. It shows that the Cube Voyager Network program was called to calculate the free flow time on each roadway segment with its distance and speed values, and the Cube Voyager Highway program was called to generate the skim matrix file. This was implemented by using Cube Voyager script programming.

3.5.2. Parcel-level Trip Generation

The parcel-level trip generation step estimates the trips generated by each parcel in the study area. To implement this step, the DBF file associated with the merged parcels and count sites shape file generated by data preprocessing with ArcGIS was used as the input file, and Cube Voyager Matrix program was called and customized to calculate the trips based on each parcel's land use type. The output file was also a DBF file containing fields such as "TAZ", "Production", and "Attraction". The calculated parcel trips were saved in the "Production" field, and the attraction values of the parcels were zero. The count sites have zero production values, and their attraction values were the AADTs estimated from count data. Figure 3-23 shows the components of this step.

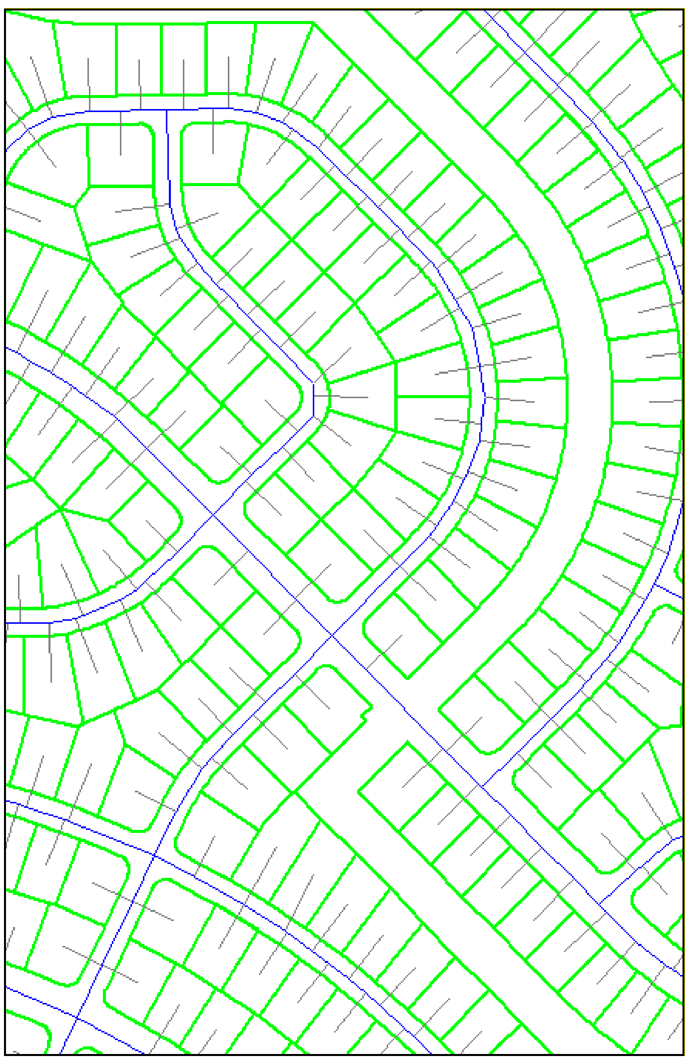


Figure 3-21: Example of Centroid Centers and Connectors Added

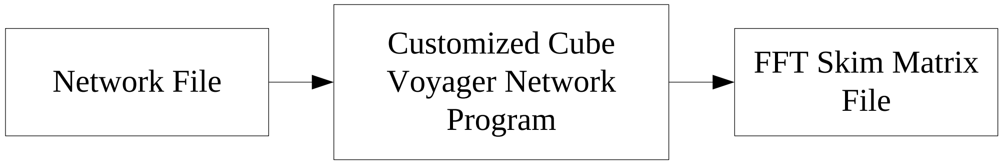


Figure 3-22: Components of FFT Skim Matrix Calculation

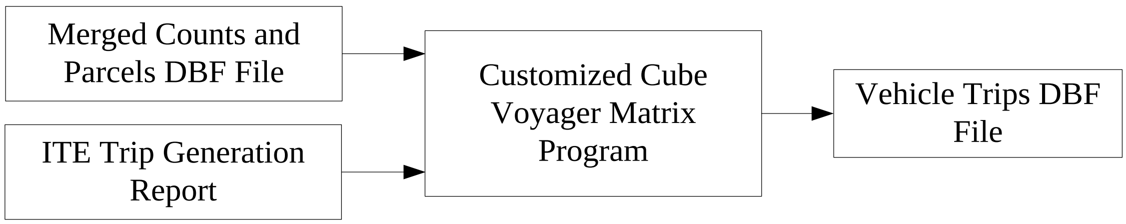


Figure 3-23: Components of Parcel-level Trip Generation Step

To calculate the trips of a parcel based on its land use type, it is necessary to match the two kinds of land use type classification from the DOR parcel data and the *ITE Trip Generation Report*. For tax assessment purpose, DOR parcel data assign a land use type to each parcel using a land use code. The DOR classified land use into a total of 100 types. The *ITE Report* is based on a more detailed land use type classification. The report has identified more than 162 land use types. Therefore, to implement the parcel-level trip generation step, it is important to accurately match the two sources of land use type.

For each land use type, the *ITE Report* provides trip rates information based on several independent variables such as Gross Floor Area (GFA), employees, and dwelling units. The DOR parcel data have many attributes, three of which can be used to match the ITE Trip Generation independent variables. Table 3-9 lists the matching of parcel attributes and the independent variables in the *ITE Report*.

The *ITE Report* provides three methods of estimating trips. The data plots can only be used to graphically obtain a rough estimation of trips, so it is not practical to use for this model. The problem with the regression equations is that there are many instances when it will result in illogical estimation of trips if the independent variable is significantly less than the average-sized value. The parcel-level trip generation is based on each parcel, so the independent variables are usually much lower than the average-sized value. Therefore, the weighted average trip rates were used for most of the land use types.

Table 3-9: Parcel Attributes and ITE Trip Generation Independent Variable Matching

Parcel Attributes	ITE Trip Generation Independent Variable
NORESUNTS	Dwelling Units
TOTLVGAREA	1000 Sq. Feet Gross Floor Area
ACRES	Acres

Appendix B summarizes the matching of land use types of parcel data and the *ITE Trip Generation Report*, the selected independent variables, and the selection of the estimation method (average rate or regression equation) for each land use types. From Table B-1 in

Appendix B, it can be noted that 42 parcel land use types can be dismissed as they generate either zero or an insignificant number of trips. All the dismissed land use types are listed as "N/A" in the "ITE Land Use" column, and their estimated parcel trips were zero.

3.5.3 Parcel-level Trip Distribution

The parcel-level trip distribution step distributes trips between the parcels and the traffic count sites. The input files of this step are the results of the two previous steps: the free flow skim matrix file generated by the network modeling step and the production and attraction DBF file generated by the parcel-level trip generation step. The Cube Voyager Distribution program was called to calculate the trips. The output file was a Cube Matrix file containing the trips between each pair of parcels/count sites. Figure 3-24 shows the components of the parcel-level trip distribution step.

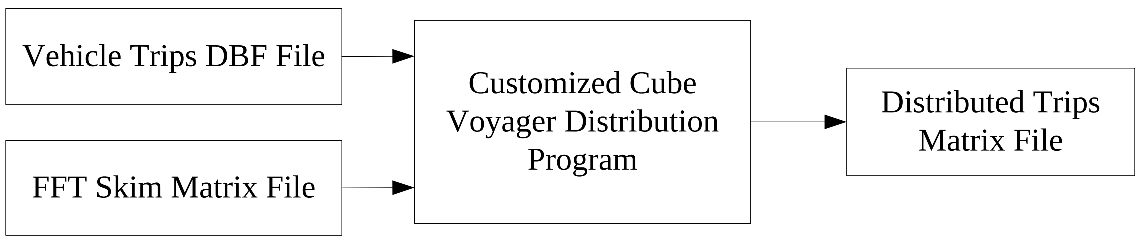


Figure 3-24: Components of Parcel-level Trip Distribution Step

It should be noted that it is not necessary that the trips generated by a parcel to be distributed to all the traffic count sites in the study area. The distribution range can be adjustable, and Cube provides a keyword, LOSRANGE, to specify the range of LOS values that are valid for use in the distribution process. For example, if the LOSRANGE is set as 0-10, the trips from a parcel will be distributed to the count sites which can be reached within 10 minutes, and there will be no trips to those count sites farther than 10 minutes. Theoretically, the travelers are most likely to access the closest higher level state-roads as soon as possible to reduce travel time, so the traffic counts close to a parcel tend to attract more trips, and the distribution range should be very small. To verify that, different distribution ranges were chosen and tested, and the final distribution range used was 5 minutes.

3.5.4 Parcel-level Trip Assignment

The parcel-level trip assignment step assigns trips between the parcels and the count sites. The trips matrix file generated by the trip distribution step and the highway network file were used as the input files. The Cube Voyager Highway program was called to perform the all-or-nothing assignment. In addition, the Cube Voyager Network program was called to extract traffic volume data for each road segment from the loaded network file and save them into a DBF file, which was later joined with the original roadway shape file to calculate the final AADT values in ArcGIS. Figure 3-25 shows the components of the parcel-level trip assignment step.

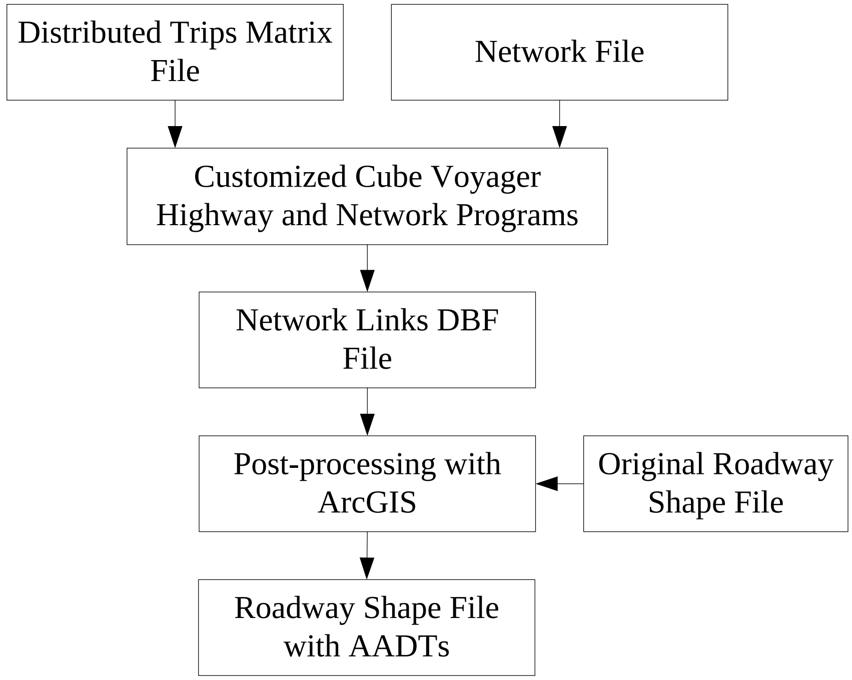


Figure 3-25: Components of Parcel-level Trip Assignment Step

Trip assignment is usually the most time consuming step for the traditional zone-level travel demand step. This is because the implementation of the equilibrium assignment method involves running several iterations of the assignment procedure with an adjustment for the travel time. However, because the all-or-nothing assignment involves only one iteration, the parcel-level trip assignment does not take a long time to execute even with a high number of parcels.

After exporting the loaded network to the DBF file containing traffic volume data, ArcGIS was used to calculate the final AADTs and link the results to the original road network shape file. Figure 3-26 shows the procedure for calculating the final AADT values.

The volume data exported from Cube have two values, one for each direction. However, AADT is bidirectional traffic volume. As such, the two directional volume values were summed up for each road segment. In addition, because the roadway polylines were split at the access points of the parcels in the network modeling step, the calculated AADTs provide results that are too detailed. This means that there could be multiple AADTs for each road segment depending on the number of access points. To address this issue, the maximum AADT value of the multiple road segments was used as the final AADT for the original segment. After calculating the AADT values for the road network, the results were joined with the original roadway shape file.

3.6 Method Evaluation

Finding a good method to evaluate the accuracy for the estimation results of the proposed model is not easy. This is mainly because there are no permanent counters installed on local roads, thus no full year volume data available to calculate the true AADTs. Therefore, the methods introduced in this research will provide only an approximate evaluation.

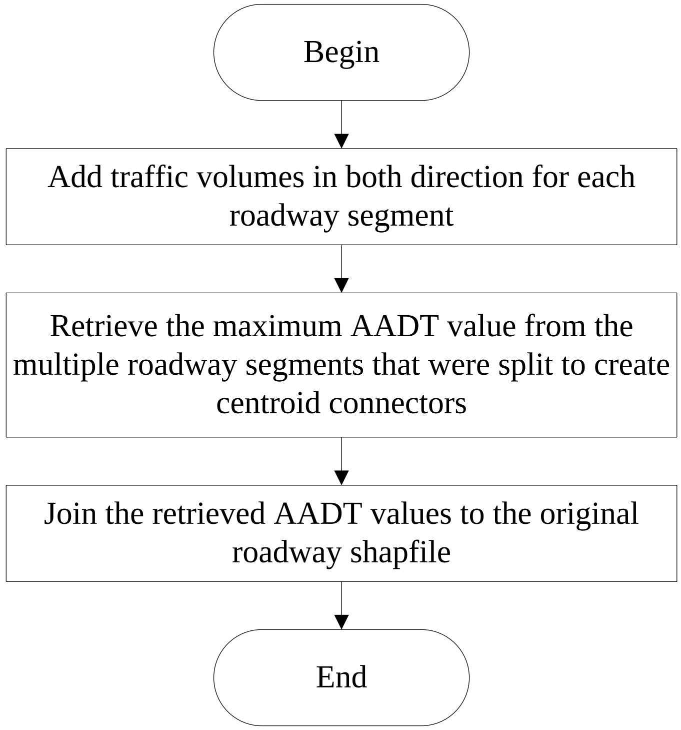


Figure 3-26: Calculating the Final AADTs

One way to evaluate the proposed method is to compare its results with those from the traditional factor method. This assumes that the traditional factor method with short-term traffic count data is more reliable and can be used as the ground truth data. Some local roads also have portable traffic counters, and the AADT values estimated with the traditional factor method are already available. Hence, those roads can be chosen from the study area as the evaluation locations.

To quantify the difference between the proposed method and the traditional factor method, the following three commonly used measures of accuracy are used: Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and Mean Absolute Percentage Error (MAPE). Their calculations are expressed as follows:

$$MAE = \frac{\sum_{i=1}^{n} \left| F(i) - G(i) \right|}{n} \tag{3-13}$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} \left(F(i) - G(i) \right)^2}{n}} \tag{3-14}$$

$$MAPE = \frac{1}{n} \sum_{i=1}^{n} \left| \frac{F(i) - G(i)}{G(i)} \right| \tag{3-15}$$

where,

G(i)	=	the ground truth AADT at location i,
F(i)	=	the estimated AADT at location i, and
n	=	the total number of locations.

To evaluate the performance of the proposed method, results of the USF regression method and the URS method were compared with those of the proposed method. The comparison was performed at different levels. Firstly, the three methods were compared based on a selected study area. The traffic count sites located on the local roads in this area were selected as the evaluation count sites. The results of the three methods were compared with the AADT values estimated from traffic count data which were used as the ground truth AADTs. The overall estimation errors for this study area were also calculated and compared.

Depending on the availability of enough traffic count data, the study areas were selected from Broward County in Florida, which was found to have the most complete traffic count data for its local roads. Hundreds of traffic counters are deployed each year in this county to collect traffic volume. Because Cube can only process a maximum of 32,000 zones at a time, the size of the study areas was limited to a maximum of 32,000 parcels and traffic count sites.
To measure the change of the three methods' performance with the change of the locations and the area types, the comparison was conducted for 10 selected study areas to cover more locations in Broward County, and the standard deviations of the estimation errors for these study areas were calculated and compared. To further compare the performance of the three methods, the overall estimation errors for the 10 study areas were also calculated and compared.

Lastly, one of the scenarios was chosen to show the performance of the three methods for the lowest level local roads without any traffic count sites. Subjective judgment was used to compare the results of the three methods. This type of comparison may not be very accurate as it is based on intuition and reasoning.

3.6.1 Single Study Area Comparison

The chosen study area was an area about 4.7 × 4.7 miles located at the center of the Broward County. As shown in Figure 3-27, the study area has a total of 19 evaluation count sites.

Table 3-10 lists the AADTs for all the estimation count sites estimated by the three methods, the ground truth AADTs, and their corresponding estimation errors. The results indicate that the URS method and the proposed method had similar performance for this study area, and they have much lower estimation errors than those of the USF method.

By further checking the AADTs estimated by the proposed method for the evaluation locations, it was found that three locations (sites 2, 6, and 19) have very high estimation errors exceeding 90%. From the locations shown in Figure 3-27, it can be seen that they are located near the boundary of the study area. It is very possible that the results were underestimated for these sites, because they were too close to the boundaries causing the trips which should have passed them to be excluded. To verify that, those three evaluation count sites were removed. Table 3-11 shows the results, and it indicates that the performance of the proposed method was improved. Therefore, one of the limitations of the proposed method is that it provides less accurate AADT estimation for roads near the boundary areas.

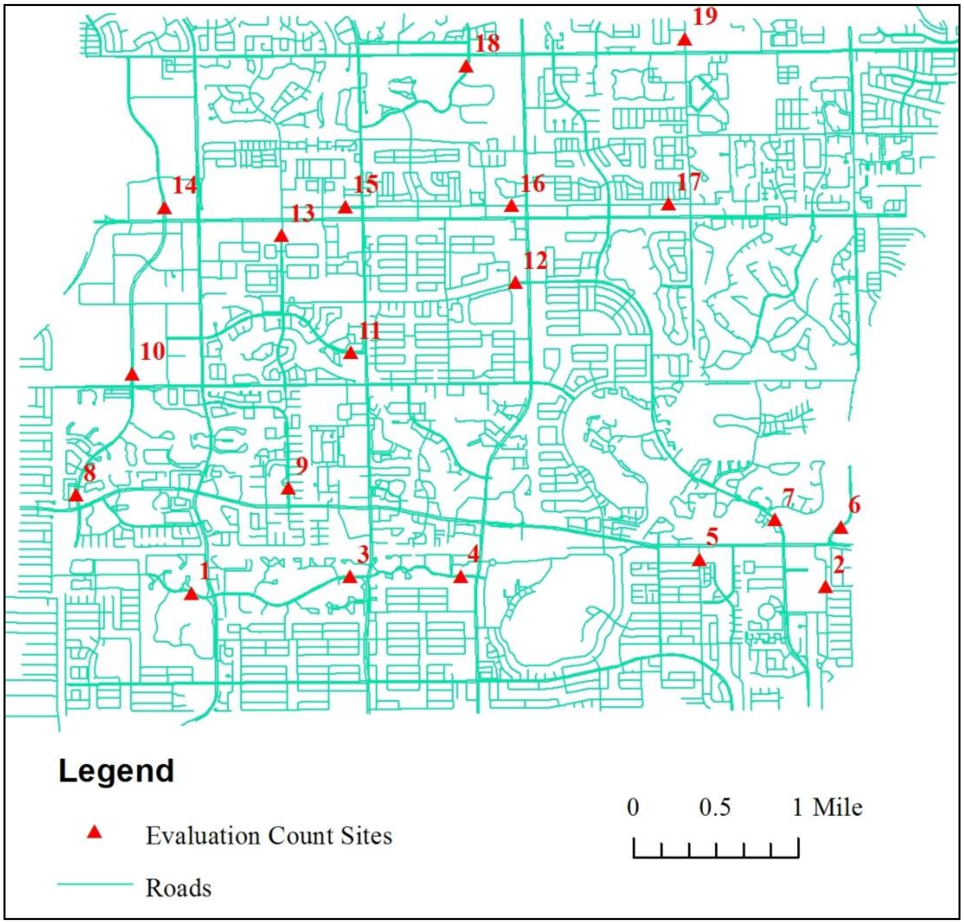


Figure 3-27: Evaluation Traffic Count Sites in the Study Area

Table 3-10: Performance of the Three Methods for the Study Area

Site No.	AADT by Count Data	AADT by USF Method	USF Method MAPE (%)	AADT by URS Method	URS Method MAPE (%)	AADT by Proposed Method	Proposed Method MAPE (%)
1	5,900	20,967	255.37	7,074	19.90	1,385	76.53
2	11,000	18,067	64.25	2,225	79.77	1,001	90.90
3	4,400	2,400	45.45	823	81.30	4,112	6.55
4	3,300	20,967	535.36	1,004	69.58	2,010	39.10
5	7,900	0	100.00	1,936	75.49	7,246	8.28
6	21,500	10,750	50.00	35,014	62.86	0	100.00
7	17,500	9,450	46.00	17,100	2.29	27,165	55.23
8	15,700	8,700	44.59	2,209	85.93	11,014	29.85
9	4,800	17,932	273.58	7,354	53.21	1,011	78.93
10	13,000	6,200	52.31	2,209	83.01	1,375	89.42
11	5,000	18,384	267.68	2,665	46.70	7,080	41.60
12	6,000	3,600	40.00	2,076	65.40	5,689	5.18
13	5,900	17,365	194.32	3,614	38.75	10,338	75.21
14	13,000	2,350	81.92	2,209	83.01	9,451	27.30
15	2,800	0	100.00	328	88.29	2,455	12.32
16	4,000	17,932	348.30	2,955	26.13	1,348	66.29
17	6,100	15,496	154.03	1,540	74.75	1,800	70.49
18	4,800	19,154	299.04	220	95.42	601	87.48
19	17,600	17,500	0.57	18,640	5.91	5	99.97
MAPE (%)			155.41		59.88		55.82

Table 3-11: Performance of the Methods without Invalid Evaluation Count Sites

Site No.	AADT by Count Data	AADT by USF Method	USF Method MAPE (%)	AADT by URS Method	URS Method MAPE (%)	AADT by Proposed Method	Proposed Method MAPE (%)
1	5,900	20,967	255.37	7,074	19.90	1,385	76.53
3	4,400	2,400	45.45	823	81.30	4,112	6.55
4	3,300	20,967	535.36	1,004	69.58	2,010	39.10
5	7,900	0	100.00	1,936	75.49	7,246	8.28
7	17,500	9,450	46.00	17,100	2.29	27,165	55.23
8	15,700	8,700	44.59	2,209	85.93	11,014	29.85
9	4,800	17,932	273.58	7,354	53.21	1,011	78.93
10	13,000	6,200	52.31	2,209	83.01	1,375	89.42
11	5,000	18,384	267.68	2,665	46.70	7,080	41.60
12	6,000	3,600	40.00	2,076	65.40	5,689	5.18
13	5,900	17,365	194.32	3,614	38.75	10,338	75.21
14	13,000	2,350	81.92	2,209	83.01	9,451	27.30
15	2,800	0	100.00	328	88.29	2,455	12.32
16	4,000	17,932	348.30	2,955	26.13	1,348	66.29
17	6,100	15,496	154.03	1,540	74.75	1,800	70.49
18	4,800	19,154	299.04	220	95.42	601	87.48
MAPE (%)			177.37		61.82		48.11

3.6.2 Multiple Study Areas Comparison

To measure the change of the three methods' performance with different locations, a total of 10 study areas were selected from Broward County. These locations cover diverse areas and as many evaluation count sites as possible. The roadway layout and the locations of the traffic count sites for evaluation and estimation are illustrated in 10 maps as shown from Figure 3-28 to Figure 3-37 in sequence.

Table 3-12 lists the MAPEs of the three methods for the 10 study areas, and the standard deviation of the MAPEs. From the results, it can be noted that the proposed method has much lower MAPEs than the USF method for all 10 study areas, and it has fairly lower MAPEs than the URS method for 9 study areas. It can also be noted that the proposed method has lower standard deviation for the MAPEs of the 10 study areas than the other two methods, which means that its performance is least affected by the locations and the area types of the study areas.

Table 3-12: Variance Measure of the Performance

Area	USF Method MAPE (%)	URS Method MAPE (%)	Proposed Method MAPE (%)
1	216.67	57.16	48.02
2	314.14	68.72	52.16
3	177.37	61.82	48.11
4	345.49	87.90	66.09
5	175.80	35.82	49.08
6	405.20	77.79	60.08
7	114.43	66.12	62.27
8	186.21	63.32	49.10
9	181.39	65.30	55.67
10	157.22	42.18	39.15
Standard Deviation	94	15	8

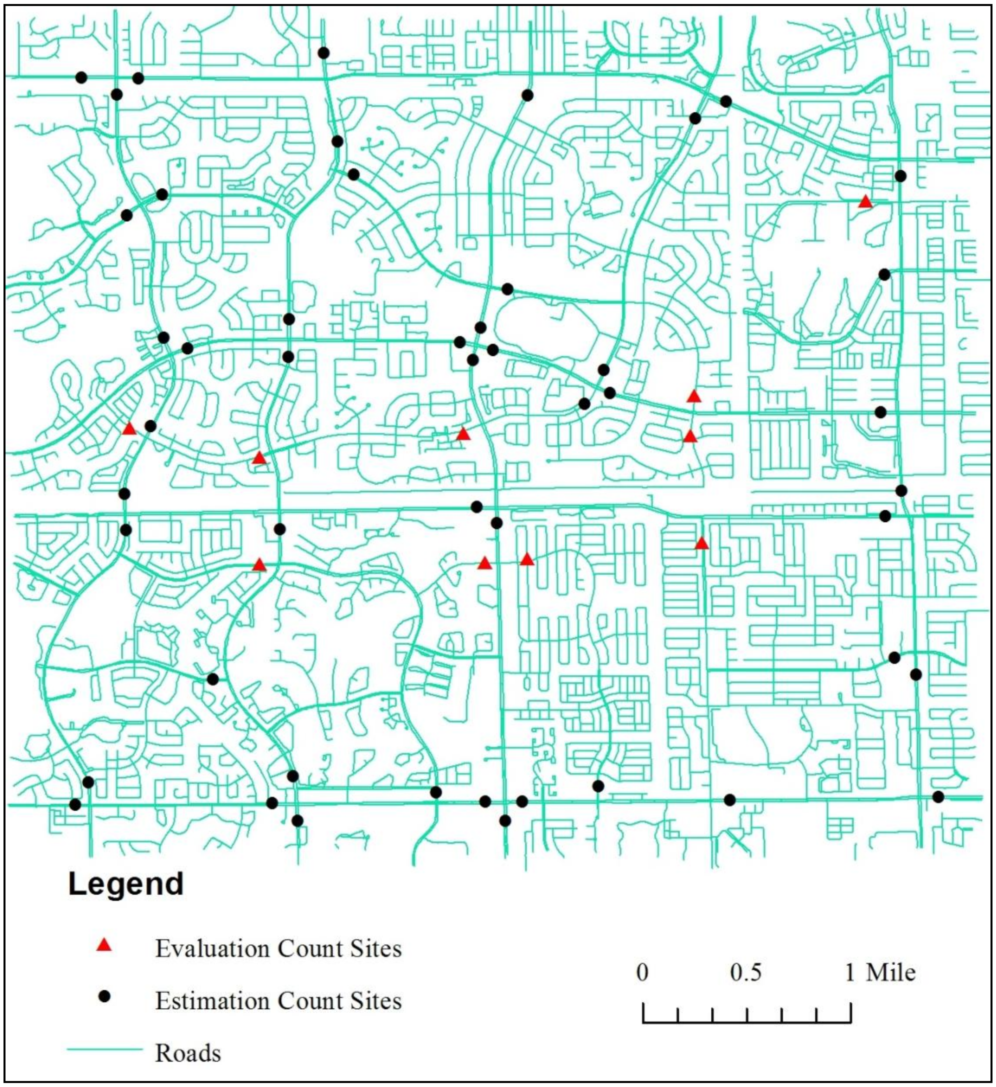


Figure 3-28: Study Area No. 1

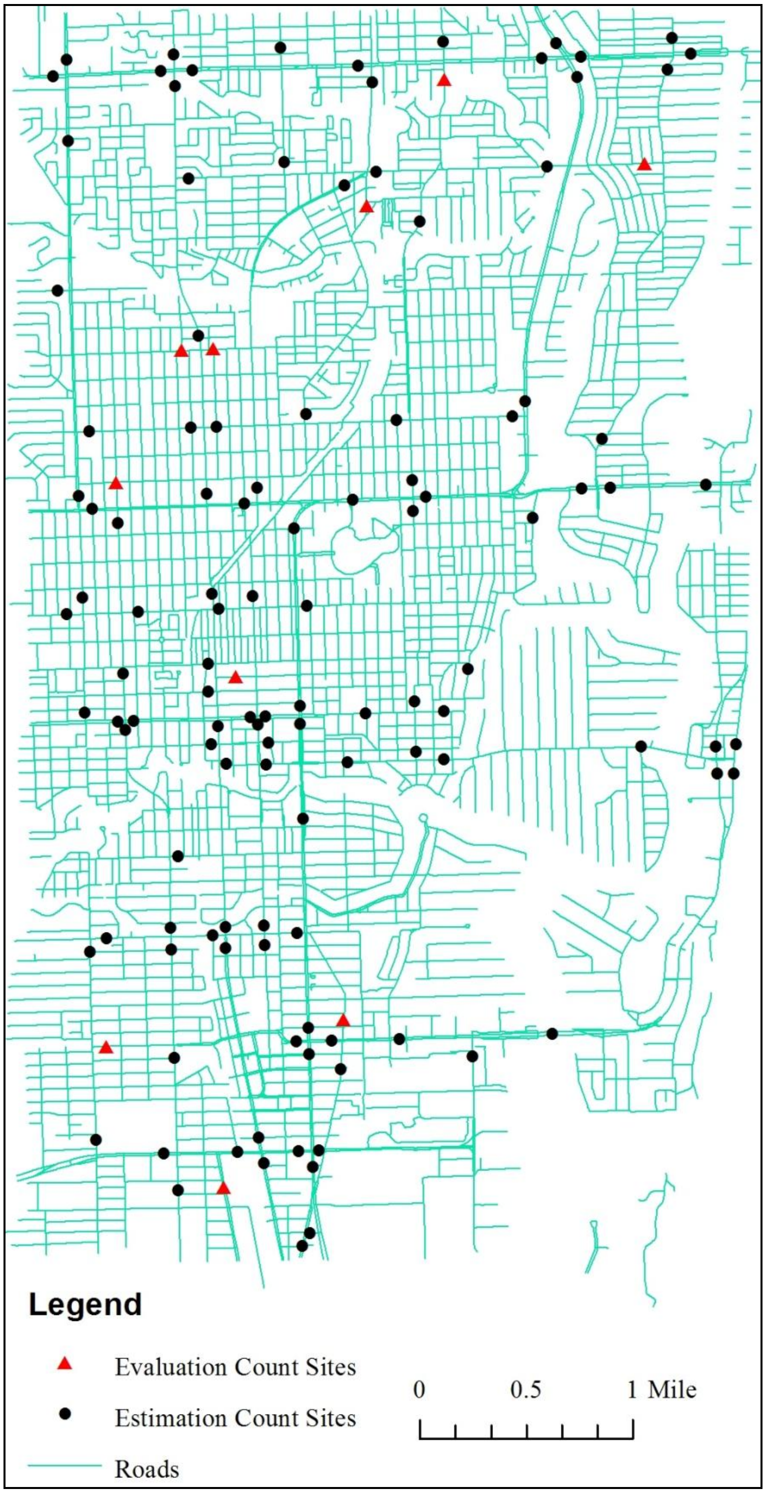


Figure 3-29: Study Area No. 2

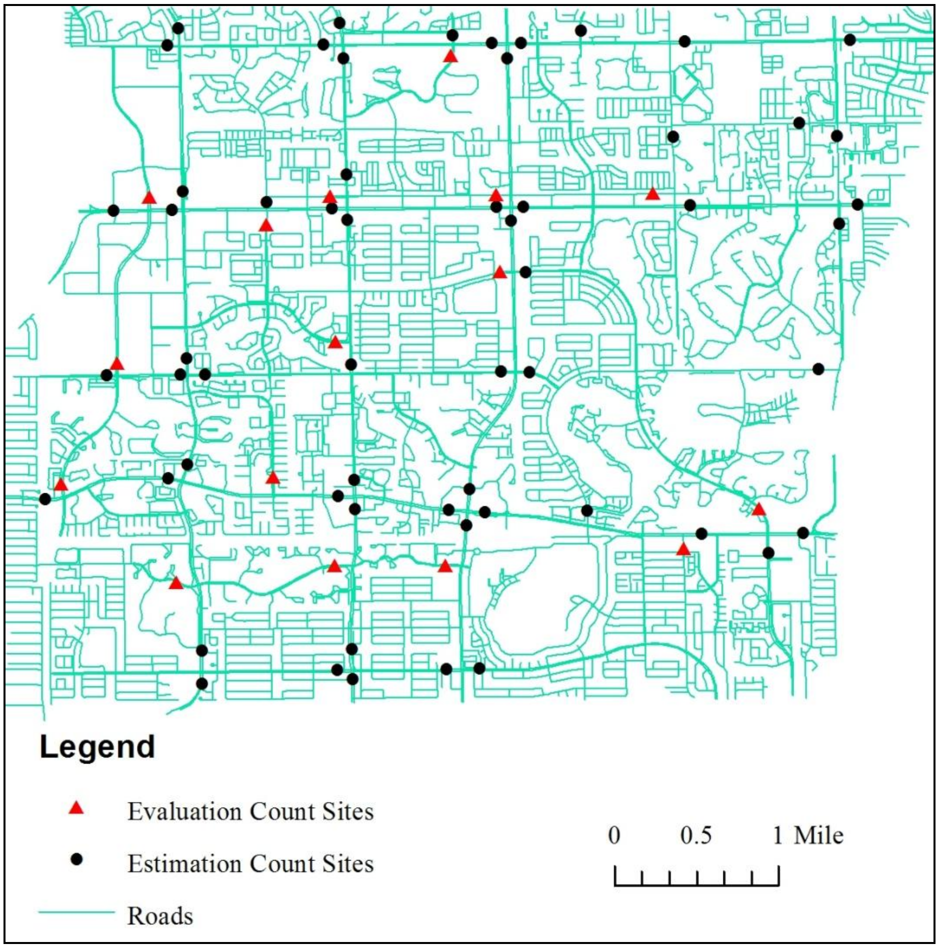


Figure 3-30: Study Area No. 3

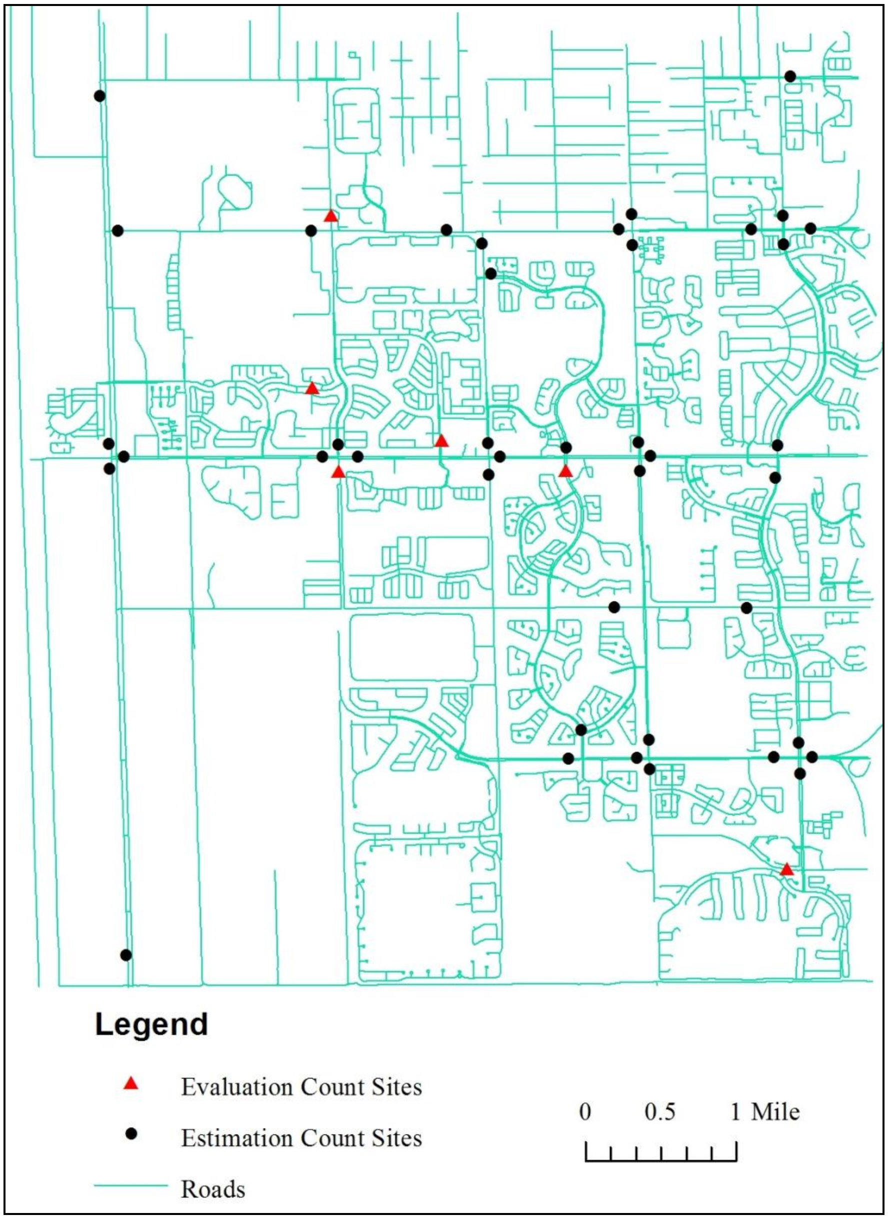


Figure 3-31: Study Area No. 4

Figure 3-32: Study Area No. 5

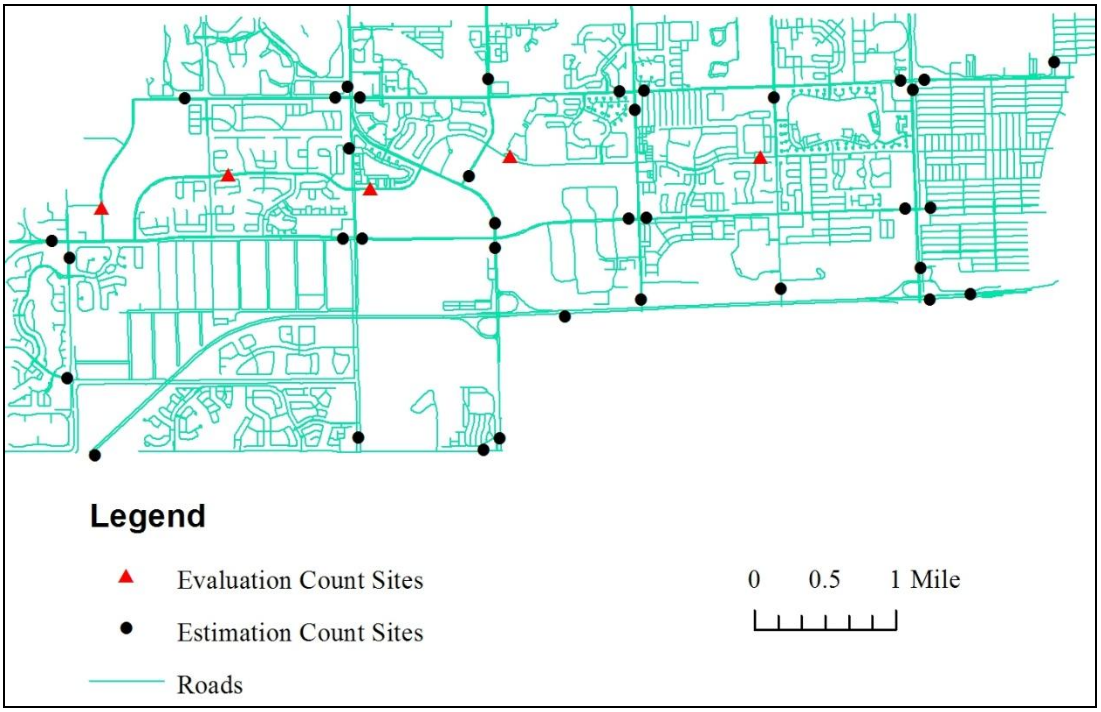


Figure 3-33: Study Area No. 6

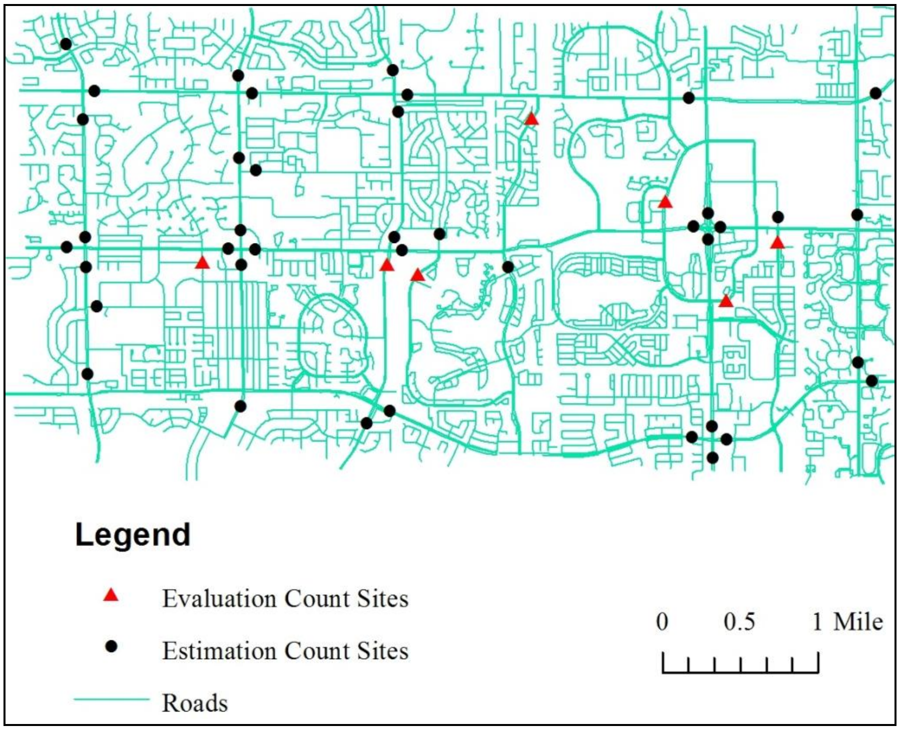


Figure 3-34: Study Area No. 7

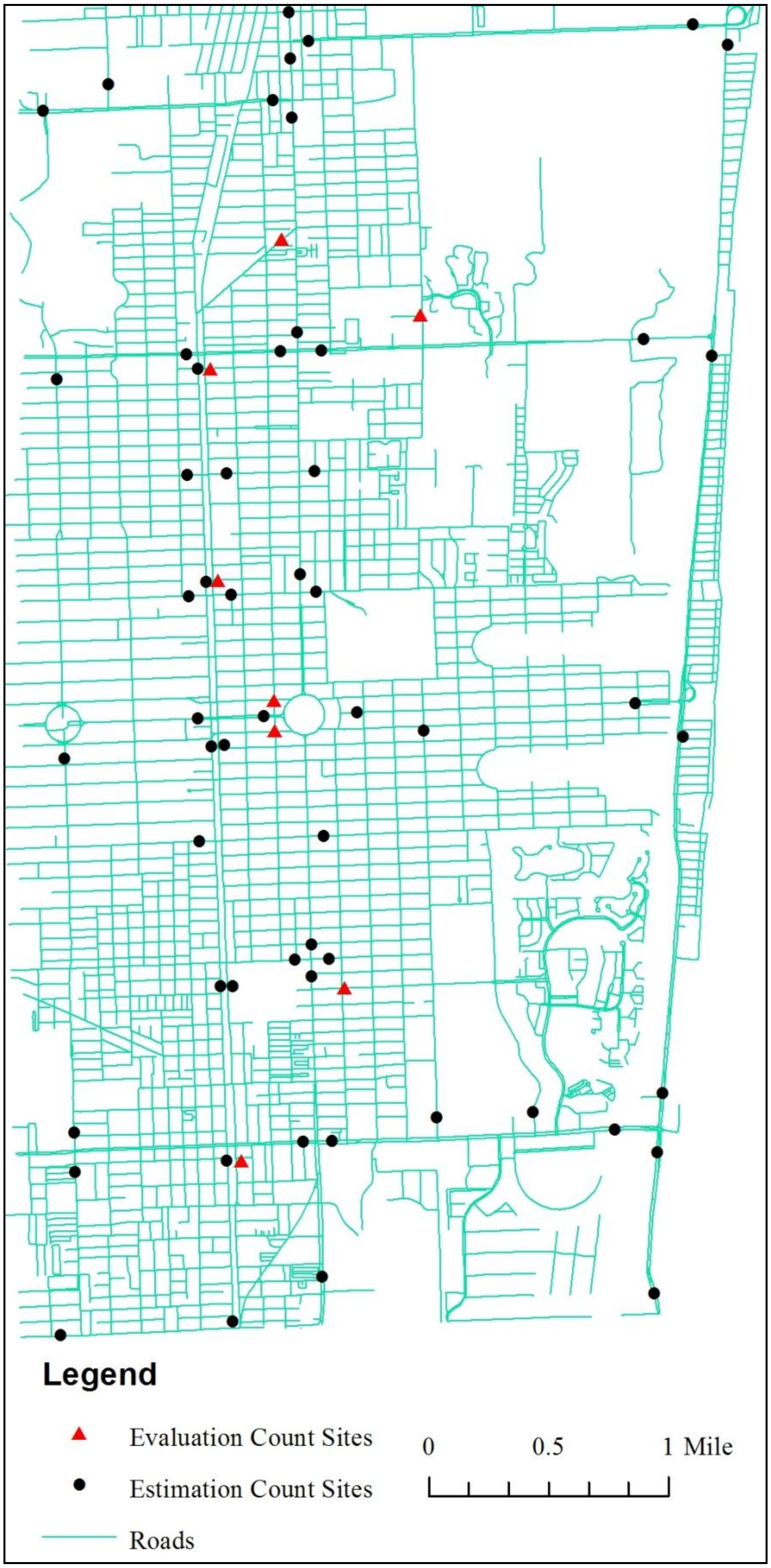


Figure 3-35: Study Area No. 8

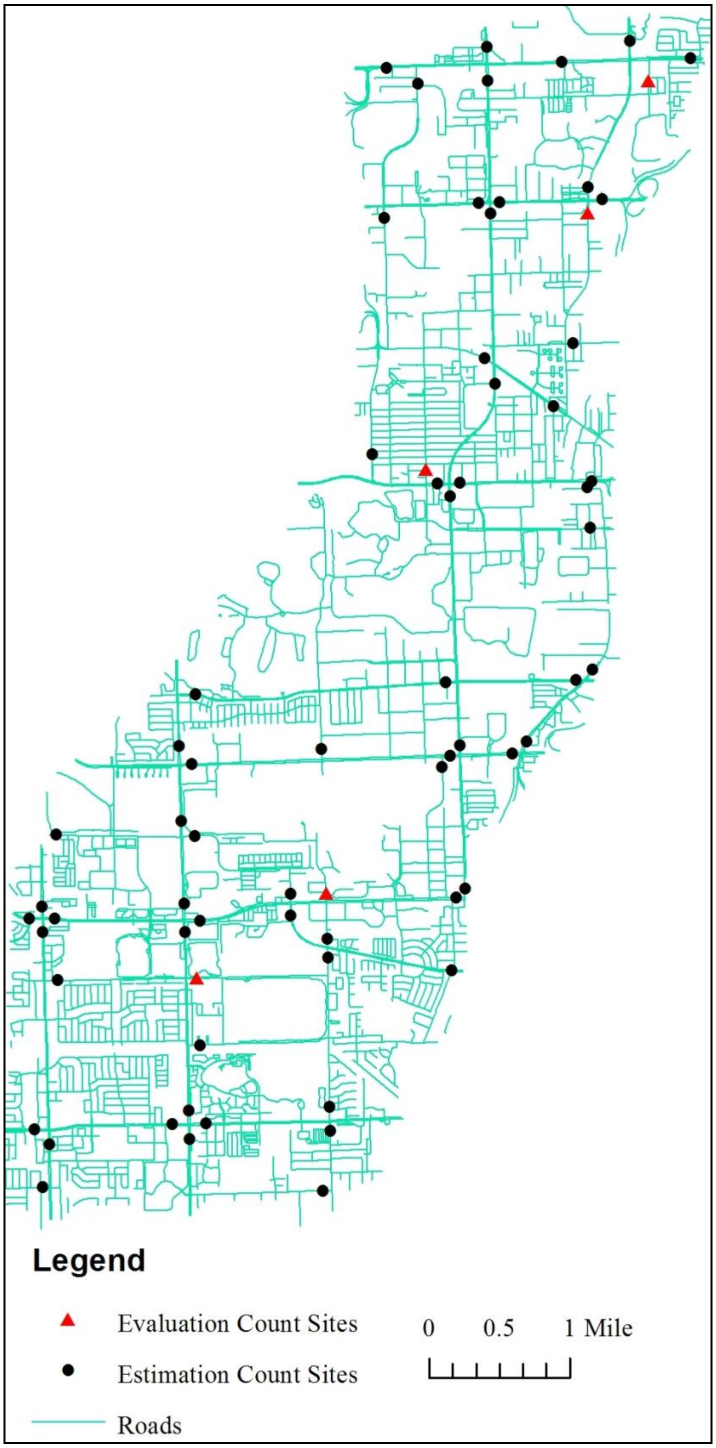


Figure 3-36: Study Area No. 9

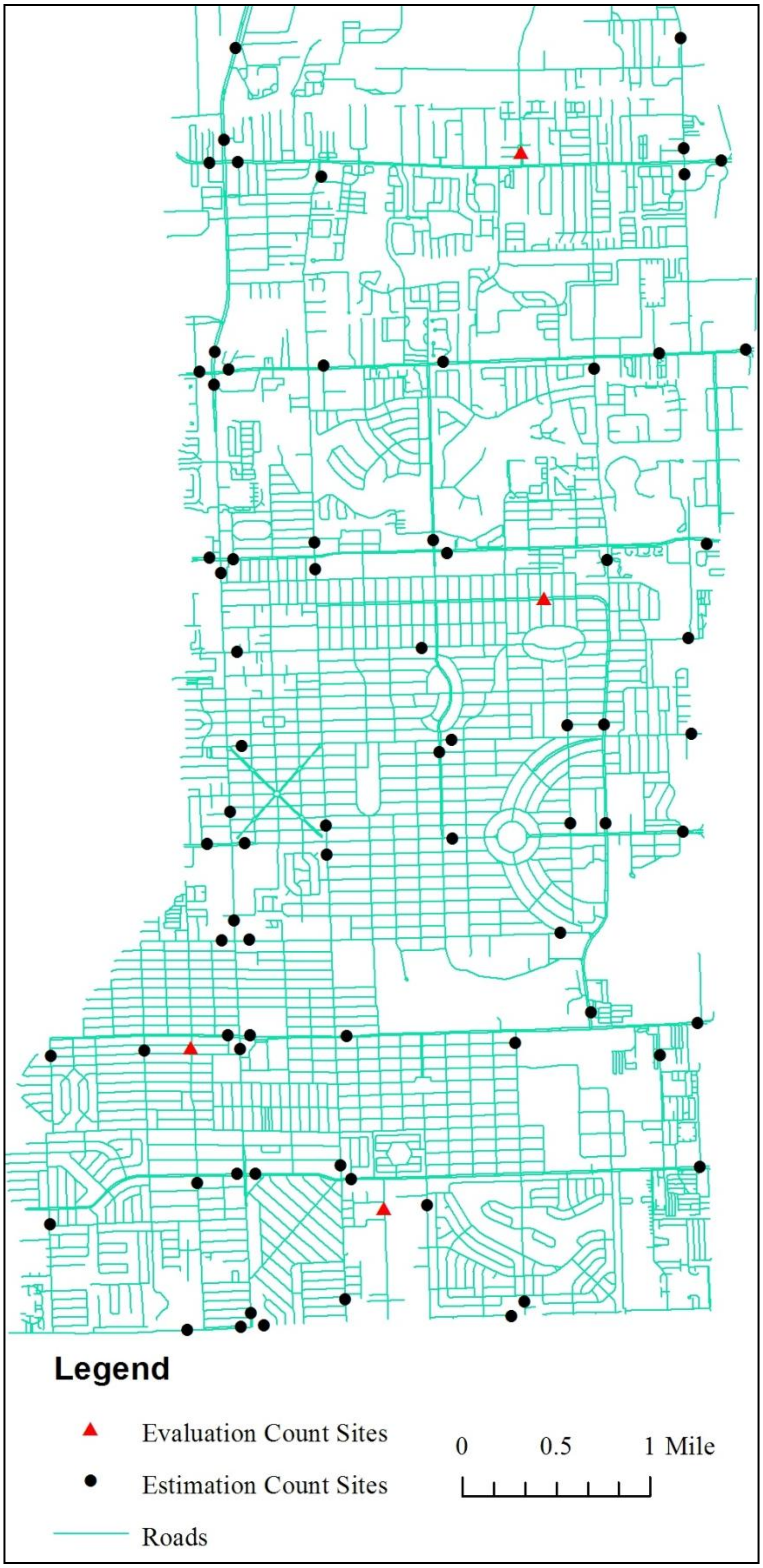


Figure 3-37: Study Area No. 10

3.6.3 Overall Performance Comparison

The AADT values estimated using the three methods were compared. Figures 3-38, 3-39, and 3-40 compare the ground truth AADTs with the results of the USF method, URS method, and the proposed method, respectively. As expected, the AADT values estimated from the three methods are within a reasonable range (i.e., lower than 30,000 vehicles/day) since all the testing locations were on local roads. Figure 3-38 shows that the USF method overestimates AADT for a greater percentage of evaluation count sites. On the contrary, as shown in Figure 3-39, the URS method underestimates AADT for a greater percentage of evaluation count sites. Figure 3-40 shows that the traffic estimations of the proposed method are more representative of the ground truth data. From the figures, it can be stated that the USF method tend to overestimate while the URS method tend to underestimate the AADT values for local roads.

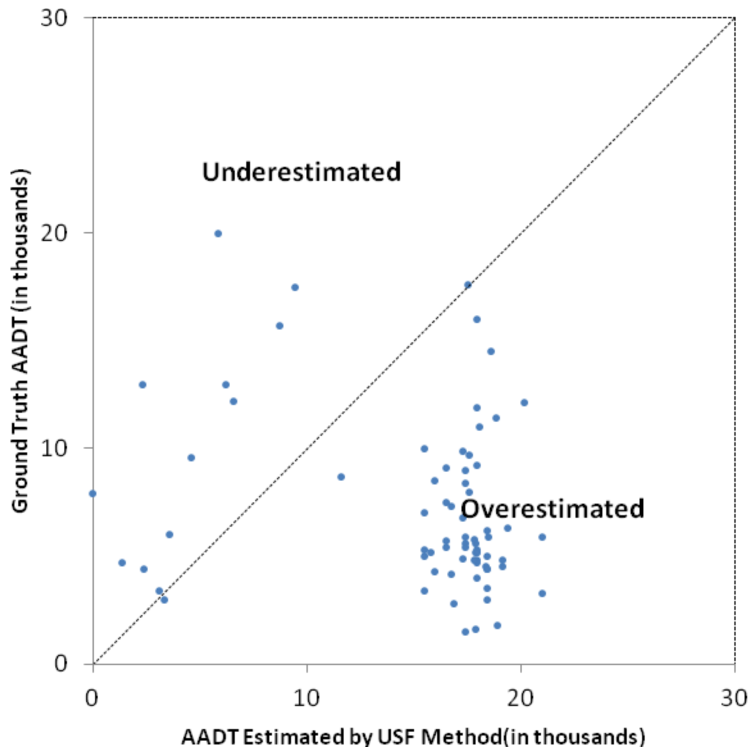


Figure 3-38: Comparison of USF Estimated AADT with Ground Truth AADT

Table 3-13 compares the accuracy of the three estimation methods using the following three error estimates: Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and Mean Absolute Percentage Error (MAPE). Compared to the USF method, both the proposed method and the URS method have consistently lower estimation errors; the proposed method has an 8% lower MAPE estimation error than the URS method. The results indicate that the proposed method has a better overall performance among the three methods.

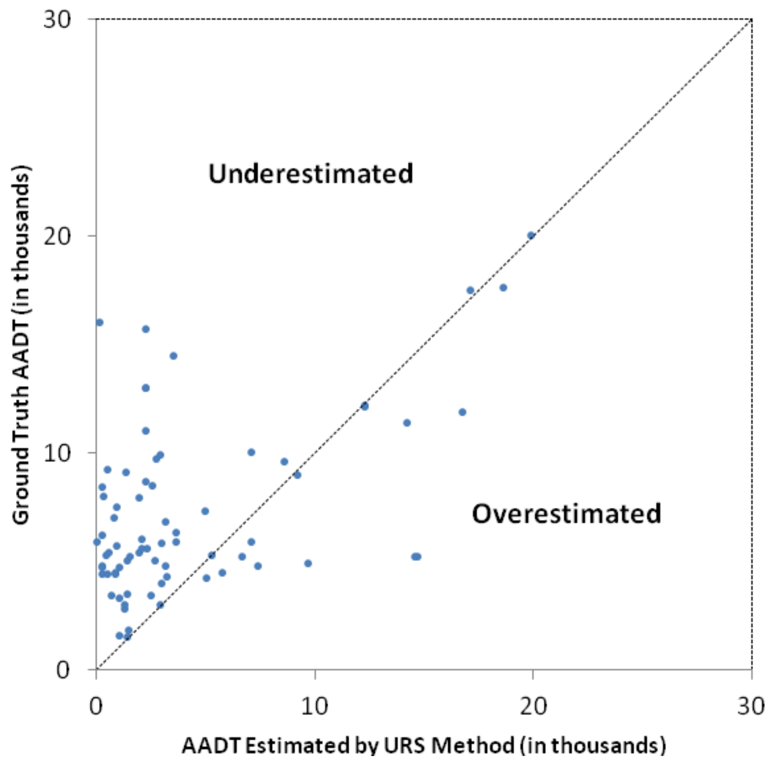


Figure 3-39: Comparison of URS Estimated AADT with Ground Truth AADT

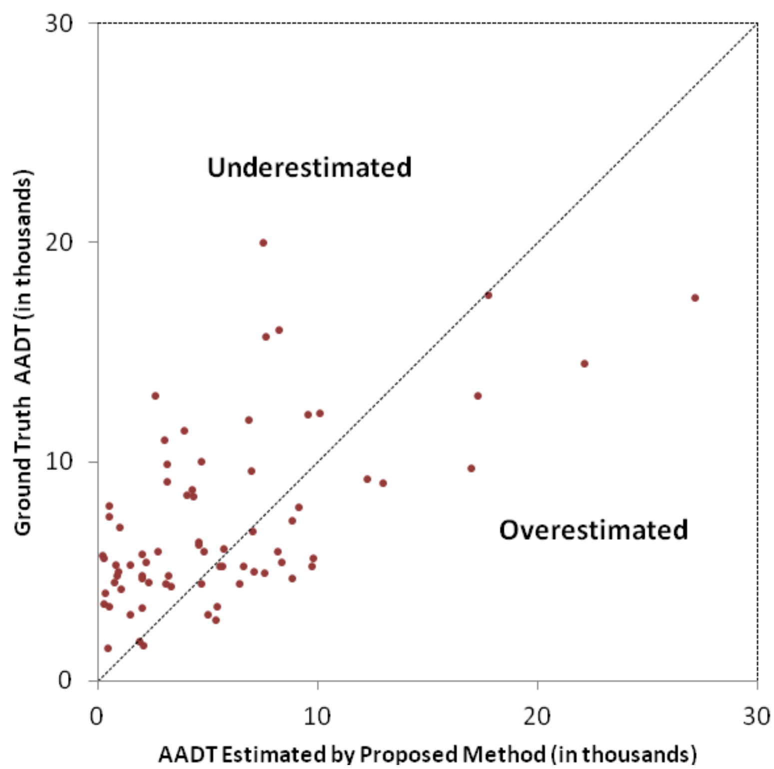


Figure 3-40: Comparison of Proposed Method Estimated with Ground Truth AADT

Table 3-13: Comparison of Estimation Errors

Errors	USF Method	URS Method	Proposed Method
MAE	10,047	4,124	3,642
RMSE	10,891	5,338	4,484
MAPE	211%	60%	52%

However, it is worth noting that there could be errors in the AADT values adjusted from the raw traffic counts and, hence, the ground truth AADT might not be the "actual" AADT value. Therefore, the results might not accurately reflect the actual difference among the three methods. Nevertheless, to some extent, this evaluation will reflect the advantages of the proposed parcel-level travel demand analysis method since the results are compared to the same ground truth data and the random errors have unbiased influence on the three methods.

3.6.4 Reasonableness Check

Depending on the availability of traffic count data, most of the traffic count sites used for this evaluation are located on local roads that are directly connected to the state roads. The lower-level local roads such as the community roads were not used in this evaluation because of the lack of traffic count data. However, the proposed method is expected to perform better even for lower-level local roads as the proposed method's trip generation is based on detailed parcel level data. To verify this assumption, the AADT values estimated using the three methods for the available lower-level local roads were checked and compared. Figure 3-41 gives an example of the comparison. The figure shows the estimation results for the roads in a community of approximately 160 houses.

In Figure 3-41, the AADTs estimated by the proposed method, the USF method, and the URS method are displayed in red, green, and blue, respectively. Since there are no traffic count data available for lower-level community roads, the estimated AADT values are compared based on the number of houses and their layout. The AADT values estimated by the USF method were obviously very high and the estimations from the URS method tend to be low for higher-level community roads. In addition, the USF method unrealistically estimated similar AADT values for all the road segments in this community, and to an extent, the URS method performed better with estimating different AADT values. The proposed method provided most accurate and reasonable estimations that are consistent with the layout of the houses.

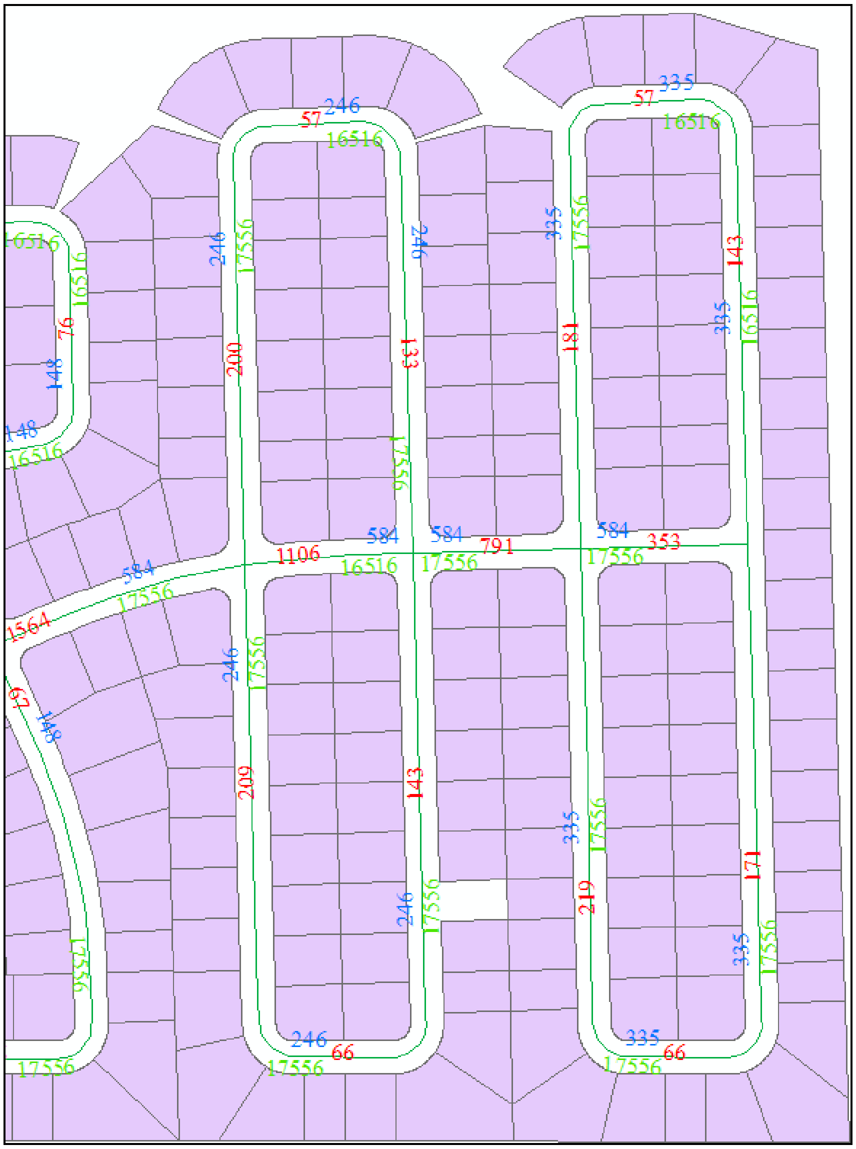


Figure 3-41: Example of AADT Estimation for Roads in a Community

3.7 Summary

AADT is one of the required variables to perform analysis in *SafetyAnalyst*. In Florida, traffic data on local roads is often sporadic. Therefore, AADT on local roads has to be either acquired from local agencies and counties or estimated. This chapter dealt with acquiring AADT data from counties, and developing a better approach to estimate AADT on local roads.

3.7.1 Summary on AADT Data Acquisition

Out of the 67 counties, traffic data were successfully obtained from 42 counties. Twenty-five counties provided AADT, 13 provided ADT, while 3 counties (Broward, Hillsborough, and Indian River) provided both AADT and ADT counts. The data were collected in 4 different formats (some counties provided information in more than one format). Thirty-two counties provided information by PDF, 7 by Excel file, 3 by maps, and 2 counties provided their information in GIS format. The data were requested and obtained from nine different sources:

1. County Development Division
2. County Engineering Department/Division
3. County Highway and Transportation Department
4. County Planning Department
5. County Traffic Operations Department
6. County Transportation Department
7. Metropolitan Planning Organization (MPO)
8. Public Works Department
9. Transportation Planning organization (TPO)

3.7.2 Summary on AADT Estimation Procedure

To estimate AADT values on local roads, a number of existing AADT estimation methods were reviewed, and a parcel-level travel demand model method was proposed. The innovation of this method is that it optimizes the traditional four-step travel demand model method on the parcel level, and the trips between the parcels and the traffic count sites are distributed and assigned to get AADTs for local roads.

The proposed method was evaluated by comparing it with the USF regression method and the URS method at different levels. First, the performance of the three estimation methods was compared for a single study area, and the results indicated that the proposed method performs better. The proposed model was found to give more accurate AADT estimations for the central region of the study area compared to the boundaries. Second, ten study areas were selected from Broward County, Florida to compare the sensitivity of the three methods to the change in the study locations and the area types. The ten study areas were chosen based on the availability of sufficient traffic count data. The standard deviations of the estimation errors for these study areas were compared. Compared to the USF and the URS methods, the results showed that the proposed method provides more reliable and stable results when the location of the study areas and area types are changed. The combined results from the ten study areas also proved that the parcel-level travel demand model method has the best overall performance. Third, the AADT values for lower-level local roads were estimated and it was found that the proposed method performs better for lower-level local roads with no traffic count data. In summary, the evaluation results showed that the parcel-level travel demand method gives more accurate AADT estimations for local roads.

While the evaluation results show the advantage of the parcel-level travel demand model method, it has a few limitations. Firstly, it requires enough traffic count site data to evenly cover the study area. Secondly, due to the fact that the maximum zone number supported by Cube is 32,000, the method cannot cover an area with more than 32,000 parcels and traffic counts. An area as broad as Broward County has to be initially divided into subareas. How to divide the area appropriately and automatically needs further research. Lastly, the process of building the Cube network file from roadway shape file and creating centroid connectors is performed by using Cube instead of programming. If Cube can provide the programming interface to implement this process by programming, it will be more convenient and time saving to run the entire model. Further inquiry and research are required for this functionality.

In spite of the above mentioned limitations, adopting the parcel-level travel demand modeling method to explore the detailed DOR parcel data and the traffic count site data is still an innovate and prospective approach to estimate AADTs for local roads.

CHAPTER 4
UPDATE OF DATA MAPPING AND CONVERSION PROGRAM

This chapter discusses the mapping of crash database and roadway characteristics database to *SafetyAnalyst* format using the *SafetyAnalyst* Data Converter (SADC) developed at the University of South Florida (USF) (Lu et al., 2009). An overview of SADC is given along with the required import files. Modifications to the SADC's mapping procedure are then discussed. Finally, the issues encountered while generating datasets to be imported into *SafetyAnalyst* are discussed.

4.1 Overview of *SafetyAnalyst* Data Converter

SADC is designed to convert FDOT's CAR (Crash Analysis Reporting) and RCI (Roadway Characteristics Inventory) data into the input data format required by *SafetyAnalyst*. The program includes four main parts: the roadway segment data conversion, intersection data conversion, ramp data conversion, and crash data conversion. Figures 4-1 and 4-2 show screenshots of SADC. The conversion of segment, intersection, and ramp data are classified under "Step 1 Convert Inventory/Traffic Data", while crash data conversion is classified under "Step 2 Convert Crash Data".

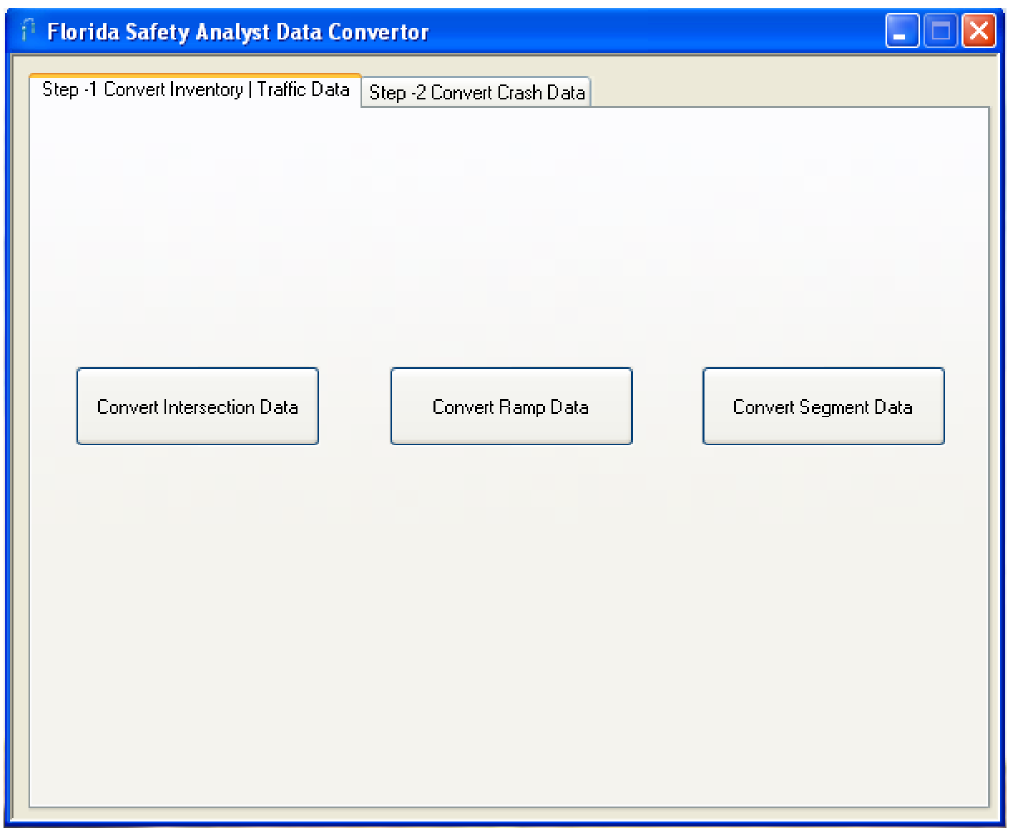


Figure 4-1: *SafetyAnalyst* Data Converter – Step 1 Convert Inventory/Traffic Data (Source: Lu et al., 2009)

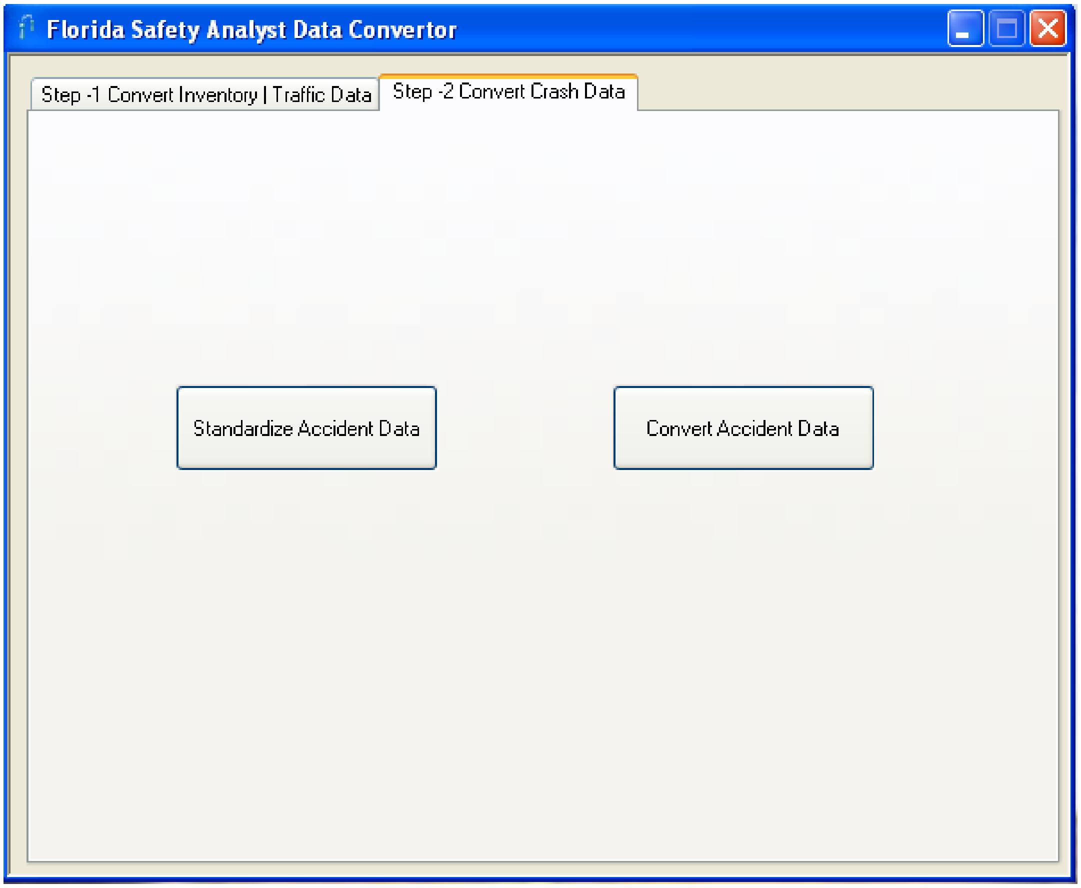


Figure 4-2: *SafetyAnalyst* Data Converter – Step 2 Convert Crash Data (Source: Lu et al., 2009)

The data required for conversion include:

1. CAR.EXTRACT: It represents crash data retrieved from CAR. It includes four separate databases: crash, vehicle, person, and citation.

2. RDWTBL_25.csv: It represents the Intersection Node List database that includes a unique node ID for each intersection along with the roadway ID and intersection mile post.

3. RCI.csv: It is the Roadway Characteristic Inventory database which includes the roadway ID, beginning and end mile posts of each segment, and roadway features of each segment, such as AADT, number of lanes, shoulder width, functional classification, land use, etc.

4. LRS.csv: It is the Linear Referencing System which is similar to the RCI database.

5. FDOT_AADT.csv: It is the Traffic database which contains traffic information, specifically AADT on different roadway segments.

6. CAR_50.csv: It is the first output file from standardizing crash data (as shown in Figure 4-2). This database represents crash data which includes crash variables, such as crash ID, time of the crash, crash severity, etc.

7. CAR_51.csv: CAR_51 is the second output file from standardizing crash data (as shown in Figure 4-2). This database includes records for every vehicle involved in the crash and incorporates variables representing vehicle year, vehicle make, vehicle type, zip code of the registered vehicle, state of registration, etc.

4.1.1 Roadway Inventory Data Conversion

To generate *SafetyAnalyst* input files for segments (altSegment.csv), SADC requires the following files:

- LRS.csv
- RCI.csv
- FDOT_AADT.csv

To generate *SafetyAnalyst* input files for intersections (altIntersection.csv), SADC requires the following files:

- RDWTBL_25.csv
- LRS.csv
- RCI.csv
- FDOT_AADT.csv

To generate *SafetyAnalyst* input files for ramps (altRamp.csv), SADC requires the following files:

- LRS.csv
- FDOT_AADT.csv

4.1.2 Crash Data Conversion

Before converting crash records to the *SafetyAnalyst* format, standardization of crashes has to be done. For standardization, the input file is "CAR.EXTRACT", and the two output files are CAR_50.csv and CAR_51.csv.

To generate *SafetyAnalyst* input files for crash data (altAccident.csv), SADC requires the following files:

- CAR_50.csv
- CAR_51.csv
- altSegment.csv
- altIntersection.csv
- altRamp.csv

The output files from SADC are ready to be imported into the *SafetyAnalyst* Data Management Tool. Detailed description of the data import process in *SafetyAnalyst* can be viewed in Lu et al. (2009).

4.2 Data Mapping

4.2.1 Review of Data Mapping in SafetyAnalyst Data Converter

SafetyAnalyst Data Converter (SADC) was used to generate import files for *SafetyAnalyst*. The criteria used to generate import files for *SafetyAnalyst* were reviewed. The review was conducted by comparing the *SafetyAnalyst* data manual with the CAR and the RCI field manuals. For some of the data variables, a more accurate and representative data mapping was suggested. Table 4-1 lists the changes that were incorporated in SADC's source code.

4.2.2 Issues with Importing Intersection and Ramp Data

From the SADC's output, it was observed that two of the required intersection attributes for *SafetyAnalyst* (area type and traffic control type) were coded as "unknown" (code "99" or "✕"). Similarly, for most of the ramp data, ramp AADT, ramp type, and ramp configuration were either unknown or missing. If any of the required attributes are unavailable, the analysis cannot be run in *SafetyAnalyst*. This is because the required variables are essential to assign intersections and ramps to the predefined site subtypes (e.g., rural three-leg signalized, rural three-leg with minor-road STOP control, etc.) for detailed analysis.

For both intersections and ramps, the area type was mapped using URBSIZE variable in the RCI. For intersections, the main issue lies with the type of traffic control. Based on the available attributes in the RCI, the closest variable for mapping was the prevailing type of signalization (SIPGPREV). Figure 4-3 shows the four possible categories for SIGPREV in the RCI Field Handbook. On the other hand, *SafetyAnalyst* covers detailed and broad categories of traffic control types.

As noted in Table 4-2, the signalized traffic control types in *SafetyAnalyst* could be pre-timed, semi-actuated, or fully actuated. Each of these control types could further be either two- or multi-phase. On the other hand, the signalized control types in the RCI manual classifies the control types as uncoordinated fixed time, actuated, progressive (or coordinated), or real-time traffic adaptive. This classification indicates that the RCI does not differentiate between semi-actuated and fully actuated control, nor does it categorize each control type by number of signal phases. These make it impossible to match the control types using SIGPREV. To address this issue, subtypes were manually assigned to signalized intersections based on number of legs and area type. A more detailed discussion on the classification is given in Chapter 6.

For the unsignalized categories, there is a detailed list in *SafetyAnalyst* (such as no control, stop sign on cross/side street only, stop sign on mainline only, all-way stop sign, yield sign, etc.). On the other hand, the RCI includes only one category to indicate a lack of signal control, which again makes it impossible to map the unsignalized categories in *SafetyAnalyst*. Therefore, due to data unavailability, unsignalized intersections could not be analyzed in *SafetyAnalyst*. To help solve this issue, it is essential to have a detailed inventory of all intersections (both signalized and unsignalized) in Florida. The inventory should ideally include data on traffic control type, number of legs, number of approach lanes, signal timing plan, etc.

Table 4-1: Changes Implemented in SADC's Source Code

Data Attribute	USF Mapping	Proposed Change
Ramp Configuration	The "direct or semi-direct connection" type in *SafetyAnalyst* was matched with "trumpet" in RCI.	The "direct or semi-direct connection" type in *SafetyAnalyst* was matched with the same type in RCI.
Area Type	The variable was not matched.	"Urban" in *SafetyAnalyst* was matched with "small urban", "small urbanized", "large urbanized", and "metropolitan" in RCI. "Rural" in *SafetyAnalyst* was matched with "rural" in RCI.
Lighting Condition	The "dusk" lighting condition in *SafetyAnalyst* was matched with "dawn" in RCI, and vice-versa.	The "dusk" and "dawn" lighting conditions in *SafetyAnalyst* were correctly matched with the exact lighting conditions in CAR.
Weather Condition	The "hail", "snow", "blowing snow", "severe crosswinds", and "blowing sand" weather conditions in *SafetyAnalyst* were not matched with CAR.	The "hail", "snow", "blowing snow", "severe crosswinds", and "blowing sand" weather conditions in *SafetyAnalyst* were matched with "all other" in CAR.
Road Surface Condition	The "snow", "slush", "sand", "mud", and "oil" road surface conditions in *SafetyAnalyst* were not matched with CAR.	The "snow", "slush", "sand", "mud", and "oil" road surface conditions in *SafetyAnalyst* were matched with "all other" in CAR.
Vehicle Maneuver	The "entering traffic lane", "leaving traffic lane", and "other" vehicle maneuvers in *SafetyAnalyst* were not matched with CAR.	The "entering traffic lane" and "leaving traffic lane" vehicle maneuvers in *SafetyAnalyst* were matched with "entering/leaving parking space" in CAR. Also, "other" in *SafetyAnalyst* was matched with "all other" in CAR.
Vehicle Configuration	The "passenger car" vehicle configuration in *SafetyAnalyst* was matched with "van" in CAR. Also, the "bus/large van" configuration was matched with "bus with seats above 15" in CAR.	The "passenger car" vehicle configuration in *SafetyAnalyst* was matched with "automobile" in CAR. Also, "bus/large van" in *SafetyAnalyst* was matched with "van" and "bus with seats above 15" in CAR.
First Harmful Event	The "other" first harmful event in *SafetyAnalyst* was not matched with CAR.	The "other" in *SafetyAnalyst* was matched with "all other" in CAR.

Table 4-2: Traffic Control Categories/Codes in *SafetyAnalyst* and the RCI

SafetyAnalyst		**RCI**	
1	No control	1	Uncoordinated Fixed Time
2	Stop signs on cross street only	2	Traffic Actuated
3	Stop signs on mainline only	3	Progressive
4	All-way stop signs	4	Real-time Traffic Adaptive
5	Two-way flasher (red on cross street)	9	No signal systems exist
6	Two-way flasher (red on mainline)		
7	All-way flasher (red on all)		
8	Yield signs on cross street only		
9	Yield signs on mainline only		
10	Other non-signalized		
11	Signals pre timed (2 phase)		
12	Signals pre timed (multi-phase)		
13	Signals semi-actuated (2 phase)		
14	Signals semi-actuated (multi-phase)		
15	Signals fully actuated (2 phase)		
16	Signals fully actuated (multi-phase)		
17	Other signalized		
18	Roundabout		
99	Unknown		

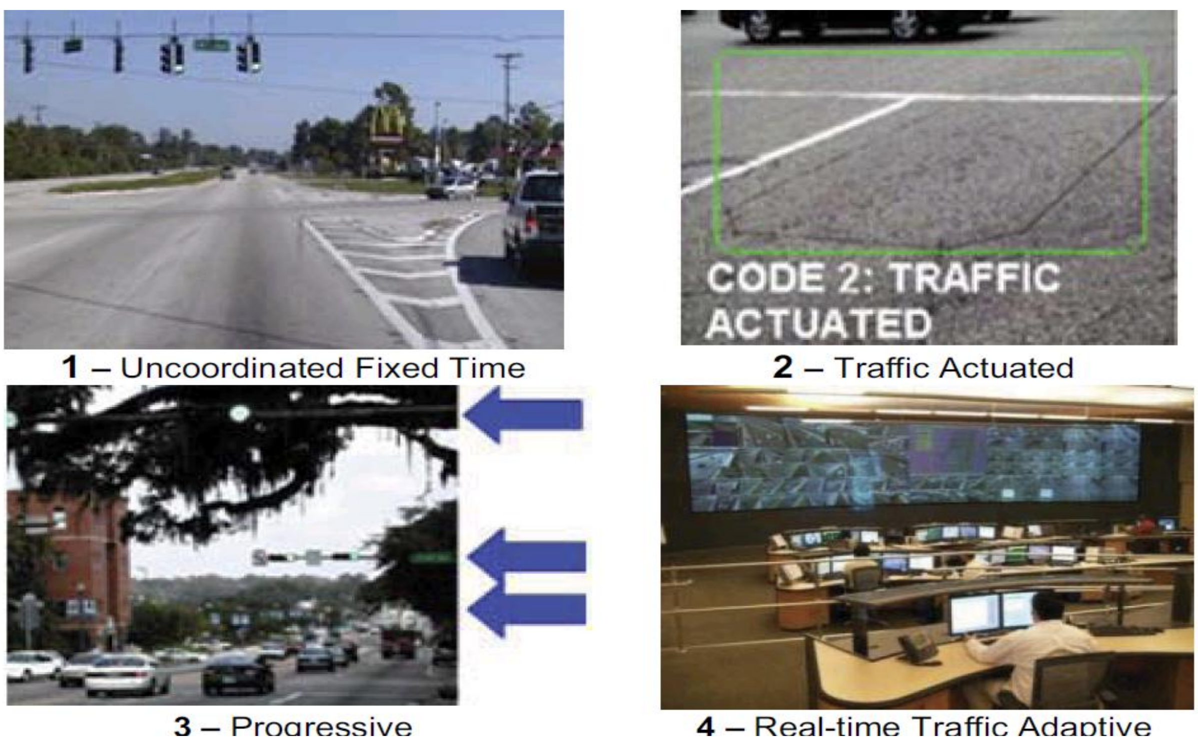


Figure 4-3: Prevailing Type of Signalization in the RCI

Generation of import files for ramps pose a different issue. Area type, ramp configuration, and ramp type are the required variables to categorize ramps into subtypes. However, the default ramp configurations used in *SafetyAnalyst* are different from those used in Florida. Table 4-3 shows the differences between the codes in *SafetyAnalyst* and in the RCI database.

Table 4-3: Ramp Configuration Categories/Codes in *SafetyAnalyst* and the RCI

SafetyAnalyst	RCI
1 - Diamond	01-Diamond
2 - Parclo loop	02-Partial Diamond
3 - Free-flow loop	03-Trumpet
4 - Free-flow outer connection	04-Y Intersection
5 - Direct or semi-direct connection	05-2 Quadrant Cloverleaf or Partial Cloverleaf
6 - C-D road or other connector	06-4 Quadrant Cloverleaf with Collector Road
0 - Other	07-4 Quadrant Cloverleaf
99 - Unknown	08-Direct Connection Design
	09-Other

For the analysis of ramps, the entire ramp database was classified into 18 subtypes, most of which are different from the default subtypes used in *SafetyAnalyst*. The import files for ramps are manually generated to accommodate Florida-specific ramp subtypes. A more detailed discussion on the classification is given in Chapter 6.

4.2.3 Segment Length Issue

Segments are identified as road sections with a given set of homogeneous characteristics. When a large number of data elements vary continuously over a stretch of road, segment length is reduced considerably. This is because segments must have homogeneous characteristics. Shorter segments result in extremely high crash rates, relatively lower crash frequencies, and a very high and unrealistic variance of expected crashes. Therefore, it is recommended to increase the segment length prior to performing any type of data analysis.

Florida collects and maintains information on about 227 variables in its RCI database. Therefore, with this level of detail, segmentation of road network might result in shorter segments as roadways are segmented whenever there is a slight change in any one of the 227 variables. However, not all 227 variables are used to generate import files for *SafetyAnalyst*. Therefore, longer segments could be generated when only the data variables required for generating import files for *SafetyAnalyst* are used in the process of segmentation.

SafetyAnalyst recommends segments to be at least 0.1 miles for unbiased results. The average segment length of segments in the initial import file (based on the SADC’s output) was 0.057 miles. The Data Management Tool in *SafetyAnalyst* provides the user with an option to generate longer homogeneous segments by merging two or more shorter segments. However, this process is limited due to the increased level of detail in the RCI file. Therefore, shorter segments are an issue to be addressed prior to importing data into *SafetyAnalyst*.

As all the 227 variables are not required for network screening, only the required variables are identified and used in the process of segmentation. Dynamic Segmentation (DySeg), an in-house desktop program, was used to generate longer segments. The following is the list of variables that were considered in re-segmenting the road network.

- Roadway ID (ROADWAY)
- Functional Class (FUNCLASS)

- Presence of Interchange Influence Area
- Median Width (MEDWIDTH)
- Number of lanes (NOLANES)
- Access Control Type (RDACCESS)
- Median Type (RDMEDIAN)
- Roadway Type (TYPEROAD)
- Urban Size (URBSIZE)
- Traffic Volume (AADT)

The above discussed process resulted in a database with relatively longer segments. The average segment length has increased from 0.057 miles to 0.83 miles. These longer segments, along with the corresponding traffic and crash data, were then inputted into the SADC.

4.2.4 SADC Source Code Issues

In addition to the changes to the SADC source code discussed in Section 4.2.1, a few more issues were addressed prior to importing data into *SafetyAnalyst*. Due to the complexity of the proposed changes and time constraints, these changes were not fixed in the source code. However, changes were made in the input files itself.

Two of the segment variables in *SafetyAnalyst*, roadway class (roadwayClass1) and route type (routeType) were mapped to the functional class attribute in the RCI (FUNCLASS). Table 4-4 shows the enumeration values of roadway class and route type variables in *SafetyAnalyst*. In *SafetyAnalyst*, the variable “roadwayClass1” has numerical codes, while “routeType” has character codes. It was observed that the output from the SADC for “roadwayClass1” had a few character codes (e.g., “I”, “L”, and “TR”) in addition to the numerical codes. This issue was resolved by manually recoding the character values to numerical ones.

Table 4-4: Levels for Roadway Class1 and Route Type Variables in *SafetyAnalyst*

Roadway Class1	Route Type
1 Principal arterial – interstate	I Interstate
2 Principal arterial – other freeway/expressway	US US route
3 Principal arterial – other	SR State route
4 Minor arterial	BR Business route
5 Major collector	BL Business loop
6 Minor collector	SP Spur route
7 Local	CR County road
0 Other	TR Township road
99 Unknown	L Local road
	O Other
	X Unknown

4.3 Summary and Conclusions

This chapter discussed the steps for mapping CAR and RCI data to the appropriate *SafetyAnalyst* data format using SADC. A few modifications were suggested and incorporated within the SADC source code for a more precise mapping. Once imported into *SafetyAnalyst*, it is anticipated that the entire safety management analysis of the road network (e.g., high crash segment locations, countermeasure selection, and economic appraisal of suggested countermeasures) can be performed.

Import files for segments and signalized intersections, and their corresponding crash and traffic data were generated. Import files for unsignalized intersections were not generated due to missing data on traffic control type. Import files for ramps were generated manually because Florida-specific ramp subtypes were used in the analysis.

An important issue to be considered while importing segment data into *SafetyAnalyst* is to avoid shorter segments. Shorter segments are believed to result in relatively high crash rates, relatively lower crash frequencies, and unrealistic variance of expected crashes. One way to produce longer segments is to consider fewer attributes for segment generation.

CHAPTER 5
DEVELOPMENT OF GIS TOOL FOR *SAFETYANALYST*

SafetyAnalyst does not include a GIS component. It assumes that an agency will adapt its existing GIS system to provide that capability. However, it is unlikely for an agency to have an existing system that is suitable for such implementation. This chapter introduces a new GIS system developed specifically to work with *SafetyAnalyst*. The data flow between the system and *SafetyAnalyst* is first discussed. Specific capabilities of the system are explained in the later sections. Finally, the system interface and the major functions of the Tool are described in detail.

5.1 Introduction

SafetyAnalyst consists of three primary independent tools that interact with a database using a two-tier, client-server architecture, as follows:

- *Administration Tool:* This tool is used to set up and manage the *SafetyAnalyst* deployment. It enables an agency to tailor the *SafetyAnalyst* data model and to modify the federal default Safety Performance Functions (SPFs) used in performing safety analysis.
- *Data Management Tool:* This tool is used to import and prepare an agency's roadway inventory, traffic volume, and crash data for analysis.
- *Analytical Tool:* This tool is used to conduct safety analyses. To ensure data integrity, this client application accesses the agency data in a read-only mode.

The GIS system developed in this project is designed to generate new input files for Analytical Tool and display the results from the network screening module of the same tool. Figure 5-1 illustrates the relationship and the data flow between *SafetyAnalyst* and the GIS system. To serve the two major functions of spatial selection and display, the system includes four major GIS tools:

- a basic GIS toolbox that is used to zoom in, zoom out, pan, and identify the geographic feature or place;
- a selection tool that assists the user in selecting roadway locations by routes, counties, or districts to reduce the input data set to be analyzed in *SafetyAnalyst*;
- a display tool that displays specific roadway locations with potential for safety improvement and labels the major attributes of the *SafetyAnalyst* output; and
- a Google Map tool that overlays the user selected roadway location on Web-based Google Map.

5.2 System Implementation

The implementation of the system requires: (1) a good understanding of the *SafetyAnalyst* input and output file structures; and (2) the development of functions to select site locations for analysis and to display output for the selected locations.

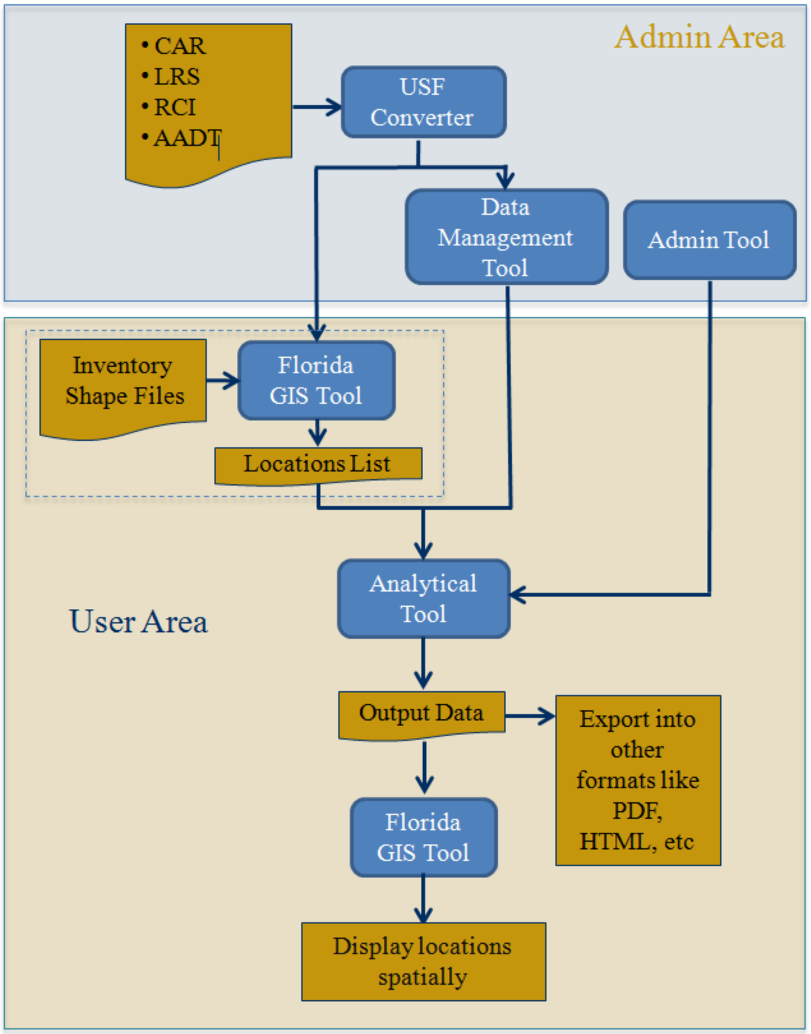


Figure 5-1: Data Flow Between *SafetyAnalyst* and Florida GIS System

5.2.1 SafetyAnalyst Input File Structure

Two types of input data can be exported from the *SafetyAnalyst's* Data Management Tool: XML files (Extensible Markup Language) and CSV (comma-separated value) files. XML files contain crash data, intersection data, ramp data, and roadway segment data in four separate files; CSV files include traffic data files in addition to the four files identified earlier. Figure 5-2 shows the interface of *SafetyAnalyst* Data Management Tool for exporting the calibrated input files.

The XML format is a compact format that eliminates duplicate specification of data and makes it easier to populate from a relational database. It contains tags, elements, and attributes, wherein each element is a data record in a database. The CSV file contains a header specification row that defines the content of the file, and the items in the header row are the attributes of the data elements in the XML files.

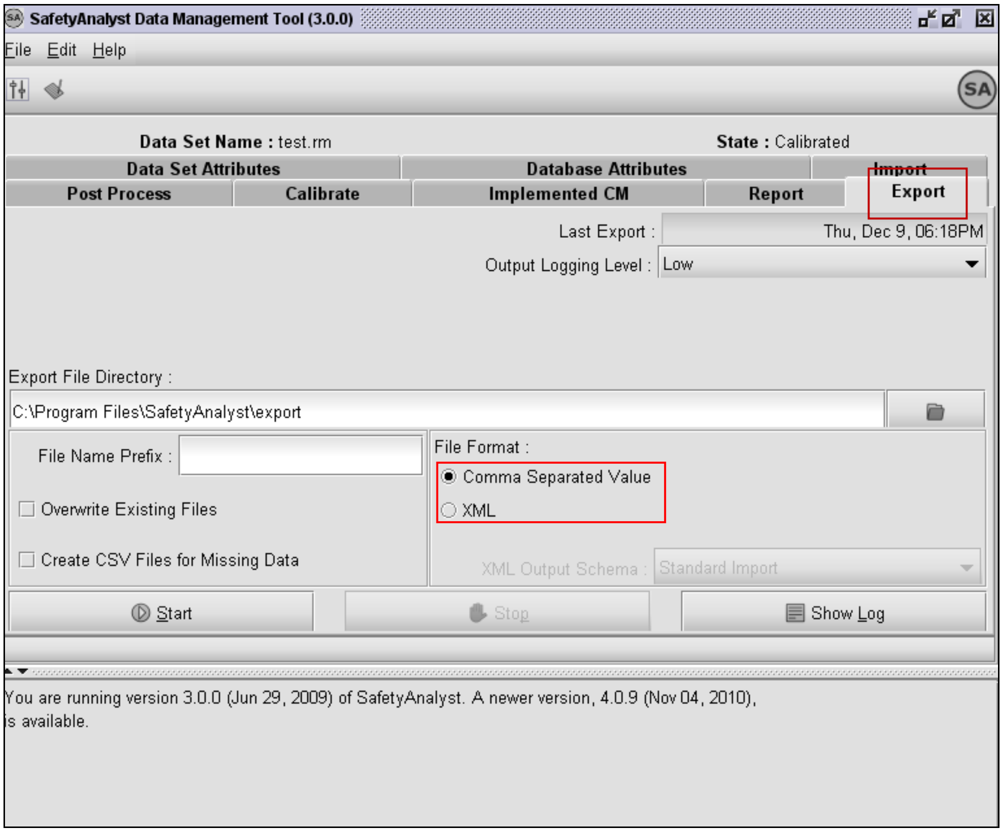


Figure 5-2: Screenshot of *SafetyAnalyst* Data Management Tool: Export Data Files

A file comparison was performed by selecting a data record (record with agency ID = "1516") from both the roadway segment XML and roadway segment CSV files. There are 34 data elements in the roadway segment XML file and 53 data elements in the CSV roadway segment file. The XML files do not export attributes with no data values, thus each data record in the XML file might contain different number of attributes. All the data records in the CSV files, however, contain the same number of attributes. Following is an example of a data record in the roadway segment XML file:

<AltRoadwaySegment agencyID="**1516**" segmentLength="**0.14400000**" terrain="**X**"
roadwayClass1="**3**" medianType1="**0**" medianWidth="**0.00000000**" accessControl="**3**"
growthFactor="**1.03280**" operationWay="**2**" travelDirection="**X**" increasingMilesposts="**EB**"
interchangeInfluence="**N**" discontinuity="**N**" routeName="**00000036**" routeType="**SR**"
county="**80**" jurisdiction="**2**" areaType="**R**" corridor="**52**" locSystem="**A**"
startOffset="**190.416000**" endOffset="**190.560000**" d1numThruLane="**1**"
d1avgLaneWidth="**22.00000000**" d1shoulderTypeOut="**6**" d1shoulderTypeIn="**98**"
d1avgShoulderWidthOut="**2.00000000**" d1bikeway="**99**" d2numThruLane="**1**"
d2avgLaneWidth="**22.00000000**" d2shoulderTypeOut="**6**" d2shoulderTypeIn="**98**"
d2avgShoulderWidthOut="**2.00000000**" d2bikeway="**99**" />

Table 5-1 shows the same data record (record with agency ID = "1516") in the CSV file. Each segment contains roadway name, county, and district number which could be queried within the GIS module.

Table 5-1: Data Elements in Roadway Segment CSV File

AgencyID	LocSystem	RouteType	RouteName	County
1516	A	SR	36	80
AltRoute Names	MajorRoad Name	Segment Length	Driveway Density	Growth Factor
		0.144		1.0328
D2auxLane2	D1auxLane1	D1auxLane2	D1auxLane3	D2auxLane1
Median Width	D1shoulder TypeOut	D1shoulder TypeIn	D2shoulder TypeOut	D2shoulder TypeIn
0	6	98	6	98
District	City	PostedSpeed	OperationWay	GisID
			2	
D1num ThruLane	D2num ThruLane	EndOffset	AgencySite Subtype	Travel Direction
1	1	190.56		X
Jurisdiction	AreaType	Terrain	Roadway Class1	LocSection
2	R	X	3	
StartOffset	D2auxLane3	D1avgLane Width	D2avgLane Width	Median Type1
190.416		22	22	0
D1avgShoulder WidthOut	D1avgShoulder WidthIn	D2avgShoulder WidthOut	Access Control	D2avgShoulder WidthIn
2		2	3	
Increasing Milesposts	D1bikeway	D2bikeway	Interchange Influence	OpenedTo Traffic
EB	99	99	N	
Discontinuity	Corridor	Comment		
N	52			

As the CSV files include attributes with null or missing values for each data records, this file format was chosen for developing the GIS system.

The crash file contains data on all crashes that occurred on roadway segments, intersections, and ramps, with different attributes used to identify and distinguish the individual files. For example, a crash on a roadway segment will contain a data value for the “accidentSegmentID” attribute, but have null or missing values for the “accidentIntersectionID” and “accidentRampID” attributes. However, an intersection crash record will necessarily contain a data value for the “accidentIntersectionID” attribute.

The “accidentSegmentID”, “accidentIntersectionID”, and accidentRampID” are the key attributes to map a data record in the crash file to a record in the inventory files. In roadway inventory files (segment file, intersection file, and ramp file), each record has a unique identifier, “agencyID”, which is used to map the data record in the crash file. Figure 5-3 illustrates the relation between the crash data file and the roadway inventory file.

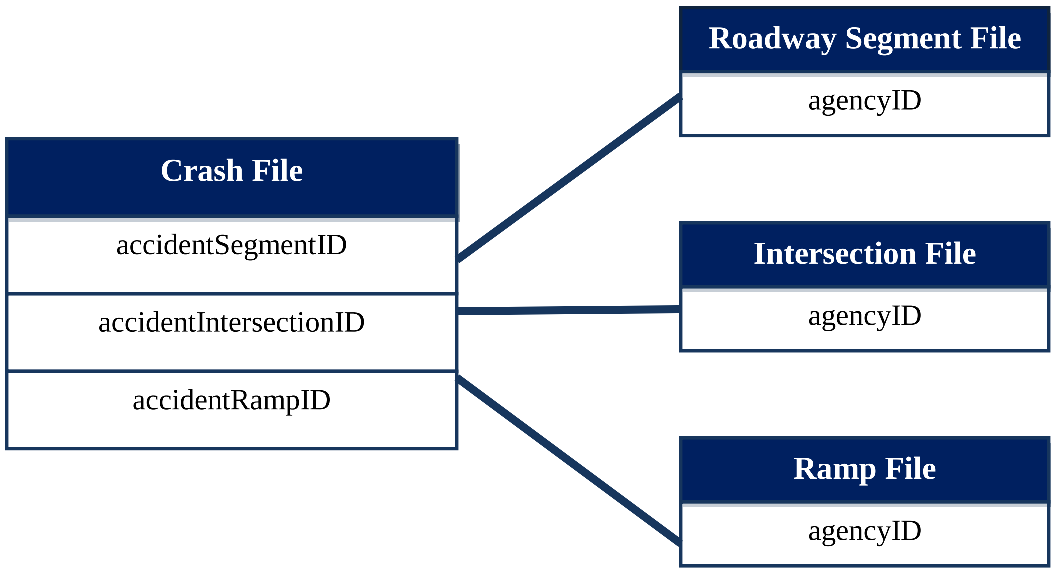


Figure 5-3: Relationship between Input Data Files

5.2.2 Select Locations to Input as SafetyAnalyst Input Files

Based on the attributes of the input files in *SafetyAnalyst*, the GIS system was designed to select locations using the following features: routes, counties, and districts. For single route selection, the system allows the user to input the begin milepost and end milepost of a specific route to narrow down the roadway segment analysis.

Prior to selecting locations using one of the above-mentioned attributes, the GIS system will automatically specify one of the six layers (intersections, freeways, state road, all road, county, and district) as the selectable layer. For example, if the user wants to select locations by state road where many of the roads are in counties, both state roads and nearby counties will be selected. To avoid selection of overlapping features from other layers, the system will set only one layer as selectable layer for each selection method.

The **Select** function allows the user to spatially locate routes. The user can select features by clicking on a feature or by dragging a box around several features.

Based on the selected locations, a screening algorithm is used to create a new input file with just the queried records. For example, while selecting records by counties, the first step of the algorithm is to store the selected county IDs in an array list. Next, for each record of the original input file, the algorithm is developed to check the value of the county attribute. If the value exists within the array list, the third step of the algorithm will create a new file and insert the data as a new record in the file. The new file with the selected locations is the queried data set from the original input file.

5.2.3 SafetyAnalyst Output File Structure

A general safety management process can be described in six main steps:

1. identification of sites with potential for safety improvement,
2. diagnosis of the nature of safety problems at specific sites,
3. selection of countermeasures at specific sites,
4. economic appraisal for sites and countermeasures under consideration,
5. priority rankings of improvement projects, and
6. safety effectiveness evaluation of implemented countermeasures.

SafetyAnalyst comprises of four modules that implement the six main steps for highway safety management process: Network Screening, Diagnosis and Countermeasure Selection, Economic Appraisal and Priority-Ranking, and Countermeasure Evaluation.

The purpose of network screening module is to identify sites that have a higher proportion of specific target crashes than expected and to rank sites based on their potential for safety improvement. The system is designed to display the output data generated by network screening module of *SafetyAnalyst*. Figure 5-4 shows the interface of *SafetyAnalyst* to generate output files of network screening module.

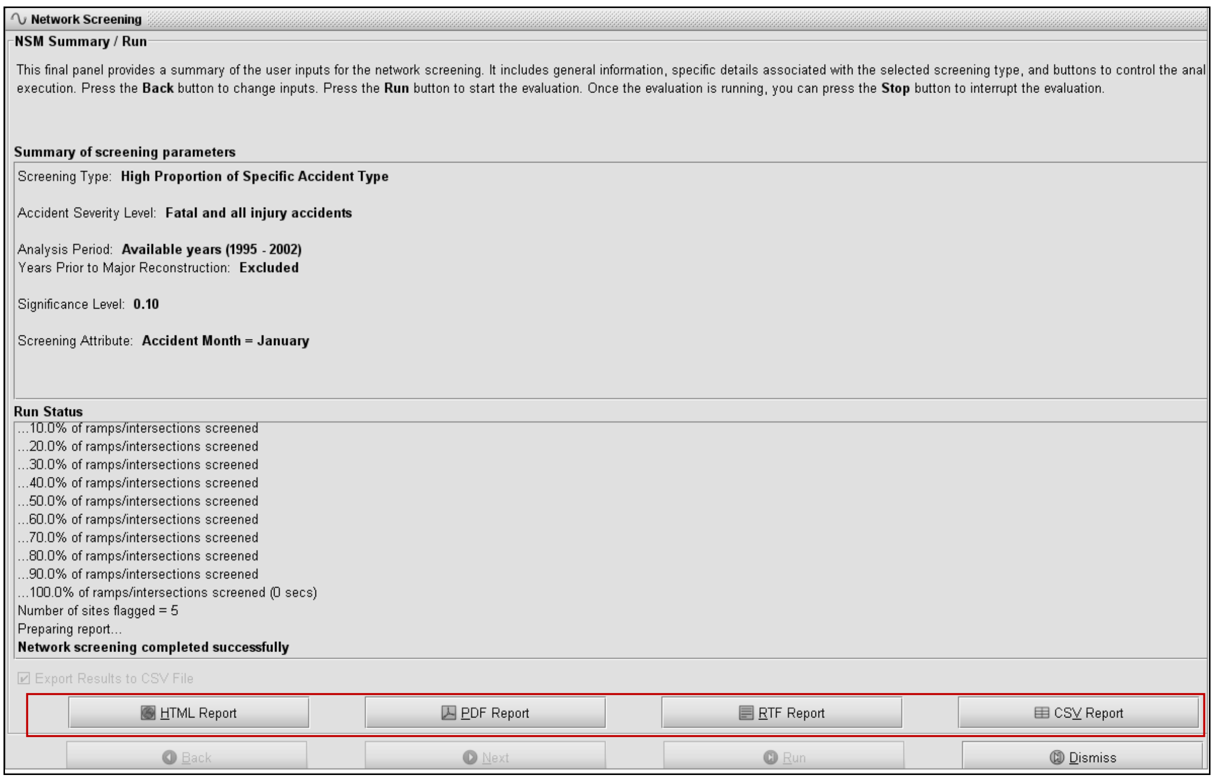


Figure 5-4: Screenshot of Network Screening Module in *SafetyAnalyst*: Export Output Data

The output data file in CSV format includes two tables: High Proportion of Specific Accident Type and Sites Excluded from the Analysis Due to Missing or Incomplete Data. Tables 5-2 and 5-3 show a sample of the two files. The system is developed to spatially locate high crash locations from the *SafetyAnalyst* output file.

Table 5-2: *SafetyAnalyst*: High Proportion of Specific Accident Type Screening Output

ID	Site Type	Site Subtype	County	Route	Site Start Location (mile)	Site End Location (mile)	Average Observed Accidents for Entire Site*	Location with Potential for Safety Improvement						
								Average Observed Accidents*	Predicted Accident Frequency*	Expected Accident Frequency*	Variance **	Start Loc	End Loc	Rank
1	Segment	Seg/Urb; Multilane divided	86	X8647 0000	17.014	17.034	1700	1700	9.62	908.86	483.5	17.014	17.034	1
2	Segment	Seg/Urb; Multilane divided	14	X1409 0000	0	0.015	2800	2800	4.96	858.95	262.44	0	0.015	2
3	Segment	Seg/Urb; Multilane divided	87	X8703 0000	24.635	24.649	2214.29	2214.29	6.4	770.63	266.74	24.635	24.649	3
4	Segment	Seg/Urb; Multilane divided	15	X1515 0000	25.831	25.839	2750	2750	7.34	713.91	183.92	25.831	25.839	4
5	Segment	Seg/Urb; Multilane divided	87	X8703 0000	24.386	24.393	3000	3000	6.4	632.92	132.46	24.386	24.393	5

* expressed as crashes/mile/year for segments and ramps, and as crashes/year for intersections
** expressed as crashes/mile^2/year for segments and ramps, and as crashes/year for intersections

Table 5-3: Sites Excluded from the Analysis Due to Missing or Incomplete Data

ID	Site Type	Site Subtype	County	Route	Site Start Location	Site End Location	Reason For Exclusion
int0100010	Intersection		1	X01010000	13.816	-	Missing or invalid site subtype
int0100199	Intersection		1	X01010000	13.242	-	Missing or invalid site subtype
int0100212	Intersection		1	X01010000	15.21	-	Missing or invalid site subtype
int0100493	Intersection		1	X01040000	1.507	-	Missing or invalid site subtype
int0100519	Intersection		1	X01010101	1.478	-	Missing or invalid site subtype
int0100571	Intersection		1	X01075000	8.259	-	No minor road traffic
int0100575	Intersection		1	X01075000	8.731	-	No minor road traffic
int0100577	Intersection		1	X01075000	10.662	-	No minor road traffic
int0100583	Intersection		1	X01075000	11.544	-	No minor road traffic

5.2.4 Spatially Locate High Crash Locations from SafetyAnalyst Output Files

The system presents an intuitive way to visualize and display the output data of the network screening module. In addition to looking at locations, ranks, and other information in text/table format, the user can see the data in relation to space. Based on the output files from the network screening module, the system provides an interface for the user to define the locations displayed on the map and label the attributes of the defined locations.

It is difficult to locate a route on a paper map as route measures are typically not displayed. Therefore, to display locations on a map, the GIS component must first define the parameters of the relationship between the table storing the locations and the routes that the locations reference. This process could be performed through linear referencing. For example, a crash could be easily located if the milepost or other measured location on the roadway are known.

A route location describes a portion of a route or a single location along a route. When route locations are stored in tables, they are known as route event tables. There are two types of route events: point and line. Point events occur at precise locations along a route. Line events describe a portion of a route. A route event table has at least two fields: a route identifier and one or two measure locations. The route identifier indicates what the route event is located along. The measure location is either one or two values that describe the positions on the route where the event occurs.

To find a location by linear referencing, a route layer containing measure values, also called M-values, must be created. There are two units of measure: milepost distance from a set location and distance from a reference marker. Highway milepost measurement system is most commonly used by Departments of Transportation (DOTs) for recording crash locations and other incidents along highways.

The following are the four primary steps to map high crash locations from the *SafetyAnalyst* output:

1. create routes from existing route layers,
2. calibrate individual route features,
3. set measures on an entire route or a portion of a route, and
4. locate the route by begin and end milepost.

While displaying the locations on the map, three attributes of the sites are labeled: site sub type, expected crash frequency, and rank.

5.3 GIS Interface and Major Functions

The GIS system includes a suite of integrated functions that allow the user to perform GIS tasks including mapping, selection, and visualization.

A map is the most common view for the user to work with geographic information. The GIS system represents geographic information as a collection of layers and other elements in a map view. There are two primary map display panels in this system: the data frame and the layout view. The data frame provides a geographic "window", or map frame, in which geographic information is displayed as a series of map layers. The layout view displays the arrangement of map elements and their overall design on a page layout.

Figure 5-5 shows the main screen of the GIS interface design and data layers. Three panels are arranged on the left. The first panel is the map's table of contents, which helps to manage the display order and symbols' properties of each map layer. The table of contents lists all the layers on the map and shows the list of features in each layer. Next to each layer, a check box indicates whether its display is currently turned on or off. The order of layers within the table of contents specifies their drawing order in the data frame. The panel in the middle is an input window for roadway selection. The third panel is an overview window which navigates the selections on the map.

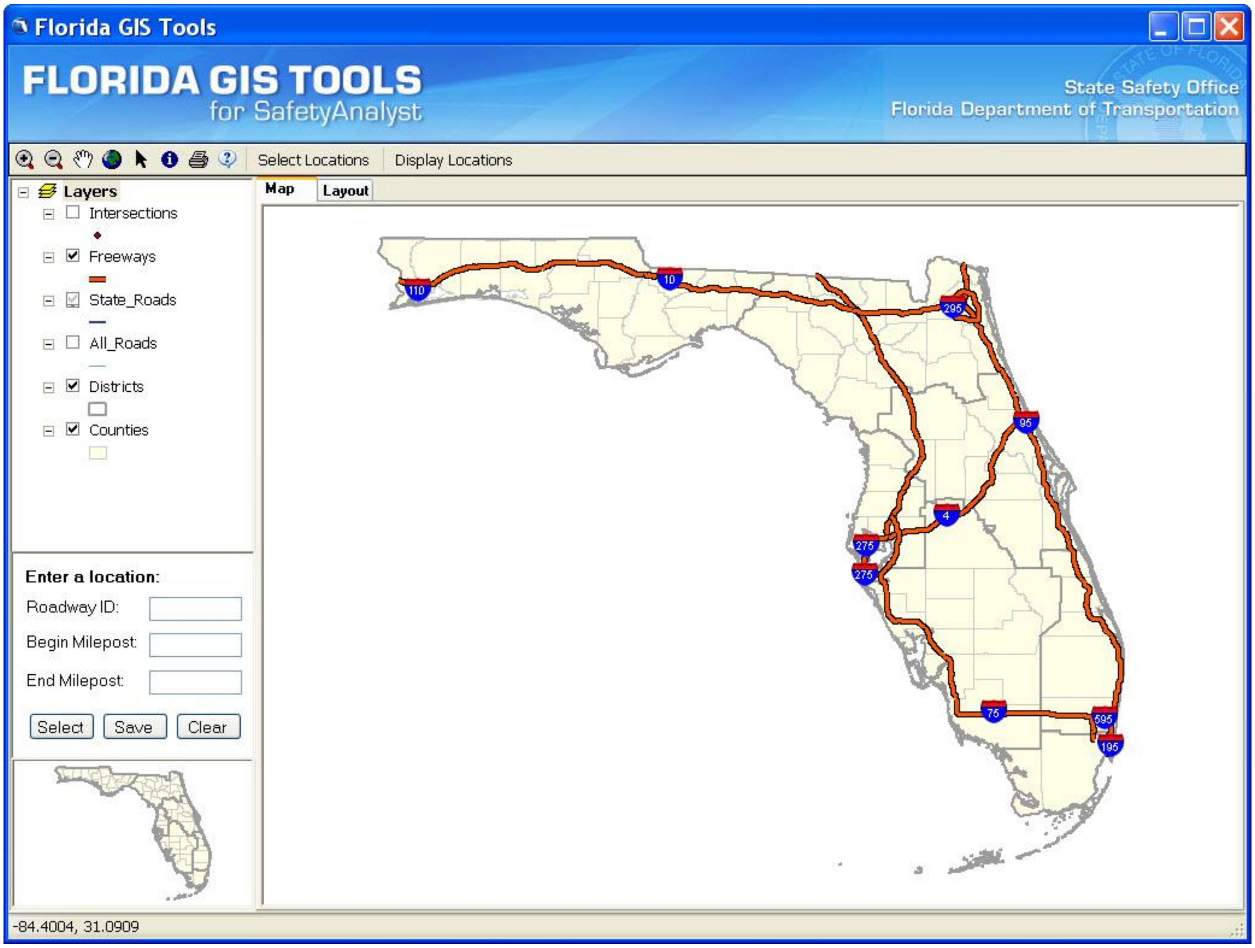


Figure 5-5: Main Screen of the GIS Interface

<u>*5.3.1 Basic GIS Tools*</u>

The GIS interface includes a number of basic GIS tools that are used to interact with the map and its elements. Figure 5-6 shows the organization of these tools.

Figure 5-6: Basic GIS Tools

-  Zoom In: Zoom in to a geographic window by clicking a point or dragging a box
-  Zoom Out: Zoom out from a geographic window by clicking a point or dragging a box
-  Pan: Pan the data frame
-  Full Extent: Zoom to the full extent of the map
-  Select Elements: Select, resize, and, move text, graphics, and other objects placed on the map
-  Identify: Identify the geographic feature

- Print: Print the current map layout
- Help: Get help for the application

5.3.2 Functions for Selecting Locations

The system provides a variety of methods for the user to graphically select roadway locations on the map. The selection process involves the following four steps:

1. load *SafetyAnalyst* input file,
2. choose the selection method from selecting locations by route, county, or district,
3. select locations, and
4. save selected locations to a new *SafetyAnalyst* input file.

In this function, the user can select an individual graphic by clicking it, or select multiple records by dragging a rectangle around the graphics. To add graphics to, or remove them from the current selection, the user can hold down the Shift key while selecting. Figure 5-7 shows an example of selecting locations by county.

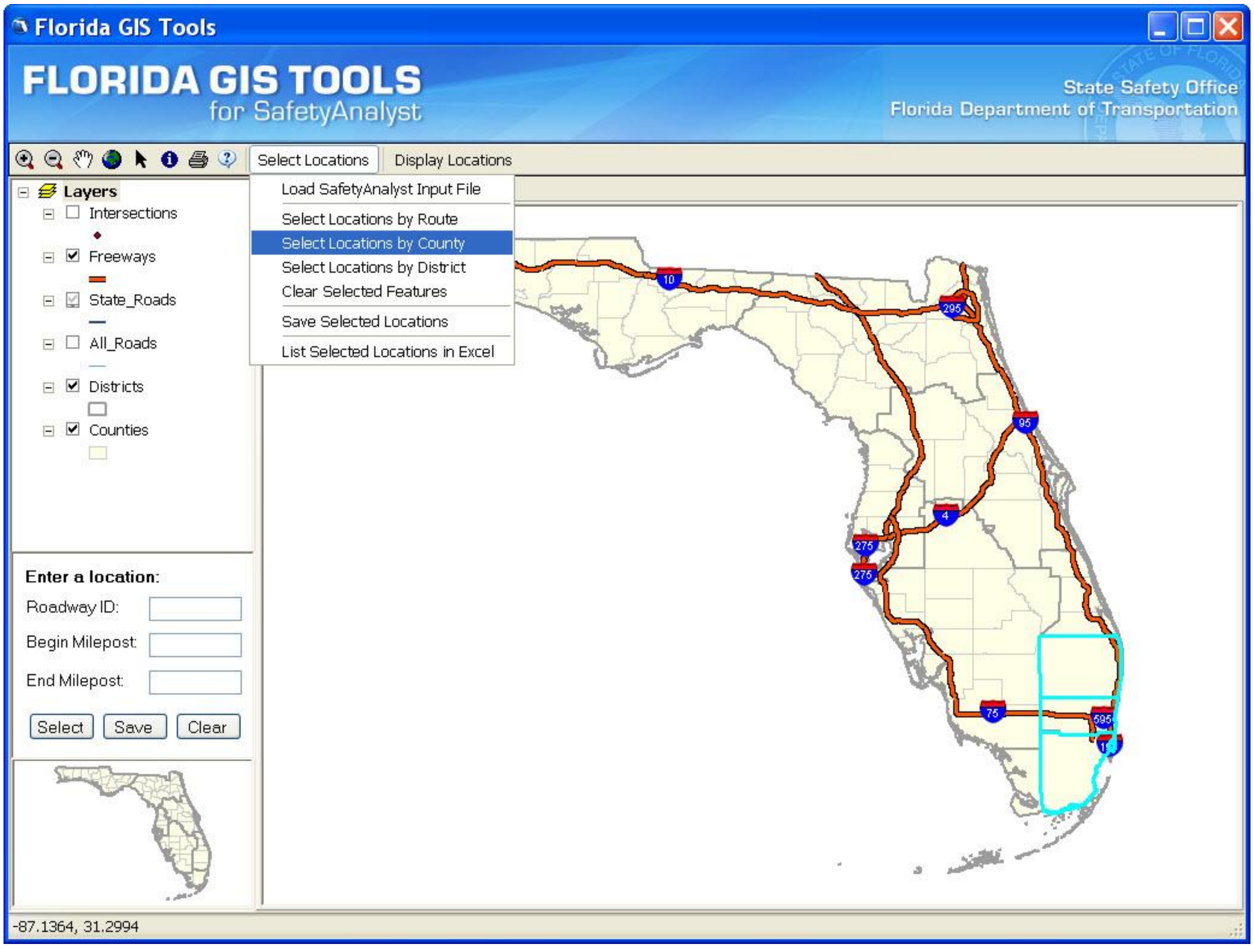


Figure 5-7: Select Locations by County

The state road layer has a scale range set that prevents the layer from displaying at certain scales (1:100,000). Before selecting locations by route, the user can zoom in to make this layer visible. Figure 5-8 gives an example of selecting locations by route.

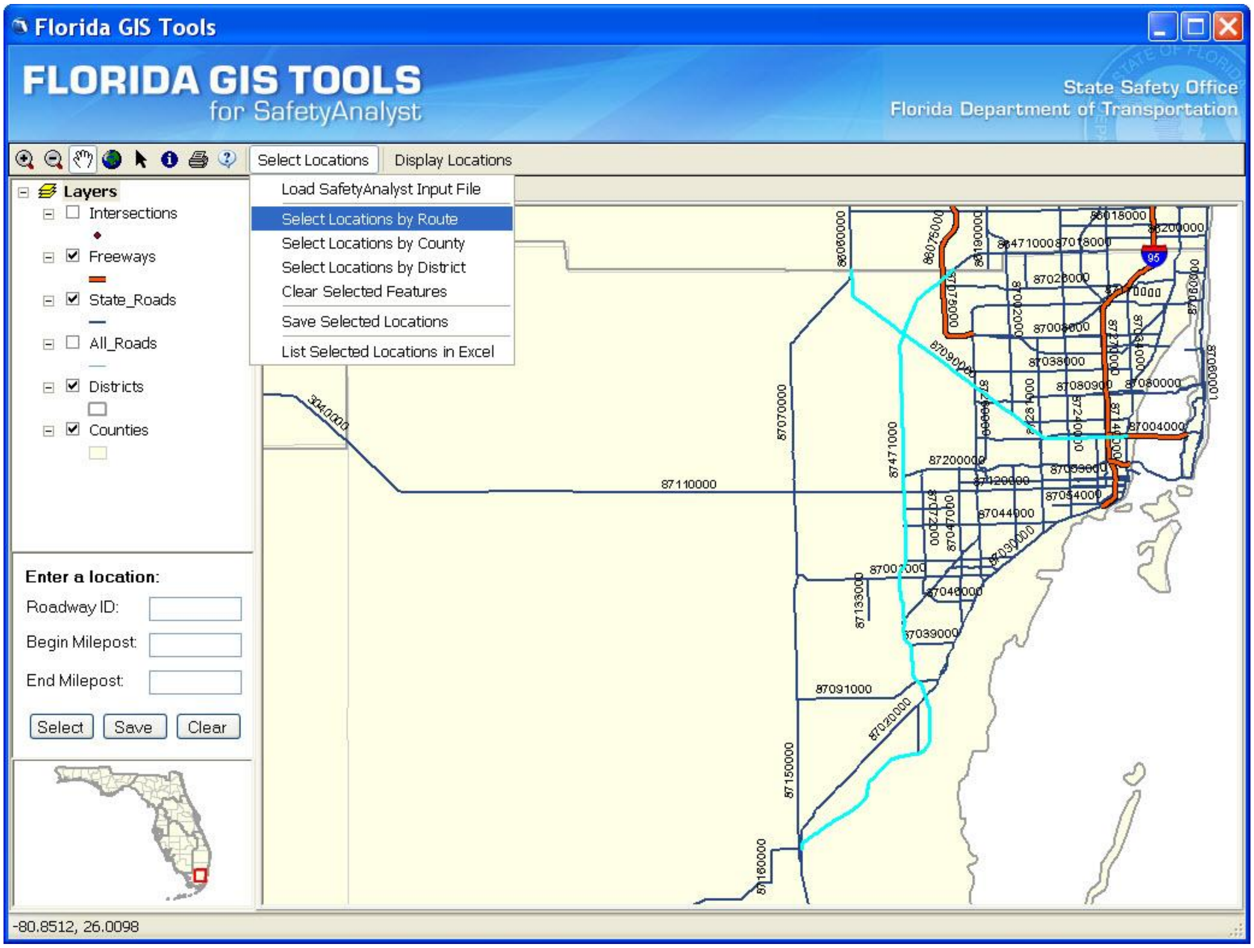


Figure 5-8: Select Locations by Route

The system also allows the user to select a segment on a specific road by specifying the begin milepost and end milepost. The three steps for selecting a segment are:

1. select a road on the map,
2. change the value of begin milepost and end milepost, and
3. click the **Select** button.

Alternatively, if the user is familiar with roadway numbers, they can:

- enter the roadway ID, begin milepost, and end milepost, and
- click the **Select** button.

After clicking the **Select** button, the map automatically zooms to the selected location. Figure 5-9 shows the procedure to select a location by entering route information.

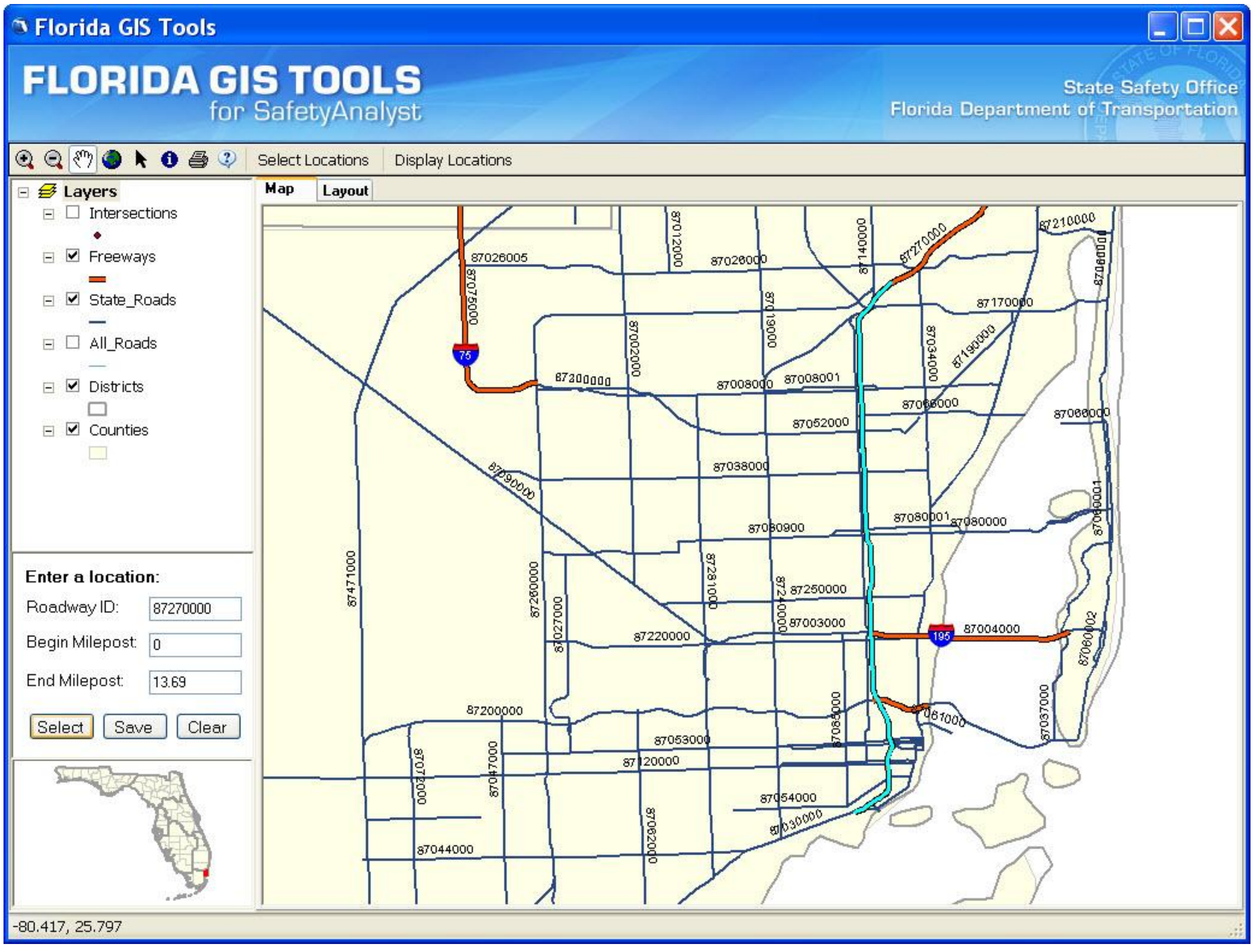


Figure 5-9: Select a Location by Entering Information

<u>*5.3.3 Functions for Displaying Locations*</u>

Another major function of the system is to display high crash locations from the *SafetyAnalyst* output files. The three steps to perform this function are:

1. load *SafetyAnalyst* output file;
2. define high crash locations by percentage or by numbers, and choose whether to display the rank, site subtype, or expected crash frequency with locations; and
3. list high crash locations in Excel file.

The system provides an interface for the user to define high crash locations by either percentage or by numbers. Moreover, the interface allows the user to select the attribute (from site subtype, rank, and expected crash frequency) to display with the locations. Figure 5-10 shows the screen for making these selections. Figure 5-11 shows a sample display of the top 100 high crash locations with their corresponding ranks.

Figure 5-10: Display Option Dialogue Box

Figure 5-11: Display High Crash Locations with Ranks

5.3.4 Functions for Overlaying Locations on Google Map

After displaying locations on the map, the system can overlay satellite data from Google Map to help the user get a spatial reference. In this function, the user can select a displayed location by double clicking it to display a Google satellite map of the selected location.

5.4 Summary

SafetyAnalyst provides only the data interface needed to exchange GIS data. Given the spatial nature of crash analysis, a GIS component would be an asset to Florida's application of *SafetyAnalyst*. Therefore, there is a need to design and develop a system to allow the user to graphically select locations and to display results from *SafetyAnalyst*.

To work with *SafetyAnalyst*, two major functions are served in the GIS system:

1. Provide an alternate method for selecting locations for analysis by *SafetyAnalyst* using a graphical display and to create new input file from graphical selections.
2. Provide a graphical display of the output from network screening module of *SafetyAnalyst*.

This GIS application comprises of three major GIS tools to implement the above identified two functions:

1. A basic GIS toolbox: Zoom In, Zoom Out, Pan, and Identify the geographic feature on which the user clicks;
2. A selection tool: assist the user in selecting roadway locations by routes, counties, or districts spatially;
3. A display tool: display specific roadway locations with potential for safety improvement and label the major attributes of the *SafetyAnalyst* output file on the map;

In summary, the system presents an intuitive way to visualize both the input data and output data of *SafetyAnalyst*. With this application, the user will be able to perceive data in relation to space.

CHAPTER 6
IDENTIFICATION OF HIGH CRASH LOCATIONS USING *SAFETYANALYST*

SafetyAnalyst was used to perform network screening to rank high crash locations (HCLs) using Florida-specific SPFs. This chapter explains the process used to generate the list of HCLs. Statewide and district-wide lists of HCLs for each of the 17 segment subtypes from *SafetyAnalyst* are presented. Statewide lists of HCLs for ramps and signalized intersections are also included. Finally, the error logs in *SafetyAnalyst* are discussed.

6.1 Identify High Crash Locations

SafetyAnalyst was used to perform network screening (i.e., identify and prioritize locations with greatest potential for safety improvement). *SafetyAnalyst* Data Converter (SADC) was used to generate segment, crash, and traffic import files for *SafetyAnalyst*. Import files for signalized intersections and ramps were generated manually. The GIS system described in Chapter 5 was used to spatially locate high crash locations identified by *SafetyAnalyst*. Table 6-1 gives the descriptions of the various columns in the output from the network screening module of *SafetyAnalyst*.

Table 6-1: Columns in the Output from the *SafetyAnalyst*'s Network Screening Module

<table>
<tr><th colspan="2">Column in SafetyAnalyst</th><th>Description</th></tr>
<tr><td colspan="2">ID</td><td>Roadway Segment/Intersection/Ramp ID</td></tr>
<tr><td colspan="2">Site Type</td><td>Whether Segment/Intersection/Ramp</td></tr>
<tr><td colspan="2">Site Subtype</td><td>Sub-categories in the site type</td></tr>
<tr><td colspan="2">County</td><td>County where the roadway segment is located</td></tr>
<tr><td colspan="2">Route</td><td>Route number of the roadway segment</td></tr>
<tr><td colspan="2">Site Start Location</td><td>Start location of the roadway segment</td></tr>
<tr><td colspan="2">Site End Location</td><td>End location of the roadway segment</td></tr>
<tr><td colspan="2">Average Observed Accidents for Entire Site*</td><td>Observed crashes for the entire site</td></tr>
<tr><td rowspan="8">Location with Highest PSI</td><td>Average Observed Accidents*</td><td>Observed crashes for the roadway sub segment</td></tr>
<tr><td>Predicted Accident Frequency*</td><td>Predicted crash frequency</td></tr>
<tr><td>Expected Accident Frequency*</td><td>PSI Expected crash frequency</td></tr>
<tr><td>Variance**</td><td>Variance</td></tr>
<tr><td>Start Location</td><td>Start location of the roadway sub segment where PSI is greater</td></tr>
<tr><td>End Location</td><td>End location of the roadway sub segment where PSI is greater</td></tr>
<tr><td>No. of Expected Fatalities</td><td>Total number of expected fatalities per mile per year</td></tr>
<tr><td>No. of Expected Injuries</td><td>Total number of expected injuries per mile per year</td></tr>
<tr><td colspan="2">Rank</td><td>Overall Rank based on PSI</td></tr>
<tr><td colspan="2">Additional Windows of Interest</td><td>Additional windows whose PSI exceeded the threshold limits, but the expected crash frequencies are between the limiting crash threshold and the highest calculated PSI for the site</td></tr>
</table>

* expressed as crashes/mile/year for segments and ramps, and as crashes/year for intersections
** expressed as crashes/mile^2/year for segments and ramps, and as crashes/year for intersections

6.1.1 Segments

As listed in Table 6-2, *SafetyAnalyst* reclassifies segments into 17 site subtypes prior to performing any type of analysis. This helps in accurately assessing the safety performance of segments as the safety performance depends on roadway characteristics, such as area type, functional classification, number of lanes, etc.

RCI data for 2009 was used to generate import files for segments. Crash data and traffic data from the years 2007-2010 were used to perform the analysis. The following steps were performed to obtain the list of high crash locations:

- Input the required data files into SADC to generate import files for *SafetyAnalyst*.
- Address a few issues with the generated import files.
- Replace the default SPFs in *SafetyAnalyst* Administration Tool with Florida-specific SPFs.
- Import, post-process, and calibrate the data files in *SafetyAnalyst* Data Management Tool.
- Open network screening module in *SafetyAnalyst* Analytical Tool and create site lists by districts.
- Perform EB analysis within the network screening module.
- Spatially locate the list of high crash locations using the GIS system.

Table 6-2: Classification of Segments in *SafetyAnalyst*

Site Subtype	**Code**
Rural two-lane roads	101
Rural multilane undivided roads	102
Rural multilane divided roads	103
Rural freeways--4 lanes	104
Rural freeways--6+ lanes	105
Rural freeways within interchange area - 4 lanes	106
Rural freeways within interchange area - 6+ lanes	107
Urban two-lane arterial streets	151
Urban multilane undivided arterial streets	152
Urban multilane divided arterial streets	153
Urban one-way arterial streets	154
Urban freeways - 4 lanes	155
Urban freeways - 6 lanes	156
Urban freeways - 8+ lanes	157
Urban freeways within interchange area - 4 lanes	158
Urban freeways within interchange area - 6 lanes	159
Urban freeways within interchange area - 8+lanes	160

Basic network screening was performed on the entire state's data and on each district separately. The analysis was performed on segments with data-set specific distributions and Florida-specific SPFs.

The following are the additional parameters considered in the analysis:

- Type of analysis: Basic Network Screening
- Roadway Segments: Peak Searching
- Accident Severity Level: Total Accidents
- Site Types: Segments
- Screening Attribute: Accident Type and Manner of Collision
- Potential for Safety Improvement Using: Excess Accident Frequency
- Analysis Period: From 2007 To 2010
- CV limit: 0.5 (for roadway segments)
- Area Weights (Rural): 1.0
  Area Weights (Urban): 1.0
- Limiting Value: 1.0 crash/mi/yr (for roadway segments)

Tables 6-3 through 6-17 give the list of HCLs by site subtype. For each subtype, the top 20 sites were identified using statewide data, and top 10 sites were identified in each district. It is to be noted that some districts might not have 10 HCLs. Also, no HCLs were identified for Urban Multilane Undivided Arterial Streets and Rural Multilane Undivided Roads. This is because locations should experience a minimum of 1 crash/mile/year to be listed as an HCL. Note that the following tables display only relevant columns from the output.

Table 6-3: List of High Crash Locations on Rural Two Lane Roads (Site Subtype 101)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
all-state												
14	X14090000	12.57	14.16	14.93	91.57	8.54	48.83	43.16	12.67	12.77	1	
14	X14010000	7.17	7.47	22.68	59.27	4.31	26.2	11.81	7.27	7.37	2	
87	X87150000	13.7	14.15	17.52	59.82	4.62	24.34	13.39	13.8	13.9	3	
87	X87150000	9.93	10.08	37.94	46.07	4.74	18.51	13.22	9.93	10.03	4	9.98 - 10.08
87	X87150000	10.2	10.59	15.29	46.07	4.74	18.51	13.22	10.3	10.4	5	
79	X79120000	2.06	2.36	15.36	41.58	4.4	15.15	11.35	2.26	2.36	6	
55	X55070000	16.21	16.82	12.14	52.91	1.88	14.89	2.67	16.31	16.41	7	
10	X10210000	4.94	5.22	21.18	42.27	2.92	13.88	5.43	5.04	5.14	8	5.12 - 5.22
12	X12070000	9.19	9.5	9.65	29.9	3.9	12.37	8.6	9.29	9.39	9	
91	X91070000	18.44	18.76	10.31	31.98	7.5	11.39	29.65	18.54	18.64	10	
60	X60010000	2.64	2.75	40.26	44.28	1.63	11.27	1.96	2.64	2.74	11	2.65 - 2.75
7	X7010000	11.05	11.25	16.43	32.85	3.53	10.39	7.26	11.05	11.15	12	
60	X60040000	0.01	0.96	3.8	28.35	3.52	9.63	7.07	0.01	0.11	13	
14	X14010000	18.33	18.83	5.39	24.49	4.47	9.18	10.79	18.63	18.73	14	
87	X87150000	11.7	12.15	12.08	24.47	4.62	8.75	11.52	11.8	11.9	15	
87	X87150000	10.94	11.08	21.29	24.39	4.62	8.73	11.52	10.94	11.04	16	
14	X14120000	23.51	23.66	15.14	22.71	4.82	8.41	12.37	23.51	23.61	17	
12	X12070000	11.13	11.36	12.16	21.88	5.48	8.38	15.68	11.13	11.23	18	
76	X76010000	0	0.24	11.84	25.84	1.37	8.07	1.27	0	0.1	19	
12	X12070000	16.09	16.33	10.88	22.25	5.48	8.01	15.74	16.19	16.29	20	
District 1												
12	X12070000	9.19	9.5	9.65	29.9	3.9	12.37	8.6	9.29	9.39	1	
91	X91070000	18.44	18.76	10.31	31.98	7.5	11.39	29.65	18.54	18.64	2	
7	X7010000	11.05	11.25	16.43	32.85	3.53	10.39	7.26	11.05	11.15	3	
12	X12070000	11.13	11.36	12.16	21.88	5.48	8.38	15.68	11.13	11.23	4	
12	X12070000	16.09	16.33	10.88	22.25	5.48	8.01	15.74	16.19	16.29	5	

Table 6-3: List of High Crash Locations on Rural Two Lane Roads (Site Subtype 101) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
4	X4040000	11.06	11.61	5.25	25.18	1.4	6.94	1.29	11.46	11.56	6	
9	X9080000	0.93	1.09	16.7	25.06	2.07	6.81	2.58	0.99	1.09	7	
16	X16160000	7.35	7.53	17.73	21.1	3.07	5.78	5.22	7.43	7.53	8	
90	X90060000	34.76	38.28	1.75	14.89	3.62	5.35	6.89	36.76	36.86	9	
90	X90060000	38.45	38.77	9.01	14.89	3.62	5.35	6.89	38.67	38.77	10	
District 2												
76	X76010000	0	0.24	11.84	25.84	1.37	8.07	1.27	0	0.1	1	
26	X26130000	2.73	2.95	12.27	26.99	2.41	7.7	3.48	2.73	2.83	2	
26	X26070000	1.87	2.19	10.54	16.34	3.29	5.96	5.8	2.09	2.19	3	
28	X28020000	3.79	4.03	9.64	20.24	2.99	5.59	4.96	3.93	4.03	4	3.89 - 3.99
76	X76010000	18.22	18.35	11.46	13.65	1.55	4.45	1.39	18.22	18.32	5	18.25 - 18.35
78	X78090000	10.44	10.6	11.33	18.13	2.07	4.34	2.43	10.5	10.6	6	
29	X29020000	17.59	17.96	4.92	17.7	1.5	4.24	1.34	17.69	17.79	7	
31	X31030000	8.09	8.38	9.11	20.88	1.37	4.2	1.15	8.28	8.38	8	
29	X29030000	6.68	7	5.49	17.01	1.15	4.08	0.83	6.78	6.88	9	
38	X38030000	4.62	4.99	7.29	22.49	1.07	3.88	0.74	4.72	4.82	10	
District 3												
55	X55070000	16.21	16.82	12.14	52.91	1.88	14.89	2.67	16.31	16.41	1	
60	X60010000	2.64	2.75	40.26	44.28	1.63	11.27	1.96	2.64	2.74	2	2.65 - 2.75
60	X60040000	0.01	0.96	3.8	28.35	3.52	9.63	7.07	0.01	0.11	3	
59	X59020000	2.84	3.57	8.91	21.38	4.03	7.14	8.75	3.34	3.44	4	2.84 - 2.94
59	X59020000	6.04	6.15	24.3	21.38	4.03	7.14	8.75	6.05	6.15	5	
60	X60050000	13.67	13.85	10.96	19.73	3.2	6.68	5.64	13.67	13.77	6	13.75 - 13.85
50	X50010000	0.62	0.76	19.73	20.52	2.63	5.77	3.91	0.66	0.76	7	
55	X55070000	15.85	16.03	12.45	19.05	1.88	5.01	2.06	15.85	15.95	8	
59	X59010000	9.14	9.39	9.33	19.6	2.36	4.85	3.16	9.29	9.39	9	
50	X50020000	2.22	2.56	6.02	9.09	1.76	3.07	1.9	2.32	2.52	10	

Table 6-3: List of High Crash Locations on Rural Two Lane Roads (Site Subtype 101) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
District 4												
No high crash locations were identified												
District 5												
79	X79120000	2.06	2.36	15.36	41.58	4.4	15.15	11.35	2.26	2.36	1	
11	X11110000	18.19	18.72	8.52	28.21	2.73	7.89	4.38	18.49	18.59	2	
36	X36110000	9.05	9.34	7.51	19.54	2.27	7.11	2.96	9.15	9.25	3	
36	X36080000	16.69	16.91	15.22	18.03	3.74	5.75	7.47	16.69	16.79	4	
73	X73040000	14.23	14.48	7.22	12.89	1.87	2.77	1.92	14.23	14.33	5	
11	X11140000	4.62	4.79	6.62	10.59	1.32	2.08	0.97	4.62	4.72	6	
District 6												
87	X87150000	13.7	14.15	17.52	59.82	4.62	24.34	13.39	13.8	13.9	1	
87	X87150000	9.93	10.08	37.94	46.07	4.74	18.51	13.22	9.93	10.03	2	9.98 - 10.08
87	X87150000	10.2	10.59	15.29	46.07	4.74	18.51	13.22	10.3	10.4	3	
87	X87150000	11.7	12.15	12.08	24.47	4.62	8.75	11.52	11.8	11.9	4	
87	X87150000	10.94	11.08	21.29	24.39	4.62	8.73	11.52	10.94	11.04	5	
87	X87010000	0.24	1.51	2.6	21.06	4.17	7.65	9.34	0.94	1.04	6	
87	X87070000	13.95	14.22	11.41	15.4	3.2	7.4	6.01	14.02	14.22	7	
87	X87010000	13.73	13.94	25.74	15.21	4.17	6.88	9.7	13.73	13.93	8	
87	X87070000	0.04	0.58	8.48	12.25	3.53	6.16	7.19	0.04	0.34	9	
90	X90060000	34.76	38.28	1.75	14.89	3.62	5.35	6.89	36.76	36.86	10	
District 7												
14	X14090000	12.57	14.16	14.93	91.57	8.54	48.83	43.16	12.67	12.77	1	
14	X14010000	7.17	7.47	22.68	59.27	4.31	26.2	11.81	7.27	7.37	2	
10	X10210000	4.94	5.22	21.18	42.27	2.92	13.88	5.43	5.04	5.14	3	5.12 - 5.22
14	X14010000	18.33	18.83	5.39	24.49	4.47	9.18	10.79	18.63	18.73	4	
14	X14120000	23.51	23.66	15.14	22.71	4.82	8.41	12.37	23.51	23.61	5	
10	X10210000	1.91	2.5	7.59	24.87	2.92	7.74	4.89	2.11	2.21	6	

Table 6-3: List of High Crash Locations on Rural Two Lane Roads (Site Subtype 101) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
14	X14120000	23.17	23.32	25.48	20.38	4.82	7.28	12.24	23.22	23.32	7	
14	X14010000	9.67	9.95	11.76	17.56	4.31	6.32	9.73	9.67	9.77	8	
2	X2010000	24.4	24.79	5.36	18.31	4.04	5.96	8.66	24.6	24.7	9	
10	X10120000	9.73	9.89	11.61	14.93	1.79	5.27	1.85	9.79	9.89	10	

Table 6-4: List of High Crash Locations on Rural Multilane Divided Roads (Site Subtype 103)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
all-state												
75	X75002000	16.1	18.6	8.37	91.41	7.15	43.78	30.62	16.3	16.4	1	16.1 - 16.2
8	X8150000	0.44	2.36	8.01	88.93	4.19	37.08	12.18	1.94	2.04	2	0.94 - 1.04
55	X55060000	0	0.37	25.85	91.75	2.55	32.83	5.44	0	0.1	3	
8	X8150000	3.74	6.46	8.96	76.91	4.19	31.82	11.62	3.94	4.04	4	4.94 - 5.04; 5.94 - 6.04
8	X8150000	2.36	3.74	5.75	67.3	4.19	27.61	11.18	2.96	3.06	5	
11	X11200000	0	0.18	58.72	69.54	4.23	26.4	11.44	0	0.1	6	0.08 - 0.18
8	X8070000	3.94	4.09	78.03	87.16	2.51	26.24	5.03	3.94	4.04	7	3.99 - 4.09
75	X75002000	20.77	22.65	6.65	57.7	7.15	25.21	27.99	22.27	22.37	8	21.27 - 21.37
1	X1010000	0	5.55	2.35	72.93	2.34	24.85	4.27	0	0.1	9	
10	X10110000	14.18	14.5	20.18	58.71	5.54	24.31	17.71	14.4	14.5	10	14.38 - 14.48
16	X16110000	21.36	27.39	4.9	73.92	2.74	24.13	5.52	21.76	21.86	11	25.16 - 25.26; 26.16 - 26.26
11	X11210000	1.16	1.3	54.43	56.61	4.36	23.6	11.44	1.2	1.3	12	
26	X26020000	23.95	24.6	15.86	78.01	2.72	22.85	5.47	23.95	24.05	13	24.15 - 24.25
10	X10110000	22.15	23.74	9.78	53.59	5.54	21.12	17.4	23.64	23.74	14	22.65 - 22.75
26	X26010000	0	2.74	4.35	72.26	1.54	19.5	2.11	0	0.1	15	
60	X60020000	9.24	10.2	7.47	50.47	3.55	17.52	7.71	10.04	10.14	16	10.1 - 10.2
79	X79030000	11.4	11.54	41.49	53.04	3	17.32	5.78	11.4	11.5	17	11.44 - 11.54
75	X75002000	23.61	26.96	5.37	41.67	7.15	17.22	26.71	24.31	24.41	18	25.31 - 25.41; 26.31 - 26.41
60	X60020000	11.8	13.18	6.56	48.77	3.23	16.38	6.47	13.08	13.18	19	13.0 - 13.1
87	X87090000	0.38	0.49	44.65	46.88	2.77	15.72	4.9	0.38	0.48	20	0.39 - 0.49
District 1												
1	X1010000	0	5.55	2.35	72.93	2.34	24.85	4.27	0	0.1	1	
16	X16110000	21.36	27.39	4.9	73.92	2.74	24.13	5.52	21.76	21.86	2	25.16 - 25.26; 26.16 - 26.26

Table 6-4: List of High Crash Locations on Rural Multilane Divided Roads (Site Subtype 103) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
1	X1075000	1.09	4.3	3.64	38.11	4.48	15.34	11.09	1.39	1.49	3	2.39 - 2.49; 3.39 - 3.49
9	X9010000	12.21	14	4.13	45.91	1.47	11.68	1.6	13.9	14	4	
16	X16060000	1.13	3.66	4.67	30.8	4.44	11.48	10.56	1.53	1.63	5	
16	X16110000	7.73	12.37	4.81	32.15	2.73	9.7	4.33	9.73	9.83	6	7.73 - 7.83; 8.83 - 8.93; 9.03 - 9.13
16	X16110000	17.69	21.27	5.1	30.72	2.74	9.54	4.34	18.99	19.09	7	19.59 - 19.69; 20.29 - 20.39
1	X1075000	0	1.09	4.37	23.82	4.48	8.82	10.38	0.4	0.5	8	
16	X16170000	8.62	14.83	2.74	28.75	2.46	8.25	3.49	14.12	14.22	9	
1	X1075000	9.28	11.2	6.69	21.81	4.64	7.91	10.98	9.48	9.58	10	9.78 - 9.88
District 2												
26	X26020000	23.95	24.6	15.86	78.01	2.72	22.85	5.47	23.95	24.05	1	24.15 - 24.25
26	X26010000	0	2.74	4.35	72.26	1.54	19.5	2.11	0	0.1	2	
28	X28010000	0	1.76	5.96	42.47	3.06	13.92	5.67	0	0.1	3	
26	X26020000	19.24	19.35	41.31	38.73	2.72	11.52	4.48	19.24	19.34	4	
26	X26060000	0	0.55	10.35	45.07	1.69	10.48	1.98	0	0.1	5	
74	X74030000	0	0.28	12.72	35.62	2.47	10.02	3.68	0	0.1	6	
76	X76060000	1.55	6.66	2.97	38.58	2.17	9.97	2.96	3.35	3.45	7	1.65 - 1.75
78	X78010000	0	7.36	2.45	30.29	1.93	9.61	2.32	0	0.1	8	0.4 - 0.5; 0.5 - 0.6; 0.6 - 0.7; 0.9 - 1.0
76	X76030000	1.29	4.39	3.32	30.77	1.94	7.28	2.28	2.29	2.39	9	2.19 - 2.29
34	X34010000	0.12	6.58	3.69	29.76	2.04	6.98	2.47	5.02	5.12	10	0.72 - 0.82; 1.72 - 1.82; 4.52 - 4.62
District 3												
55	X55060000	0	0.37	25.85	91.75	2.55	32.83	5.44	0	0.1	1	
60	X60020000	9.24	10.2	7.47	50.47	3.55	17.52	7.71	10.04	10.14	2	10.1 - 10.2
60	X60020000	11.8	13.18	6.56	48.77	3.23	16.38	6.47	13.08	13.18	3	13.0 - 13.1
60	X60020000	14.8	16.28	4.05	46.03	3.23	14.87	6.36	16.1	16.2	4	16.18 - 16.28

Table 6-4: List of High Crash Locations on Rural Multilane Divided Roads (Site Subtype 103) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
50	X50030000	12.03	12.45	17.71	50.28	2.75	14.51	4.85	12.23	12.33	5	
50	X50030000	11.62	11.9	17.96	30.73	2.75	8.54	4.34	11.62	11.72	6	
60	X60040000	9.66	9.83	20	34	1.95	8.44	2.36	9.66	9.76	7	
57	X57050000	9.6	13.47	2.55	21.69	3.86	7.43	7.76	12.6	12.7	8	
57	X57050000	4.11	9.51	2.82	19.28	3.86	6.42	7.66	6.01	6.11	9	
48	X48060000	19.02	20.07	5.09	26.72	1.78	5.71	1.87	19.92	20.02	10	19.97 - 20.07
District 4												
93	X93120000	0.27	3.68	1.65	19.44	2.43	5.69	3.23	2.17	2.27	1	
86	X86060000	13.11	27.67	1.61	15.79	2.14	3.63	2.45	22.91	23.01	2	23.91 - 24.01
District 5												
75	X75002000	16.1	18.6	8.37	91.41	7.15	43.78	30.62	16.3	16.4	1	16.1 - 16.2
11	X11200000	0	0.18	58.72	69.54	4.23	26.4	11.44	0	0.1	2	0.08 - 0.18
75	X75002000	20.77	22.65	6.65	57.7	7.15	25.21	27.99	22.27	22.37	3	21.27 - 21.37
11	X11210000	1.16	1.3	54.43	56.61	4.36	23.6	11.44	1.2	1.3	4	
79	X79030000	11.4	11.54	41.49	53.04	3	17.32	5.78	11.4	11.5	5	11.44 - 11.54
75	X75002000	23.61	26.96	5.37	41.67	7.15	17.22	26.71	24.31	24.41	6	25.31 - 25.41; 26.31 - 26.41
75	X75002000	27.75	29.7	4.13	35.26	7.15	14.02	26.2	28.25	28.35	7	29.25 - 29.35
70	X70100000	0	2.91	3.44	40.91	2.3	12.88	3.38	0	0.1	8	1.7 - 1.8
75	X75002000	26.96	27.75	4.06	32.05	7.15	12.42	25.94	27.26	27.36	9	
11	X11210000	0.88	1.16	21.9	30.66	4.36	11.88	10.19	0.88	0.98	10	1.06 - 1.16
District 6												
87	X87090000	0.38	0.49	44.65	46.88	2.77	15.72	4.9	0.38	0.48	1	0.39 - 0.49
87	X87120000	0.04	2.03	3.22	29.17	2.61	10.35	3.96	0.94	1.04	2	
87	X87020000	0	0.32	17.86	25.62	3.14	9.34	5.42	0	0.1	3	0.1 - 0.2
87	X87090000	3.91	4.63	5.58	23.62	3.09	7.57	5.19	4.11	4.21	4	
87	X87090000	1.28	1.87	4.38	19.07	2.52	5.73	3.43	1.38	1.48	5	

Table 6-4: List of High Crash Locations on Rural Multilane Divided Roads (Site Subtype 103) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
87	X87090000	0	0.38	9.99	17.86	2.77	5.38	4.07	0	0.1	6	
87	X87090000	1.87	3.81	3.78	17.8	2.75	5.35	4.02	2.27	2.37	7	
87	X87090000	4.63	4.97	7.16	16.53	3.09	4.95	4.96	4.63	4.73	8	
District 7												
8	X8150000	0.44	2.36	8.01	88.93	4.19	37.08	12.18	1.94	2.04	1	0.94 - 1.04
8	X8150000	3.74	6.46	8.96	76.91	4.19	31.82	11.62	3.94	4.04	2	4.94 - 5.04; 5.94 - 6.04
8	X8150000	2.36	3.74	5.75	67.3	4.19	27.61	11.18	2.96	3.06	3	
8	X8070000	3.94	4.09	78.03	87.16	2.51	26.24	5.03	3.94	4.04	4	3.99 - 4.09
10	X10110000	14.18	14.5	20.18	58.71	5.54	24.31	17.71	14.4	14.5	5	14.38 - 14.48
10	X10110000	22.15	23.74	9.78	53.59	5.54	21.12	17.4	23.64	23.74	6	22.65 - 22.75
8	X8070000	4.27	5	8.96	53.31	2.37	15.47	3.82	4.47	4.57	7	
10	X10060000	0	3.38	3.12	49.28	1.45	13.19	1.62	0	0.1	8	1.0 - 1.1
2	X2030000	0	1.86	2.5	34.92	1.78	9.63	2.06	0	0.1	9	
10	X10110000	13.52	14.18	14	26.42	5.54	9.54	15.73	13.72	13.82	10	

Table 6-5: List of High Crash Locations on Rural Freeway-4 Lanes (Site Subtype 104)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
all-state												
14	X14140000	5.67	11.19	8.02	95	6.76	40.73	19.98	6.07	6.17	1	7.07 - 7.17; 8.07 - 8.17; 9.67 - 9.77; 10.67 - 10.77
79	X79110000	15.46	16.3	9.66	72.11	11.68	33.36	50.73	16.06	16.16	2	
17	X17075000	6.78	7.07	24.23	70.27	5.48	31.8	12.81	6.97	7.07	3	
14	X14140000	12.25	17.44	9.9	76.65	7.03	30.61	20.35	14.75	14.85	4	12.75 - 12.85; 13.75 - 13.85; 15.75 - 15.85; 16.75 - 16.85; 17.05 - 17.15
88	X88081000	15.84	18.3	9.24	88.44	4.49	29.13	9.52	18.2	18.3	5	16.14 - 16.24; 17.14 - 17.24; 18.2 - 18.3; 18.2 - 18.3
17	X17075000	26.71	28.22	9.83	60.33	6.07	29	14.82	26.71	26.81	6	27.71 - 27.81; 27.81 - 27.91
79	X79110000	16.3	17.95	5.31	63.1	11.68	28.39	49.91	17.1	17.2	7	
79	X79110000	21.24	24.04	10.3	63.1	11.68	28.39	49.91	22.74	22.84	8	21.64 - 21.74; 23.74 - 23.84
79	X79110000	17.95	18.76	10.02	60.09	11.68	26.73	49.63	18.15	18.25	9	
50	X50001000	32.7	32.97	39.69	98.22	3.63	26.35	6.65	32.87	32.97	10	32.8 - 32.9
88	X88081000	0	4.58	7.29	82.16	4.09	26.21	7.92	4	4.1	11	0.0 - 0.1; 1.0 - 1.1; 2.0 - 2.1; 3.0 - 3.1
79	X79110000	14.61	15.46	10.73	57.09	11.68	25.07	49.36	15.11	15.21	12	
88	X88081000	8.35	14.67	6.78	75.04	4.49	24.48	9.09	9.05	9.15	13	10.05 - 10.15; 10.15 - 10.25; 11.15 - 11.25; 12.05 - 12.15; 12.15 - 12.25; 13.15 - 13.25; 14.15 - 14.25
18	X18130000	14.79	15.88	7.22	65.57	5.53	24.05	12.79	15.09	15.19	14	
14	X14140000	19.7	20.13	17.7	59.21	7.03	23.03	19.39	20	20.1	15	20.03 - 20.13

Table 6-5: List of High Crash Locations on Rural Freeway-4 Lanes (Site Subtype 104) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
18	X18130000	2.48	7.06	6.86	63.32	4.41	22.01	8.48	5.58	5.68	16	2.68 - 2.78; 3.58 - 3.68; 4.58 - 4.68; 4.78 - 4.88; 6.58 - 6.68
18	X18130000	20.92	21.77	16.97	60.33	5.53	21.95	12.57	21.52	21.62	17	21.62 - 21.72
14	X14140000	17.92	18.48	11.15	56.78	7.03	21.87	19.26	18.02	18.12	18	
11	X11470000	11.9	14.5	6.61	61.89	4	20.61	7.08	14	14.1	19	12.8 - 12.9; 13.8 - 13.9
11	X11470000	11.9	14.5	6.61	18.34	4	5.11	5.81	12.8	12.9	20	
District 1												
17	X17075000	6.78	7.07	24.23	70.27	5.48	31.8	12.81	6.97	7.07	1	
17	X17075000	26.71	28.22	9.83	60.33	6.07	29	14.82	26.71	26.81	2	27.71 - 27.81; 27.81 - 27.91
17	X17075000	25.19	26.71	4.96	43.57	6.07	20.05	14.02	25.69	25.79	3	
17	X17075000	11.41	15.34	4.23	36.81	6.07	15.71	13.73	12.01	12.11	4	13.01 - 13.11; 14.01 - 14.11
17	X17075000	18.9	19.16	14.16	36.81	6.07	15.71	13.73	19	19.1	5	
17	X17075000	5.85	6.78	3.92	36.03	5.48	15	11.32	5.95	6.05	6	
17	X17075000	15.34	18.37	3.7	34.97	6.07	14.77	13.64	18.04	18.14	7	16.04 - 16.14; 17.04 - 17.14
17	X17075000	22.88	23.67	7.74	32.29	6.07	13.92	13.49	23.28	23.38	8	
12	X12075000	29.1	29.76	4.84	36.81	10.71	13.14	40.41	29.4	29.5	9	
91	X91470000	0	3.51	6.44	48.44	3.15	12.27	4.28	0.9	1	10	1.9 - 2.0; 2.9 - 3.0
District 2												
35	X35090000	4.8	5.15	22.21	68.76	2.98	15.8	4.17	4.9	5	1	
29	X29170000	0	1.62	6.38	62.04	2.73	13.42	3.44	1.4	1.5	2	
72	X72270000	0	2.56	2.7	21.19	3.94	9.11	5.68	2.2	2.3	3	0.2 - 0.3; 1.2 - 1.3
37	X37120000	0	5.69	2.73	38.82	2.3	8.02	2.26	5.3	5.4	4	2.3 - 2.4; 3.3 - 3.4; 4.3 - 4.4
35	X35090000	2.91	4.8	5.41	32.88	2.98	7.18	3.55	3.91	4.01	5	2.91 - 3.01
29	X29170000	13.33	17.63	2.43	35.76	2.29	7	2.2	13.73	13.83	6	14.73 - 14.83

Table 6-5: List of High Crash Locations on Rural Freeway-4 Lanes (Site Subtype 104) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
37	X37120000	22.25	23.24	3.93	32.08	2.01	6.89	1.71	22.85	22.95	7	
27	X27090000	12.95	17.83	2.52	29.49	2.51	6.6	2.54	15.25	15.35	8	13.25 - 13.35; 17.25 - 17.35
35	X35090000	28.28	31.05	3.5	31.45	2.23	6.2	2.04	29.48	29.58	9	28.48 - 28.58
27	X27090000	0	9.14	2.19	28.62	2.29	6.15	2.14	3.4	3.5	10	0.4 - 0.5; 4.4 - 4.5; 5.4 - 5.5; 7.4 - 7.5
District 3												
50	X50001000	32.7	32.97	39.69	98.22	3.63	26.35	6.65	32.87	32.97	1	32.8 - 32.9
55	X55320000	0	1.08	7.85	34.37	3.86	10.62	5.87	0.1	0.2	2	0.3 - 0.4
50	X50001000	14.23	19.74	3.85	43.82	3.63	10.22	5.35	15.03	15.13	3	16.03 - 16.13; 18.83 - 18.93
54	X54001000	5.75	8.57	3.32	33.04	2.87	7.5	3.32	6.25	6.35	4	7.25 - 7.35; 8.25 - 8.35
50	X50001000	21.1	25.45	3.58	31.08	3.63	7.41	5.09	22.9	23	5	
50	X50001000	25.78	26.18	13.55	27.97	3.63	6.57	5.02	25.88	25.98	6	25.78 - 25.88
57	X57002000	3.61	3.87	15.75	30.93	2.58	6.39	2.68	3.61	3.71	7	
54	X54001000	9.97	11.4	4.72	29.8	2.3	6.24	2.15	11.27	11.37	8	10.27 - 10.37; 10.77 - 10.87; 11.3 - 11.4
50	X50001000	8.78	11.1	4.88	30.52	2.03	6.14	1.72	11	11.1	9	9.08 - 9.18; 9.98 - 10.08; 10.98 - 11.08
57	X57002000	18.74	19.05	11.83	30.03	2.44	6.09	2.4	18.84	18.94	10	
District 4												
88	X88081000	15.84	18.3	9.24	88.44	4.49	29.13	9.52	18.2	18.3	1	16.14 - 16.24; 17.14 - 17.24; 18.2 - 18.3; 18.2 - 18.3
88	X88081000	0	4.58	7.29	82.16	4.09	26.21	7.92	4	4.1	2	0.0 - 0.1; 1.0 - 1.1; 2.0 - 2.1; 3.0 - 3.1
88	X88081000	8.35	14.67	6.78	75.04	4.49	24.48	9.09	9.05	9.15	3	10.05 - 10.15; 10.15 - 10.25; 11.15 - 11.25; 12.05 - 12.15; 12.15 - 12.25; 13.15 - 13.25; 14.15 - 14.25

Table 6-5: List of High Crash Locations on Rural Freeway-4 Lanes (Site Subtype 104) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
88	X88081000	7.05	8.2	11.65	58.96	4.49	18.9	8.57	7.15	7.25	4	8.1 - 8.2
89	X89470000	0	7.35	6.93	38.14	4.65	11.76	8.44	5.1	5.2	5	2.1 - 2.2; 2.2 - 2.3; 3.1 - 3.2; 4.1 - 4.2; 6.1 - 6.2; 6.7 - 6.8; 7.1 - 7.2
88	X88470000	0	7.99	4.92	45.75	3.15	11.54	4.22	3.9	4	6	1.9 - 2.0; 2.9 - 3.0; 4.9 - 5.0; 5.9 - 6.0; 6.9 - 7.0
94	X94470000	20.44	34.95	5.4	31.37	3.86	8.26	5.76	33.94	34.04	7	21.04 - 21.14; 22.04 - 22.14; 24.84 - 24.94; 27.04 - 27.14; 27.84 - 27.94; 28.04 - 28.14; 31.84 - 31.94; 32.94 - 33.04; 34.04 - 34.14; 34.84 - 34.94; 34.85 - 34.95
86	X86075000	19.23	19.61	5.29	17.86	2.23	6.06	1.93	19.51	19.61	8	
86	X86075000	26.71	43.24	0.97	13.37	2.23	4.32	1.85	28.01	28.11	9	
88	X88470000	15.46	17.45	4.45	18.71	3.12	4.21	3.62	16.86	16.96	10	
District 5												
79	X79110000	15.46	16.3	9.66	72.11	11.68	33.36	50.73	16.06	16.16	1	
79	X79110000	16.3	17.95	5.31	63.1	11.68	28.39	49.91	17.1	17.2	2	
79	X79110000	21.24	24.04	10.3	63.1	11.68	28.39	49.91	22.74	22.84	3	21.64 - 21.74; 23.74 - 23.84
79	X79110000	17.95	18.76	10.02	60.09	11.68	26.73	49.63	18.15	18.25	4	
79	X79110000	14.61	15.46	10.73	57.09	11.68	25.07	49.36	15.11	15.21	5	
18	X18130000	14.79	15.88	7.22	65.57	5.53	24.05	12.79	15.09	15.19	6	
18	X18130000	2.48	7.06	6.86	63.32	4.41	22.01	8.48	5.58	5.68	7	2.68 - 2.78; 3.58 - 3.68; 4.58 - 4.68; 4.78 - 4.88; 6.58 - 6.68
18	X18130000	20.92	21.77	16.97	60.33	5.53	21.95	12.57	21.52	21.62	8	21.62 - 21.72
11	X11470000	11.9	14.5	6.61	61.89	4	20.61	7.08	14	14.1	9	12.8 - 12.9; 13.8 - 13.9
79	X79110000	18.76	20.42	8.19	48.07	11.68	20.09	48.53	19.06	19.16	10	

Table 6-5: List of High Crash Locations on Rural Freeway-4 Lanes (Site Subtype 104) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
District 7												
14	X14140000	5.67	11.19	8.02	95	6.76	40.73	19.98	6.07	6.17	1	7.07 - 7.17; 8.07 - 8.17; 9.67 - 9.77; 10.67 - 10.77
14	X14140000	12.25	17.44	9.9	76.65	7.03	30.61	20.35	14.75	14.85	2	12.75 - 12.85; 13.75 - 13.85; 15.75 - 15.85; 16.75 - 16.85; 17.05 - 17.15
14	X14140000	19.7	20.13	17.7	59.21	7.03	23.03	19.39	20	20.1	3	20.03 - 20.13
14	X14140000	17.92	18.48	11.15	56.78	7.03	21.87	19.26	18.02	18.12	4	
14	X14470000	2.65	10.33	2.61	34.78	2.87	7.63	3.34	5.75	5.85	5	3.25 - 3.35
14	X14470000	11.8	19.04	2.62	28.41	2.78	5.6	3.04	15.7	15.8	6	17.8 - 17.9

Table 6-6: List of High Crash Locations on Rural Freeway-6+ Lanes (Site Subtype 105)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
all-state												
79	X79110000	1.03	2.93	18.89	151.25	16.84	73.7	76.86	2.43	2.53	1	1.43 - 1.53
26	X26260000	2.39	4.57	14.49	153.03	8.32	61.28	22.35	2.99	3.09	2	3.99 - 4.09
89	X89095000	0.32	6.61	11.75	148.56	9.06	60.74	25.69	3.42	3.52	3	0.42 - 0.52; 1.42 - 1.52; 2.42 - 2.52; 4.42 - 4.52; 5.42 - 5.52; 6.42 - 6.52
16	X16320000	30	31.51	13.52	109.16	8.82	49.83	22.63	30.1	30.2	4	31.1 - 31.2
26	X26260000	6.17	9.32	13.24	113.54	8.32	44.56	20.6	7.67	7.77	5	6.67 - 6.77; 8.67 - 8.77; 9.17 - 9.27
26	X26260000	26.78	30.87	11.67	118.01	7.94	44.34	19.14	27.18	27.28	6	28.18 - 28.28; 29.18 - 29.28; 30.48 - 30.58
26	X26260000	1.68	2.39	16.22	106.13	8.32	41.42	20.27	1.98	2.08	7	
26	X26260000	19.41	20.86	9.97	103.91	7.94	39.5	18.57	20.11	20.21	8	
36	X36210000	32.98	33.87	10.22	98.23	10.72	38.49	31.51	33.28	33.38	9	
36	X36210000	0	2.91	8.29	88.37	8.9	35.62	22.04	0	0.1	10	0.9 - 1.0; 1.9 - 2.0
26	X26260000	21.59	25.82	10.53	94.02	7.94	35.43	18.15	22.09	22.19	11	23.09 - 23.19; 24.09 - 24.19; 24.99 - 25.09; 25.09 - 25.19; 25.59 - 25.69
89	X89095000	14.88	18.64	12.13	90.37	9.31	33.89	23.98	17.58	17.68	12	14.88 - 14.98; 15.88 - 15.98; 16.18 - 16.28; 18.54 - 18.64
72	X72290000	7.14	10.51	6.96	85.99	8.18	33.78	18.82	7.34	7.44	13	8.34 - 8.44; 9.34 - 9.44
16	X16320000	16.97	17.86	10.34	79.15	8.82	33.29	21.22	17.37	17.47	14	
16	X16320000	18.96	20.07	9.26	78.75	8.82	32.71	21.21	19.36	19.46	15	
26	X26260000	20.86	21.59	17.53	86.6	7.94	32.37	17.84	21.16	21.26	16	21.06 - 21.16
16	X16320000	20.07	21.8	9.79	76.56	8.82	31.69	21.1	21.37	21.47	17	20.37 - 20.47
16	X16320000	24.07	25.11	9.95	75.42	8.82	31.4	21.04	24.37	24.47	18	

Table 6-6: List of High Crash Locations on Rural Freeway-6+ Lanes (Site Subtype 105) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
18	X18130000	23.42	28.99	7.72	89.95	5.21	30.69	8.51	25.62	25.72	19	23.62 - 23.72; 24.62 - 24.72; 26.62 - 26.72; 27.62 - 27.72; 28.62 - 28.72
26	X26260000	0	0.44	21.66	82.87	5.99	29.73	10.68	0	0.1	20	
District 1												
16	X16320000	30	31.51	13.52	109.16	8.82	49.83	22.63	30.1	30.2	1	31.1 - 31.2
16	X16320000	16.97	17.86	10.34	79.15	8.82	33.29	21.22	17.37	17.47	2	
16	X16320000	18.96	20.07	9.26	78.75	8.82	32.71	21.21	19.36	19.46	3	
16	X16320000	20.07	21.8	9.79	76.56	8.82	31.69	21.1	21.37	21.47	4	20.37 - 20.47
16	X16320000	24.07	25.11	9.95	75.42	8.82	31.4	21.04	24.37	24.47	5	
16	X16320000	22.98	24.07	8.58	68.96	8.82	28.36	20.73	23.38	23.48	6	
16	X16320000	25.11	27.25	11.18	64.65	8.82	26.32	20.53	27.11	27.21	7	25.11 - 25.21; 25.41 - 25.51; 26.11 - 26.21; 27.15 - 27.25
13	X13130000	9.51	9.92	16.95	53.07	6.84	15.52	12.4	9.71	9.81	8	
17	X17075000	30.11	32.86	3.76	32.93	5.69	12.64	8.27	32.31	32.41	9	30.81 - 30.91
17	X17075000	32.86	33.47	5.4	28.64	5.69	10.65	8.14	33.26	33.36	10	
District 2												
26	X26260000	2.39	4.57	14.49	153.03	8.32	61.28	22.35	2.99	3.09	1	3.99 - 4.09
26	X26260000	6.17	9.32	13.24	113.54	8.32	44.56	20.6	7.67	7.77	2	6.67 - 6.77; 8.67 - 8.77; 9.17 - 9.27
26	X26260000	26.78	30.87	11.67	118.01	7.94	44.34	19.14	27.18	27.28	3	28.18 - 28.28; 29.18 - 29.28; 30.48 - 30.58
26	X26260000	1.68	2.39	16.22	106.13	8.32	41.42	20.27	1.98	2.08	4	
26	X26260000	19.41	20.86	9.97	103.91	7.94	39.5	18.57	20.11	20.21	5	
26	X26260000	21.59	25.82	10.53	94.02	7.94	35.43	18.15	22.09	22.19	6	23.09 - 23.19; 24.09 - 24.19; 24.99 - 25.09; 25.09 - 25.19; 25.59 - 25.69

Table 6-6: List of High Crash Locations on Rural Freeway-6+ Lanes (Site Subtype 105) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
72	X72290000	7.14	10.51	6.96	85.99	8.18	33.78	18.82	7.34	7.44	7	8.34 - 8.44; 9.34 - 9.44
26	X26260000	20.86	21.59	17.53	86.6	7.94	32.37	17.84	21.16	21.26	8	21.06 - 21.16
26	X26260000	0	0.44	21.66	82.87	5.99	29.73	10.68	0	0.1	9	
26	X26260000	32.16	33.05	8.82	77.77	7.94	27.95	17.46	32.56	32.66	10	
District 3												
No high crash locations were identified												
District 4												
89	X89095000	0.32	6.61	11.75	148.56	9.06	60.74	25.69	3.42	3.52	1	0.42 - 0.52; 1.42 - 1.52; 2.42 - 2.52; 4.42 - 4.52; 5.42 - 5.52; 6.42 - 6.52
89	X89095000	14.88	18.64	12.13	90.37	9.31	33.89	23.98	17.58	17.68	2	14.88 - 14.98; 15.88 - 15.98; 16.18 - 16.28; 18.54 - 18.64
89	X89095000	18.64	20.72	8.01	79.08	9.31	29.17	23.42	20.62	20.72	3	19.54 - 19.64; 20.54 - 20.64
89	X89095000	22.38	24.29	7.69	66.74	9.31	24.23	22.81	22.58	22.68	4	23.58 - 23.68
89	X89095000	24.29	24.83	8.92	44.49	9.31	14.84	21.71	24.59	24.69	5	
89	X89095000	0	0.25	18.44	38.42	9.06	12.78	20.34	0.1	0.2	6	0.15 - 0.25
District 5												
79	X79110000	1.03	2.93	18.89	151.25	16.84	73.7	76.86	2.43	2.53	1	1.43 - 1.53
36	X36210000	32.98	33.87	10.22	98.23	10.72	38.49	31.51	33.28	33.38	2	
36	X36210000	0	2.91	8.29	88.37	8.9	35.62	22.04	0	0.1	3	0.9 - 1.0; 1.9 - 2.0
18	X18130000	23.42	28.99	7.72	89.95	5.21	30.69	8.51	25.62	25.72	4	23.62 - 23.72; 24.62 - 24.72; 26.62 - 26.72; 27.62 - 27.72; 28.62 - 28.72
36	X36210000	34.4	38.28	8.08	74.42	10.72	28.02	30.14	37.3	37.4	5	35.3 - 35.4; 36.3 - 36.4
73	X73001000	2.47	4.42	9.63	72.46	9.22	27.09	22.73	4.17	4.27	6	3.17 - 3.27

Table 6-6: List of High Crash Locations on Rural Freeway-6+ Lanes (Site Subtype 105) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
36	X36210000	22.88	31.71	7.25	69.87	10.72	26.34	29.87	23.08	23.18	7	24.08 - 24.18; 25.08 - 25.18; 26.08 - 26.18; 27.08 - 27.18; 28.28 - 28.38; 29.28 - 29.38; 30.28 - 30.38; 31.28 - 31.38
79	X79110000	0.48	1.03	16.81	63.53	16.84	25.6	68.88	0.48	0.58	8	
36	X36210000	33.87	34.4	14.6	68.47	10.72	25.4	29.8	34.27	34.37	9	34.3 - 34.4
79	X79002000	38.28	40.47	8.81	43.2	9.55	14.12	22.75	38.78	38.88	10	39.78 - 39.88
District 6												
87	X87471000	36.18	36.46	28.11	62.28	9.85	27.5	24.95	36.36	36.46	1	
87	X87471000	36.46	38.3	9.31	60.34	9.85	26.48	24.84	37.36	37.46	2	
District 7												
10	X10075000	1.29	4.27	7.06	65.04	6.53	26.56	11.86	3.39	3.49	1	1.39 - 1.49; 2.39 - 2.49

Table 6-7: List of High Crash Locations on Rural Freeways within Interchange Area - 4 Lanes (Site Subtype 106)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
all-state												
92	X92470000	2.36	3.48	16.1	140.66	4.6	47.9	12.74	2.56	2.66	1	
79	X79110000	24.49	24.91	21.79	67.01	15.75	32.33	95.49	24.69	24.79	2	
50	X50001000	31.74	31.96	61.05	73.72	5.44	25.26	13.88	31.84	31.94	3	31.74 - 31.84; 31.86 - 31.96
88	X88081000	14.67	15.84	13.31	60.57	6.61	23.86	19.01	15.17	15.27	4	
14	X14140000	11.19	12.25	19.73	43.77	9.92	18.3	38.52	11.59	11.69	5	11.79 - 11.89
11	X11470000	10.98	11.9	10.6	34.03	7.7	12.75	23.34	10.98	11.08	6	
17	X17075000	22.5	22.88	17.17	28.88	8.69	12.31	28.59	22.6	22.7	7	
50	X50001000	13.94	14.12	27.86	39.4	5.44	11.7	12.36	14.02	14.12	8	
18	X18130000	7.06	8.33	12.21	26.98	7.24	9.5	20.3	7.76	7.86	9	7.86 - 7.96
50	X50001000	13.02	13.18	14.43	23.09	3.22	6.01	4.3	13.02	13.12	10	13.08 - 13.18
14	X14470000	10.33	11.8	3.22	22.06	4.28	5.68	7.34	10.53	10.63	11	
29	X29170000	1.87	2.32	15.73	22.02	4.2	5.63	7.08	1.87	1.97	12	2.17 - 2.27; 2.22 - 2.32
29	X29170000	2.32	2.9	12.16	21.1	3.77	5.24	5.75	2.32	2.42	13	2.52 - 2.62
37	X37120000	5.69	6.85	5.13	19.66	3.63	4.95	5.3	6.29	6.39	14	
27	X27090000	9.14	10.18	5.25	18.21	3.59	4.73	5.16	9.44	9.54	15	
61	X61001000	16.75	16.94	10.35	16.86	2.79	3.6	3.15	16.75	16.85	16	
District 1												
17	X17075000	22.5	22.88	17.17	28.88	8.69	12.31	28.59	22.6	22.7	1	
District 2												
29	X29170000	1.87	2.32	15.73	22.02	4.2	5.63	7.08	1.87	1.97	1	2.17 - 2.27; 2.22 - 2.32
29	X29170000	2.32	2.9	12.16	21.1	3.77	5.24	5.75	2.32	2.42	2	2.52 - 2.62
37	X37120000	5.69	6.85	5.13	19.66	3.63	4.95	5.3	6.29	6.39	3	
27	X27090000	9.14	10.18	5.25	18.21	3.59	4.73	5.16	9.44	9.54	4	
District 3												
50	X50001000	31.74	31.96	61.05	73.72	5.44	25.26	13.88	31.84	31.94	1	31.74 - 31.84; 31.86 - 31.96

Table 6-7: List of High Crash Locations on Rural Freeways within Interchange Area - 4 Lanes (Site Subtype 106) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
50	X50001000	13.94	14.12	27.86	39.4	5.44	11.7	12.36	14.02	14.12	2	
50	X50001000	13.02	13.18	14.43	23.09	3.22	6.01	4.3	13.02	13.12	3	13.08 - 13.18
61	X61001000	16.75	16.94	10.35	16.86	2.79	3.6	3.15	16.75	16.85	4	
District 4												
88	X88081000	14.67	15.84	13.31	60.57	6.61	23.86	19.01	15.17	15.27	1	
District 5												
92	X92470000	2.36	3.48	16.1	140.66	4.6	47.9	12.74	2.56	2.66	1	
79	X79110000	24.49	24.91	21.79	67.01	15.75	32.33	95.49	24.69	24.79	2	
11	X11470000	10.98	11.9	10.6	34.03	7.7	12.75	23.34	10.98	11.08	3	
18	X18130000	7.06	8.33	12.21	26.98	7.24	9.5	20.3	7.76	7.86	4	7.86 - 7.96
District 6												
No high crash locations were identified												
District 7												
14	X14140000	11.19	12.25	19.73	43.77	9.92	18.3	38.52	11.59	11.69	1	11.79 - 11.89
14	X14470000	10.33	11.8	3.22	22.06	4.28	5.68	7.34	10.53	10.63	2	

Table 6-8: List of High Crash Locations on Rural Freeways within Interchange Area – 6+ Lanes (Site Subtype 107)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
all-state												
16	X16320000	28.43	29.99	19.96	117.54	12.56	71.19	66.25	29.13	29.23	1	29.23 - 29.33; 29.63 - 29.73
87	X87471000	38.3	38.5	46.62	80.52	14.03	47	76.81	38.4	38.5	2	
16	X16320000	28.14	28.43	30.47	79.54	12.56	44.4	62.88	28.14	28.24	3	
79	X79110000	2.93	3.08	48.78	73.17	24.12	35.92	214.74	2.98	3.08	4	2.93 - 3.03
26	X26260000	0.44	1.66	21.23	65.92	10.14	33.38	41.72	0.44	0.54	5	0.94 - 1.04; 1.04 - 1.14; 1.44 - 1.54
78	X78080000	31.38	32.71	13.2	58.51	8.83	30.7	31.56	31.98	32.08	6	
26	X26260000	9.32	9.68	27.48	53.16	11.83	25.54	54.28	9.58	9.68	7	
26	X26260000	30.87	32.16	11.59	53.4	11.29	25.01	49.85	30.97	31.07	8	
89	X89095000	6.61	7.42	15.85	47.15	12.9	21.58	63.31	6.91	7.01	9	
73	X73001000	0	0.58	16.03	46.47	13.14	20.82	65.52	0	0.1	10	
29	X29180000	5.49	6.28	15.97	43.78	8.08	18.59	26.19	5.89	5.99	11	5.79 - 5.89
26	X26260000	26.25	26.78	19.95	37.25	11.29	15.44	48.32	26.65	26.75	12	26.68 - 26.78
18	X18130000	21.98	23.42	14.76	33.57	7.37	13.95	21.36	22.48	22.58	13	22.28 - 22.38; 22.88 - 22.98
78	X78080000	25.34	26.86	6.48	28.73	8.83	11.9	29.49	26.04	26.14	14	
29	X29180000	26.04	27.46	10.81	30.48	7.96	11.22	24.55	26.64	26.74	15	
32	X32100000	17.81	19.02	5.34	23.75	5.14	7.97	10.47	18.81	18.91	16	
32	X32100000	24.54	25.46	4.06	21.02	5.14	6.86	10.35	25.34	25.44	17	
District 1												
16	X16320000	28.43	29.99	19.96	117.54	12.56	71.19	66.25	29.13	29.23	1	29.23 - 29.33; 29.63 - 29.73
16	X16320000	28.14	28.43	30.47	79.54	12.56	44.4	62.88	28.14	28.24	2	
District 2												
26	X26260000	0.44	1.66	21.23	65.92	10.14	33.38	41.72	0.44	0.54	1	0.94 - 1.04; 1.04 - 1.14; 1.44 - 1.54
78	X78080000	31.38	32.71	13.2	58.51	8.83	30.7	31.56	31.98	32.08	2	

Table 6-8: List of High Crash Locations on Rural Freeways within Interchange Area – 6+ Lanes (Site Subtype 107) (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
26	X26260000	9.32	9.68	27.48	53.16	11.83	25.54	54.28	9.58	9.68	3	
26	X26260000	30.87	32.16	11.59	53.4	11.29	25.01	49.85	30.97	31.07	4	
29	X29180000	5.49	6.28	15.97	43.78	8.08	18.59	26.19	5.89	5.99	5	5.79 - 5.89
26	X26260000	26.25	26.78	19.95	37.25	11.29	15.44	48.32	26.65	26.75	6	26.68 - 26.78
78	X78080000	25.34	26.86	6.48	28.73	8.83	11.9	29.49	26.04	26.14	7	
29	X29180000	26.04	27.46	10.81	30.48	7.96	11.22	24.55	26.64	26.74	8	
32	X32100000	17.81	19.02	5.34	23.75	5.14	7.97	10.47	18.81	18.91	9	
32	X32100000	24.54	25.46	4.06	21.02	5.14	6.86	10.35	25.34	25.44	10	
District 3												
No high crash locations were identified												
District 4												
89	X89095000	6.61	7.42	15.85	47.15	12.9	21.58	63.31	6.91	7.01	1	
District 5												
79	X79110000	2.93	3.08	48.78	73.17	24.12	35.92	214.74	2.98	3.08	1	2.93 - 3.03
73	X73001000	0	0.58	16.03	46.47	13.14	20.82	65.52	0	0.1	2	
18	X18130000	21.98	23.42	14.76	33.57	7.37	13.95	21.36	22.48	22.58	3	22.28 - 22.38; 22.88 - 22.98
District 6												
87	X87471000	38.3	38.5	46.62	80.52	14.03	47	76.81	38.4	38.5	1	
District 7												
No high crash locations were identified												

Table 6-9: List of High Crash Locations on Urban Two-Lane Arterial Streets (Site Subtype 151)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
all-state												
75	X75260000	0	0.8	31.54	252.32	8.25	173.24	83.44	0	0.1	1	
87	X87037000	0	0.13	156.49	190.73	12.02	139.3	137.99	0	0.1	2	0.03 - 0.13
10	X10090000	4.3	4.57	129.62	210.63	8.98	139.27	91.15	4.3	4.4	3	4.4 - 4.5; 4.47 - 4.57
15	X15040000	0	0.12	133.61	160.33	11.86	115.77	130.07	0	0.1	4	
87	X87090000	19.01	19.18	98.65	151.77	11.24	103.25	120.05	19.01	19.11	5	
87	X87090000	17.81	17.97	104.67	145.35	11.24	97.48	119.48	17.81	17.91	6	17.87 - 17.97
14	X14090000	10.37	11.12	64.24	133.42	10.85	93.96	107.9	10.87	10.97	7	10.37 - 10.47; 10.57 - 10.67; 10.67 - 10.77; 10.77 - 10.87; 10.97 - 11.07; 11.02 - 11.12
10	X10090000	4.74	5.04	72.22	108.33	8.98	68.61	76.47	4.84	4.94	8	4.74 - 4.84; 4.94 - 5.04
15	X15020000	7.39	7.52	79.61	103.5	6.84	64.72	47.07	7.39	7.49	9	7.42 - 7.52
70	X70004000	0	0.45	21.31	93.36	11.25	63.17	109.13	0	0.1	10	
10	X10260000	4.68	4.85	65.2	98.53	6.31	60.59	40.61	4.75	4.85	11	
48	X48050000	0	0.16	64.83	98.9	5.57	59.11	33.1	0	0.1	12	
14	X14610000	4.14	4.5	50.93	91.67	6.28	55.91	39.6	4.4	4.5	13	4.34 - 4.44
10	X10030000	9.2	9.39	56.2	85.89	4.44	51.72	21.55	9.2	9.3	14	9.29 - 9.39
55	X55003000	0	0.21	37.7	76.01	5.75	51.35	31.34	0	0.1	15	
48	X48004000	5.74	5.95	85.09	80.08	7.74	50.51	54.98	5.84	5.94	16	
87	X87090000	18.85	19.01	60.71	78.92	11.24	49.73	108.11	18.85	18.95	17	18.91 - 19.01
55	X55100000	1.41	2.05	47.92	82.28	6.06	49.18	36.38	1.51	1.61	18	1.41 - 1.51; 1.61 - 1.71; 1.71 - 1.81; 1.91 - 2.01; 1.95 - 2.05
14	X14090000	20.16	20.28	66.04	72.64	11.37	45.19	109.34	20.18	20.28	19	20.16 - 20.26
87	X87090000	17.56	17.72	55.3	72.67	11.24	44.65	107.35	17.56	17.66	20	17.62 - 17.72
District 1												
12	X12070000	4.97	5.36	26.46	67.03	8.85	41.87	67.94	5.07	5.17	1	

Table 6-9: List of High Crash Locations on Urban Two-Lane Arterial Streets (Site Subtype 151)- (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
12	X12070000	6.02	6.37	29.03	66.04	8.57	41.16	64.01	6.12	6.22	2	
16	X16006000	4.34	4.61	28.25	67.56	4.29	37.69	19.25	4.34	4.44	3	
16	X16020000	22.5	22.72	38.26	58.71	9.39	34.25	75.29	22.5	22.6	4	
13	X13050000	8.08	8.32	30.04	53.73	8.85	32.37	66.13	8.18	8.28	5	8.22 - 8.32
90	X90010000	1.33	1.46	44.03	50.54	7.46	30.52	47.79	1.33	1.43	6	
16	X16006000	6.33	6.53	28.28	51.29	5.33	28.5	26.38	6.43	6.53	7	
16	X16550000	0	0.17	29.68	50.46	4.81	26.83	21.98	0	0.1	8	
16	X16006000	0.04	0.16	29.45	35.34	4.97	18.58	21.84	0.06	0.16	9	
12	X12070000	6.94	7.49	9.66	33.81	7.74	18.4	49.26	6.94	7.04	10	
District 2												
26	X26090000	9.75	10.14	17.11	52.42	6.46	32.05	36.81	9.85	9.95	1	
72	X72040000	9.79	10.12	20.89	43.08	10.72	25.51	92.08	9.89	9.99	2	
76	X76050000	12.91	13.76	18.72	46.08	4.97	23.77	22.95	13.31	13.41	3	13.01 - 13.11; 13.51 - 13.61
26	X26250000	3.44	3.8	17.77	32.26	7	17.54	40.62	3.7	3.8	4	
78	X78040000	16.45	16.69	30.01	32.73	8.3	16	56.69	16.59	16.69	5	
26	X26250000	3.89	4.29	18.02	28.84	5.72	15.6	27.44	4.19	4.29	6	3.99 - 4.09
71	X71293000	4.79	5.27	10.74	30.28	6.09	15.57	31.23	4.99	5.09	7	
26	X26070000	18.66	18.77	51.37	28.02	7.32	14.51	43.62	18.66	18.76	8	
26	X26090000	8.91	9.75	10.98	25.16	6.46	13.04	34.03	9.65	9.75	9	
28	X28020000	11.64	11.75	18.13	19.95	2.56	8.52	5.99	11.64	11.74	10	11.65 - 11.75
District 3												
48	X48050000	0	0.16	64.83	98.9	5.57	59.11	33.1	0	0.1	1	
55	X55003000	0	0.21	37.7	76.01	5.75	51.35	31.34	0	0.1	2	
48	X48004000	5.74	5.95	85.09	80.08	7.74	50.51	54.98	5.84	5.94	3	
55	X55100000	1.41	2.05	47.92	82.28	6.06	49.18	36.38	1.51	1.61	4	1.41 - 1.51; 1.61 - 1.71; 1.71 - 1.81; 1.91 - 2.01; 1.95 - 2.05

Table 6-9: List of High Crash Locations on Urban Two-Lane Arterial Streets (Site Subtype 151) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
46	X46140000	3.84	3.97	51.03	63.58	8.02	38.03	56.81	3.84	3.94	5	3.87 - 3.97
48	X48030000	1.26	1.6	21.34	58.97	4.74	33.06	22.01	1.36	1.46	6	
48	X48050000	15.2	17.15	14.47	53.89	5.42	31.19	27.27	15.3	15.4	7	15.4 - 15.5; 16.3 - 16.4; 16.4 - 16.5; 16.5 - 16.6
46	X46020000	6.17	6.49	35.12	48.61	4.58	28.09	19.74	6.39	6.49	8	6.17 - 6.27; 6.27 - 6.37; 6.37 - 6.47
46	X46140000	5.15	5.48	19.74	39.08	7.03	21.43	41.95	5.25	5.35	9	
55	X55002000	14.71	15.03	18.43	40.54	9.92	20.46	81.16	14.81	14.91	10	
District 4												
89	X89040000	0	0.53	12.85	68.13	5.09	37.9	25.88	0	0.1	1	
93	X93060000	2	2.13	50.09	60.11	4.25	31.25	18.48	2	2.1	2	2.03 - 2.13
86	X86050000	7.33	7.44	36.9	36.08	5.78	19.91	28.8	7.34	7.44	3	7.33 - 7.43
86	X86050000	9.28	9.78	13.42	29.47	5.84	15.56	28.7	9.68	9.78	4	
89	X89040000	7.67	8.48	5.1	28.28	3.82	13.89	13.13	8.07	8.17	5	
93	X93020000	1.64	1.82	22.8	27.36	3.34	13.48	10.21	1.72	1.82	6	
93	X93020000	2.02	2.14	21.03	22.71	5.36	10.65	23.94	2.02	2.12	7	
94	X94004000	2.4	2.66	8.8	19.25	4.06	7.97	14.06	2.56	2.66	8	
89	X89070000	14.82	15.18	4.85	14.84	2.84	6.01	6.97	14.92	15.02	9	
93	X93020000	3.19	3.65	5.7	12.07	2.24	5.18	4.35	3.19	3.29	10	
District 5												
75	X75260000	0	0.8	31.54	252.32	8.25	173.24	83.44	0	0.1	1	
70	X70004000	0	0.45	21.31	93.36	11.25	63.17	109.13	0	0.1	2	
92	X92010000	0.6	0.93	16.82	55.51	10.73	34.07	94.75	0.8	0.9	3	0.83 - 0.93
36	X36180000	13.14	13.75	21.93	54.09	6.63	30.15	39.53	13.14	13.24	4	13.24 - 13.34
92	X92030000	13.73	13.9	27.84	47.33	9.25	27.59	71.06	13.8	13.9	5	
77	X77010000	13.59	13.75	29.24	43.67	11.61	23.59	108.96	13.65	13.75	6	
79	X79040000	13.28	13.5	32.29	32.54	8.98	16.79	65.32	13.28	13.38	7	13.38 - 13.48

Table 6-9: List of High Crash Locations on Urban Two-Lane Arterial Streets (Site Subtype 151)- (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
11	X11100000	5.29	5.65	9.97	33.34	4.96	16.78	21.67	5.39	5.49	8	
75	X75080000	12.57	12.78	22.97	30.62	6.02	16.56	30.4	12.57	12.67	9	
75	X75080000	11.69	12.07	17.74	24.06	6.02	12.14	29.75	11.79	11.89	10	11.97 - 12.07
District 6												
87	X87037000	0	0.13	156.49	190.73	12.02	139.3	137.99	0	0.1	1	0.03 - 0.13
87	X87090000	19.01	19.18	98.65	151.77	11.24	103.25	120.05	19.01	19.11	2	
87	X87090000	17.81	17.97	104.67	145.35	11.24	97.48	119.48	17.81	17.91	3	17.87 - 17.97
87	X87090000	18.85	19.01	60.71	78.92	11.24	49.73	108.11	18.85	18.95	4	18.91 - 19.01
87	X87090000	17.56	17.72	55.3	72.67	11.24	44.65	107.35	17.56	17.66	5	17.62 - 17.72
87	X87080000	4.01	4.17	69.73	67.36	5.06	42.43	24.86	4.01	4.11	6	4.07 - 4.17
87	X87190000	0.4	0.51	55.02	55.02	7.74	33.02	51.92	0.4	0.5	7	
87	X87090000	18.07	18.23	35.55	53.72	11.24	30.87	104.19	18.07	18.17	8	
90	X90010000	1.33	1.46	44.03	50.54	7.46	30.52	47.79	1.33	1.43	9	
87	X87150000	2.17	2.36	36.92	47.07	7.17	26.32	44.62	2.26	2.36	10	
District 7												
10	X10090000	4.3	4.57	129.62	210.63	8.98	139.27	91.15	4.3	4.4	1	4.4 - 4.5; 4.47 - 4.57
15	X15040000	0	0.12	133.61	160.33	11.86	115.77	130.07	0	0.1	2	
14	X14090000	10.37	11.12	64.24	133.42	10.85	93.96	107.9	10.87	10.97	3	10.37 - 10.47; 10.57 - 10.67; 10.67 - 10.77; 10.77 - 10.87; 10.97 - 11.07; 11.02 - 11.12
10	X10090000	4.74	5.04	72.22	108.33	8.98	68.61	76.47	4.84	4.94	4	4.74 - 4.84; 4.94 - 5.04
15	X15020000	7.39	7.52	79.61	103.5	6.84	64.72	47.07	7.39	7.49	5	7.42 - 7.52
10	X10260000	4.68	4.85	65.2	98.53	6.31	60.59	40.61	4.75	4.85	6	
14	X14610000	4.14	4.5	50.93	91.67	6.28	55.91	39.6	4.4	4.5	7	4.34 - 4.44
10	X10030000	9.2	9.39	56.2	85.89	4.44	51.72	21.55	9.2	9.3	8	9.29 - 9.39
14	X14090000	20.16	20.28	66.04	72.64	11.37	45.19	109.34	20.18	20.28	9	20.16 - 20.26

Table 6-9: List of High Crash Locations on Urban Two-Lane Arterial Streets (Site Subtype 151) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
14	X14090000	9.79	10.27	25.22	61.77	10.85	39.04	97.5	9.99	10.09	10	

Table 6-10: List of High Crash Locations on Urban Multilane Divided Arterial Streets (Site Subtype 153)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
all-state												
14	X14090000	0	0.12	650.5	765.48	23.89	620.98	535.59	0	0.1	1	0.02 - 0.12
72	X72220000	7.57	7.72	526.58	585.82	21.44	456.83	427.16	7.57	7.67	2	7.62 - 7.72
87	X87019000	1.66	1.8	457.68	543.56	20.27	441.49	363.22	1.7	1.8	3	1.66 - 1.76
87	X87030000	5.01	5.17	382.19	502.82	38.99	411.94	1119.3	5.01	5.11	4	5.07 - 5.17
46	X46020000	0	1.05	74.09	483.12	22.56	370.96	444.32	0	0.1	5	0.9 - 1.0; 0.95 - 1.05
10	X10290000	5.6	6.12	100.83	392.58	23	315.28	419.5	5.9	6	6	
87	X87240000	1.73	1.9	255.33	401.48	15.46	313.09	218.33	1.8	1.9	7	1.73 - 1.83
86	X86220000	0	0.11	352.4	385.02	25.67	310.73	505.95	0	0.1	8	
86	X86006000	6.6	6.82	210.52	373.1	22.46	298.54	398.68	6.7	6.8	9	6.6 - 6.7; 6.72 - 6.82
87	X87016000	0.52	0.64	327.36	349.88	17.42	271.43	258.15	0.52	0.62	10	0.54 - 0.64
87	X87030000	24.96	25.07	313.45	325.44	14.74	262.62	182.85	24.96	25.06	11	24.97 - 25.07
87	X87026000	9.08	9.31	170.93	332.65	23.45	260.01	427.41	9.18	9.28	12	9.21 - 9.31
87	X87030000	2.79	3.17	171.48	324.9	34.82	255.58	869.12	2.89	2.99	13	3.07 - 3.17
15	X15150000	4.33	4.56	216.38	313.79	17.42	252.02	243.72	4.43	4.53	14	4.33 - 4.43; 4.46 - 4.56
87	X87044000	2.01	2.25	154.92	316.14	25.33	250.22	481.96	2.11	2.21	15	2.15 - 2.25
75	X75200000	4.38	4.57	183.19	298.34	16.98	227.56	239.65	4.38	4.48	16	
87	X87016000	0.15	0.52	215.66	283.48	17.42	217.22	246.84	0.25	0.35	17	0.15 - 0.25; 0.35 - 0.45; 0.42 - 0.52
87	X87240000	3.45	3.57	243.32	276.93	26.01	213.1	502.31	3.47	3.57	18	3.45 - 3.55
75	X75010000	0	0.5	58.46	271.73	14.96	212.03	184.53	0	0.1	19	
12	X12010000	21.02	21.15	211.1	265.5	18.22	208.19	259.08	21.02	21.12	20	21.05 - 21.15
District 1												
12	X12010000	21.02	21.15	211.1	265.5	18.22	208.19	259.08	21.02	21.12	1	21.05 - 21.15
13	X13130000	1.81	1.96	157.99	205.8	27.01	151.89	523	1.81	1.91	2	1.86 - 1.96
13	X13130000	2.16	2.3	164.53	183.33	25.67	133.32	470.63	2.16	2.26	3	
12	X12060000	12.4	14.26	11.81	116.27	17.87	75.55	233.48	13.2	13.3	4	

Table 6-10: List of High Crash Locations on Urban Multilane Divided Arterial Streets (Site Subtype 153) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
13	X13010000	3.81	4.23	62.19	106	21.22	70.24	315.26	4.01	4.11	5	3.81 - 3.91
13	X13040000	7.53	7.7	94.96	105.19	21.89	69.15	334.43	7.6	7.7	6	
3	X3175000	58.31	59.8	16.2	108.07	26.91	68.06	499.12	59.51	59.61	7	
12	X12010000	21.58	21.92	47.56	95.05	18.22	64.78	232.02	21.68	21.78	8	
12	X12060000	7.56	8.85	9.89	91.99	16.08	59.17	186.01	8.26	8.36	9	
12	X12010000	23.07	23.23	72.25	80.1	18.22	51.64	230.28	23.13	23.23	10	23.07 - 23.17
District 2												
72	X72220000	7.57	7.72	526.58	585.82	21.44	456.83	427.16	7.57	7.67	1	7.62 - 7.72
26	X26250000	1.56	1.69	366.38	270.41	17.34	199	248.4	1.56	1.66	2	1.59 - 1.69
72	X72291000	2.65	2.78	215.37	258.44	10.7	179.77	111.07	2.68	2.78	3	2.65 - 2.75
26	X26070000	14.69	14.8	238.59	221.95	9.8	164.52	87.59	14.69	14.79	4	
72	X72160000	0	0.11	232.82	201.03	19.88	149.4	296.13	0	0.1	5	
72	X72220000	7.99	8.23	173.53	191.52	17.42	137.34	235.03	8.09	8.19	6	7.99 - 8.09; 8.13 - 8.23
72	X72040000	4.63	5.71	30.84	165.25	22.57	121.38	363.74	5.61	5.71	7	
72	X72220000	7.84	7.99	113.49	164.16	17.42	115.76	229.86	7.84	7.94	8	
26	X26070000	14.87	15.04	102.5	148.3	9.8	107.35	79.42	14.94	15.04	9	14.87 - 14.97
72	X72170000	0	0.13	135.83	159.26	36.77	107.03	925.19	0	0.1	10	
District 3												
46	X46020000	0	1.05	74.09	483.12	22.56	370.96	444.32	0	0.1	1	0.9 - 1.0; 0.95 - 1.05
55	X55080000	0	0.11	235.95	254.24	14.21	186.68	173.12	0	0.1	2	0.01 - 0.11
48	X48003000	5.37	5.47	247.55	244.92	14.01	179.23	167.4	5.37	5.47	3	
55	X55020000	0	0.21	184.28	227.82	15.41	162.07	197.08	0	0.1	4	0.1 - 0.2; 0.11 - 0.21
48	X48008000	0	0.15	120.96	174.37	9.17	118.49	76.37	0	0.1	5	
48	X48003000	3.87	4.16	86.42	164.87	14.29	117.14	160.32	3.97	4.07	6	3.87 - 3.97
46	X46140000	1.6	2.02	73.75	161.27	16.53	110.34	210.61	1.92	2.02	7	1.9 - 2.0
55	X55060000	8.11	8.35	162.2	148.3	17.2	106.05	219.28	8.25	8.35	8	8.11 - 8.21; 8.21 - 8.31
46	X46001000	1.82	1.98	103.68	146.66	13.84	104.88	147.45	1.88	1.98	9	1.82 - 1.92

Table 6-10: List of High Crash Locations on Urban Multilane Divided Arterial Streets (Site Subtype 153) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
48	X48004000	7.82	8.26	69.8	147.42	16.08	101.58	196.55	8.16	8.26	10	7.92 - 8.02; 8.02 - 8.12; 8.12 - 8.22
District 4												
86	X86220000	0	0.11	352.4	385.02	25.67	310.73	505.95	0	0.1	1	
86	X86006000	6.6	6.82	210.52	373.1	22.46	298.54	398.68	6.7	6.8	2	6.6 - 6.7; 6.72 - 6.82
86	X86090000	1.92	2.12	182.67	246.54	32.85	187.66	761.24	2.02	2.12	3	
86	X86018000	6.11	6.23	174.55	204.96	13.94	153.09	156.9	6.13	6.23	4	6.11 - 6.21
86	X86110000	7.53	7.71	133.38	199.32	20.14	152.82	297.88	7.61	7.71	5	
86	X86016000	3.06	3.2	138.04	185.31	18.23	136.65	250.28	3.1	3.2	6	3.06 - 3.16
86	X86210000	1.35	1.62	90.63	170.18	15.37	122.75	182.8	1.45	1.55	7	
86	X86020000	3.51	3.65	126.42	164.52	19.88	121.31	287.2	3.51	3.61	8	3.55 - 3.65
93	X93070000	22.69	23.36	66.42	157.62	17.38	116.42	222.79	22.79	22.89	9	22.69 - 22.79; 22.89 - 22.99; 23.09 - 23.19
86	X86190000	10.77	10.89	193.2	149.73	14.51	107.72	160.86	10.79	10.89	10	10.77 - 10.87
District 5												
75	X75200000	4.38	4.57	183.19	298.34	16.98	227.56	239.65	4.38	4.48	1	
75	X75010000	0	0.5	58.46	271.73	14.96	212.03	184.53	0	0.1	2	
92	X92090000	0	0.24	84.83	182.53	21.66	138	338.07	0	0.1	3	
75	X75037000	0.04	0.4	75.3	140.9	27.9	98.83	536.36	0.14	0.24	4	
77	X77080000	4.4	4.58	103.46	137.86	24.05	98.6	402.71	4.4	4.5	5	
75	X75060000	5.34	6.38	34.4	137.4	19.66	97.93	277.28	5.64	5.74	6	5.74 - 5.84
77	X77120000	5.07	5.23	77.79	121.7	20.79	83.81	305.79	5.13	5.23	7	
75	X75010000	9.48	10.09	65.67	120.73	25.67	81.67	455.07	9.68	9.78	8	9.58 - 9.68
11	X11040000	7.64	8.9	15.15	117.07	14.83	80.93	162.68	8.14	8.24	9	
75	X75010000	6.11	6.33	79.55	123.72	31.9	80.19	692.83	6.11	6.21	10	
District 6												
87	X87019000	1.66	1.8	457.68	543.56	20.27	441.49	363.22	1.7	1.8	1	1.66 - 1.76

Table 6-10: List of High Crash Locations on Urban Multilane Divided Arterial Streets (Site Subtype 153) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
87	X87030000	5.01	5.17	382.19	502.82	38.99	411.94	1119.34	5.01	5.11	2	5.07 - 5.17
87	X87240000	1.73	1.9	255.33	401.48	15.46	313.09	218.33	1.8	1.9	3	1.73 - 1.83
87	X87016000	0.52	0.64	327.36	349.88	17.42	271.43	258.15	0.52	0.62	4	0.54 - 0.64
87	X87030000	24.96	25.07	313.45	325.44	14.74	262.62	182.85	24.96	25.06	5	24.97 - 25.07
87	X87026000	9.08	9.31	170.93	332.65	23.45	260.01	427.41	9.18	9.28	6	9.21 - 9.31
87	X87030000	2.79	3.17	171.48	324.9	34.82	255.58	869.12	2.89	2.99	7	3.07 - 3.17
87	X87044000	2.01	2.25	154.92	316.14	25.33	250.22	481.96	2.11	2.21	8	2.15 - 2.25
87	X87016000	0.15	0.52	215.66	283.48	17.42	217.22	246.84	0.25	0.35	9	0.15 - 0.25; 0.35 - 0.45; 0.42 - 0.52
87	X87240000	3.45	3.57	243.32	276.93	26.01	213.1	502.31	3.47	3.57	10	3.45 - 3.55
District 7												
14	X14090000	0	0.12	650.5	765.48	23.89	620.98	535.59	0	0.1	1	0.02 - 0.12
10	X10290000	5.6	6.12	100.83	392.58	23	315.28	419.5	5.9	6	2	
15	X15150000	4.33	4.56	216.38	313.79	17.42	252.02	243.72	4.43	4.53	3	4.33 - 4.43; 4.46 - 4.56
15	X15070000	3.26	3.39	203.3	250.67	17.63	188.39	248.14	3.29	3.39	4	3.26 - 3.36
15	X15150000	9.15	9.29	175.96	228.39	27.33	175.75	532.37	9.19	9.29	5	9.15 - 9.25
10	X10110000	6.58	6.82	180.46	228.77	36.99	168.89	951.6	6.72	6.82	6	6.58 - 6.68; 6.68 - 6.78
10	X10350000	0.25	0.36	200.18	215.31	17.87	163.17	244.81	0.25	0.35	7	0.26 - 0.36
15	X15150000	26.69	27.32	70.03	212.26	26.34	163.02	492.45	26.79	26.89	8	26.69 - 26.79
10	X10110000	9.17	9.37	174.61	211.95	31.45	156.99	695.3	9.27	9.37	9	9.17 - 9.27
14	X14030000	0	0.22	132.75	200.78	25.45	151.52	462.22	0	0.1	10	

Table 6-11: List of High Crash Locations on Urban One-Way Arterial Streets (Site Subtype 154)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
all-state												
87	X87060000	9.61	9.81	146.89	163.84	19.2	130.83	367.88	9.71	9.81	1	9.61 - 9.71
87	X87053000	6.54	7.57	60.74	153.15	25.4	116.31	629.5	7.04	7.14	2	
15	X15090000	0.15	0.48	50.73	117.02	13.16	91.67	176.04	0.35	0.45	3	0.38 - 0.48
87	X87120000	15.85	16.02	79.34	121.39	31.18	82.52	931.23	15.85	15.95	4	
10	X10080000	3.25	3.66	72.03	106.1	12.1	81.22	150.25	3.55	3.65	5	3.25 - 3.35; 3.35 - 3.45; 3.45 - 3.55; 3.56 - 3.66
87	X87060000	6.45	6.66	96.25	103.19	12.15	80.9	148.86	6.55	6.65	6	6.45 - 6.55; 6.56 - 6.66
72	X72080000	0	0.52	68.19	108.35	20.6	77.74	415.59	0	0.1	7	0.3 - 0.4; 0.42 - 0.52
72	X72040000	15.65	15.96	73.78	103.42	23.49	73.25	530.25	15.65	15.75	8	
87	X87080000	3.6	3.72	84.69	93.16	15.94	68.27	250.39	3.6	3.7	9	3.62 - 3.72
75	X75040000	9.08	9.23	68.14	89.04	18.42	62.83	330.45	9.13	9.23	10	
87	X87060000	11.54	11.68	79.67	88.51	19.2	62.69	356.27	11.58	11.68	11	11.54 - 11.64
13	X13150000	8.4	8.55	92.18	88.86	18.68	62.55	339.47	8.45	8.55	12	8.4 - 8.5
87	X87060000	5.64	5.78	75.03	81.98	12.15	62.06	146.49	5.64	5.74	13	5.68 - 5.78
10	X10020000	0.52	0.65	68.73	82.48	18.15	56.82	320.9	0.52	0.62	14	0.55 - 0.65
16	X16020000	0	0.37	22.94	82.53	20.1	55.43	391.15	0	0.1	15	
87	X87060000	5.78	6.02	63.61	70.68	12.15	52.01	145.23	5.88	5.98	16	5.78 - 5.88; 5.92 - 6.02
55	X55090000	3.96	4.42	20.63	74.25	18.58	49.08	334.54	4.26	4.36	17	
87	X87060000	9.4	9.61	72.98	65.68	18.18	42.87	316.97	9.51	9.61	18	9.5 - 9.6
12	X12014000	3.55	3.69	46.06	60.45	14.88	39.77	215.25	3.55	3.65	19	
10	X10020000	0	0.27	77.2	61.06	16.22	39.34	254.81	0	0.1	20	0.1 - 0.2
District 1												
13	X13150000	8.4	8.55	92.18	88.86	18.68	62.55	339.47	8.45	8.55	1	8.4 - 8.5
16	X16020000	0	0.37	22.94	82.53	20.1	55.43	391.15	0	0.1	2	
12	X12014000	3.55	3.69	46.06	60.45	14.88	39.77	215.25	3.55	3.65	3	
13	X13050000	0.09	0.5	31.66	57.45	17.62	35.25	298.27	0.39	0.49	4	

Table 6-11: List of High Crash Locations on Urban One-Way Arterial Streets (Site Subtype 154) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
District 2												
72	X72080000	0	0.52	68.19	108.35	20.6	77.74	415.59	0	0.1	1	0.3 - 0.4; 0.42 - 0.52
72	X72040000	15.65	15.96	73.78	103.42	23.49	73.25	530.25	15.65	15.75	2	
72	X72300000	0.26	0.38	44.3	37.13	4.76	21.23	24.98	0.26	0.36	3	0.28 - 0.38
72	X72300000	0.09	0.26	16.38	23.2	4.76	12.1	23.59	0.09	0.19	4	
District 3												
55	X55090000	3.96	4.42	20.63	74.25	18.58	49.08	334.54	4.26	4.36	1	
48	X48100000	3.37	3.85	26.41	52.82	15.94	32.28	244.85	3.37	3.47	2	
48	X48070000	0.12	0.33	18.05	34.23	7.79	22.62	59.49	0.12	0.22	3	
District 4												
No high crash locations were identified												
District 5												
75	X75040000	9.08	9.23	68.14	89.04	18.42	62.83	330.45	9.13	9.23	1	
11	X11020000	14.01	14.16	31.63	39.79	7.41	26.49	55.19	14.06	14.16	2	
District 6												
87	X87060000	9.61	9.81	146.89	163.84	19.2	130.83	367.88	9.71	9.81	1	9.61 - 9.71
87	X87053000	6.54	7.57	60.74	153.15	25.4	116.31	629.5	7.04	7.14	2	
87	X87120000	15.85	16.02	79.34	121.39	31.18	82.52	931.23	15.85	15.95	3	
87	X87060000	6.45	6.66	96.25	103.19	12.15	80.9	148.86	6.55	6.65	4	6.45 - 6.55; 6.56 - 6.66
87	X87080000	3.6	3.72	84.69	93.16	15.94	68.27	250.39	3.6	3.7	5	3.62 - 3.72
87	X87060000	11.54	11.68	79.67	88.51	19.2	62.69	356.27	11.58	11.68	6	11.54 - 11.64
87	X87060000	5.64	5.78	75.03	81.98	12.15	62.06	146.49	5.64	5.74	7	5.68 - 5.78
87	X87060000	5.78	6.02	63.61	70.68	12.15	52.01	145.23	5.88	5.98	8	5.78 - 5.88; 5.92 - 6.02
87	X87060000	9.4	9.61	72.98	65.68	18.18	42.87	316.97	9.51	9.61	9	9.5 - 9.6
87	X87060000	6.02	6.24	28.94	39.58	12.15	24.38	141.75	6.12	6.22	10	
District 7												
15	X15090000	0.15	0.48	50.73	117.02	13.16	91.67	176.04	0.35	0.45	1	0.38 - 0.48

Table 6-11: List of High Crash Locations on Urban One-Way Arterial Streets (Site Subtype 154) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
10	X10080000	3.25	3.66	72.03	106.1	12.1	81.22	150.25	3.55	3.65	2	3.25 - 3.35; 3.35 - 3.45; 3.45 - 3.55; 3.56 - 3.66
10	X10020000	0.52	0.65	68.73	82.48	18.15	56.82	320.9	0.52	0.62	3	0.55 - 0.65
10	X10020000	0	0.27	77.2	61.06	16.22	39.34	254.81	0	0.1	4	0.1 - 0.2
15	X15010000	0.04	0.19	37.59	44	9.42	29.89	87.07	0.09	0.19	5	0.04 - 0.14
10	X10250000	7.55	7.69	33.11	43.05	7.21	29.52	52.64	7.59	7.69	6	

Table 6-12: List of High Crash Locations on Urban Freeways – 4 Lanes (Site Subtype 155)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
all-state												
87	X87200000	11.75	12.03	145.06	243.87	22.32	190.93	388.06	11.93	12.03	1	11.85 - 11.95
10	X10190000	1.48	1.74	160.75	208.97	22.15	159.77	377.8	1.48	1.58	2	1.58 - 1.68; 1.64 - 1.74
93	X93470000	16.18	19.57	20.44	180.67	11.14	125.89	112.38	16.18	16.28	3	16.88 - 16.98; 17.88 - 17.98; 18.88 - 18.98
87	X87170000	0	0.17	108.91	152.48	9.72	101.44	86.46	0	0.1	4	0.07 - 0.17
75	X75470000	19.66	22.91	17.1	145.59	10.38	98.64	95.15	22.66	22.76	5	19.76 - 19.86; 20.76 - 20.86; 21.56 - 21.66; 21.66 - 21.76; 22.56 - 22.66
93	X93470000	27.67	32.8	18.76	140.69	11.14	95.75	106.72	28.77	28.87	6	27.77 - 27.87; 29.77 - 29.87; 30.77 - 30.87; 30.87 - 30.97; 31.77 - 31.87; 31.87 - 31.97; 32.7 - 32.8
70	X70220000	31.87	35.1	9.04	131.62	12.06	88.91	121.61	34.77	34.87	7	33.77 - 33.87
93	X93470000	20.78	24.05	18.46	128.37	11.14	86.9	104.79	20.88	20.98	8	21.88 - 21.98; 22.18 - 22.28; 23.18 - 23.28; 23.68 - 23.78
14	X14140000	2.58	4.53	14.18	116.84	11.66	77.61	112.26	4.08	4.18	9	2.58 - 2.68; 3.08 - 3.18
10	X10002000	9.62	10.73	16.63	123.06	5.11	68.23	28.87	10.42	10.52	10	9.82 - 9.92
70	X70220000	17.1	20.14	15.4	103.03	7.32	66.24	48.25	19.6	19.7	11	17.3 - 17.4; 17.6 - 17.7; 18.3 - 18.4; 18.6 - 18.7
10	X10470000	2.73	3.42	16.05	99.67	9.76	63.67	80	3.03	3.13	12	
87	X87200000	11.55	11.75	65.01	94.45	22.32	62.31	360.49	11.55	11.65	13	
70	X70220000	24.25	27.61	12.52	94.42	12.06	61.25	115.72	25.55	25.65	14	24.55 - 24.65; 26.55 - 26.65; 27.25 - 27.35
12	X12075000	13.68	15.71	9.7	87.95	10.77	57.63	92.57	13.68	13.78	15	15.38 - 15.48
10	X10190000	2.3	2.51	84.81	88.61	21.32	57.39	329.6	2.4	2.5	16	
12	X12075000	0	0.37	25.45	86.31	11.33	56.14	101.57	0	0.1	17	

Table 6-12: List of High Crash Locations on Urban Freeways – 4 Lanes (Site Subtype 155) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
10	X10320000	9.49	15.08	8.03	78.68	7.4	56.08	44.54	11.79	11.89	18	9.79 - 9.89; 10.79 - 10.89; 12.79 - 12.89; 13.79 - 13.89; 14.79 - 14.89
93	X93470000	39.77	41.82	13.27	83.89	11.14	52.82	98.78	41.72	41.82	19	39.77 - 39.87; 40.77 - 40.87
93	X93470000	43.67	44.56	12.39	82.48	11.14	51.53	98.68	43.77	43.87	20	
District 1												
12	X12075000	13.68	15.71	9.7	87.95	10.77	57.63	92.57	13.68	13.78	1	15.38 - 15.48
12	X12075000	0	0.37	25.45	86.31	11.33	56.14	101.57	0	0.1	2	
12	X12075000	2.41	7.61	7.61	75.33	11.17	47.95	97.32	7.31	7.41	3	3.01 - 3.11; 4.01 - 4.11; 5.31 - 5.41; 6.31 - 6.41
12	X12075000	9.04	9.63	13.02	66.58	10.85	41.49	90.92	9.34	9.44	4	
12	X12075000	19.01	20.32	9.37	57	10.77	34.25	88.38	20.01	20.11	5	19.01 - 19.11
12	X12075000	17.1	19.01	6.14	38.87	10.77	20.82	85.8	17.4	17.5	6	
12	X12075000	9.63	11.5	5.23	38.41	10.85	20.52	86.92	10.33	10.43	7	
12	X12075000	26.67	27.68	8.64	38.19	10.77	20.04	85.88	27.07	27.17	8	
12	X12075000	24.75	25.35	11.64	36.2	10.77	18.86	85.42	24.95	25.05	9	
16	X16470000	1.31	2.15	3.74	16.92	3.46	6.16	9.48	2.01	2.11	10	2.05 - 2.15
District 2												
72	X72270000	12.05	15.28	6.03	55.84	6.68	37.71	35.47	12.45	12.55	1	14.05 - 14.15
72	X72001000	24.77	26.31	9.31	60.22	14.6	35.49	157.78	25.67	25.77	2	
72	X72270000	3.9	10.91	3.2	38.31	6.76	23.96	34.86	10.4	10.5	3	4.3 - 4.4
72	X72030000	10.08	10.27	26.68	35.38	7.32	18.68	41.22	10.17	10.27	4	
72	X72002000	14.19	14.83	8.15	31.98	6.05	18.46	28.15	14.39	14.49	5	
72	X72002000	21.16	23.17	3.06	31.48	6.05	18.19	28.09	21.36	21.46	6	
72	X72090000	7.66	7.92	10.83	23.82	4.49	11.37	15.9	7.76	7.86	7	7.82 - 7.92
72	X72031000	2.39	2.77	8.05	21.27	3.64	9.53	10.65	2.49	2.59	8	

Table 6-12: List of High Crash Locations on Urban Freeways – 4 Lanes (Site Subtype 155) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
72	X72031000	1.44	2.27	5.04	19.59	3.8	8.62	11.4	2.14	2.24	9	
District 3												
55	X55320000	13.66	14.18	6.5	31.81	4.18	16.34	14.45	13.96	14.06	1	
48	X48260000	7.53	9.4	4.47	28.72	7.16	14.09	38.89	8.03	8.13	2	9.23 - 9.33
55	X55320000	15.78	19.14	3.97	27.75	4.49	13.76	16.19	17.98	18.08	3	15.98 - 16.08; 16.98 - 17.08
58	X58002000	5.07	5.22	24.84	28.45	6.89	12.94	36.42	5.07	5.17	4	5.12 - 5.22
58	X58002000	5.22	7.26	4.19	28.34	4.26	12.81	14.83	6.12	6.22	5	5.62 - 5.72
58	X58002000	11.51	12.61	5.66	24.37	4.49	10.6	16.06	11.61	11.71	6	
55	X55320000	11.94	13.66	2.66	17.89	4.18	8.11	13.48	12.94	13.04	7	
57	X57002000	10.7	11.08	5.3	20.15	3.2	7.91	8.35	10.8	10.9	8	
District 4												
93	X93470000	16.18	19.57	20.44	180.67	11.14	125.89	112.38	16.18	16.28	1	16.88 - 16.98; 17.88 - 17.98; 18.88 - 18.98
93	X93470000	27.67	32.8	18.76	140.69	11.14	95.75	106.72	28.77	28.87	2	27.77 - 27.87; 29.77 - 29.87; 30.77 - 30.87; 30.87 - 30.97; 31.77 - 31.87; 31.87 - 31.97; 32.7 - 32.8
93	X93470000	20.78	24.05	18.46	128.37	11.14	86.9	104.79	20.88	20.98	3	21.88 - 21.98; 22.18 - 22.28; 23.18 - 23.28; 23.68 - 23.78
93	X93470000	39.77	41.82	13.27	83.89	11.14	52.82	98.78	41.72	41.82	4	39.77 - 39.87; 40.77 - 40.87
93	X93470000	43.67	44.56	12.39	82.48	11.14	51.53	98.68	43.77	43.87	5	
94	X94001000	18.37	23.37	9.57	82.33	7.72	49.19	51.25	18.67	18.77	6	19.67 - 19.77; 20.67 - 20.77; 21.07 - 21.17; 22.07 - 22.17; 23.07 - 23.17
94	X94001000	24.9	27.25	7.73	76.84	7.72	45.57	50.59	26.1	26.2	7	25.1 - 25.2; 27.1 - 27.2; 27.15 - 27.25

Table 6-12: List of High Crash Locations on Urban Freeways – 4 Lanes (Site Subtype 155)- (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
93	X93470000	34.17	35.67	7.98	60.8	11.14	36.5	95.02	34.87	34.97	8	
93	X93470000	36.81	38.36	10.27	54.97	11.14	31.82	94.37	37.91	38.01	9	36.91 - 37.01
94	X94001000	16.2	16.93	10.35	54.73	7.72	31.53	47.82	16.4	16.5	10	
District 5												
75	X75470000	19.66	22.91	17.1	145.59	10.38	98.64	95.15	22.66	22.76	1	19.76 - 19.86; 20.76 - 20.86; 21.56 - 21.66; 21.66 - 21.76; 22.56 - 22.66
70	X70220000	31.87	35.1	9.04	131.62	12.06	88.91	121.61	34.77	34.87	2	33.77 - 33.87
70	X70220000	17.1	20.14	15.4	103.03	7.32	66.24	48.25	19.6	19.7	3	17.3 - 17.4; 17.6 - 17.7; 18.3 - 18.4; 18.6 - 18.7
70	X70220000	24.25	27.61	12.52	94.42	12.06	61.25	115.72	25.55	25.65	4	24.55 - 24.65; 26.55 - 26.65; 27.25 - 27.35
75	X75470000	10.78	15.82	11.41	80.15	10.38	51.23	85.79	14.48	14.58	5	11.38 - 11.48; 12.38 - 12.48; 13.38 - 13.48; 15.48 - 15.58
70	X70220000	21.41	22.95	11.71	80.12	12.06	50.61	113.46	22.51	22.61	6	21.71 - 21.81
70	X70220000	36.62	40.97	11.38	80.12	12.06	50.61	113.46	40.42	40.52	7	36.82 - 36.92; 37.82 - 37.92; 38.42 - 38.52; 38.82 - 38.92; 39.42 - 39.52
75	X75470000	0.29	5.16	8.75	77.66	10.07	49.64	80.77	0.49	0.59	8	2.49 - 2.59; 4.29 - 4.39; 4.49 - 4.59
79	X79110000	12.81	13.24	16.72	64.18	11.58	39.78	102.16	13.11	13.21	9	
70	X70225000	1.78	3.02	10.14	54.87	5.43	30.67	25.38	2.88	2.98	10	2.08 - 2.18; 2.92 - 3.02
District 6												
87	X87200000	11.75	12.03	145.06	243.87	22.32	190.93	388.06	11.93	12.03	1	11.85 - 11.95
87	X87170000	0	0.17	108.91	152.48	9.72	101.44	86.46	0	0.1	2	0.07 - 0.17
87	X87200000	11.55	11.75	65.01	94.45	22.32	62.31	360.49	11.55	11.65	3	
87	X87003000	0.73	1.14	27.62	77.21	12.32	49.78	116.68	0.93	1.03	4	

Table 6-12: List of High Crash Locations on Urban Freeways – 4 Lanes (Site Subtype 155) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
87	X87200000	12.03	12.42	32.86	76.39	22.32	46.6	357.43	12.03	12.13	5	
87	X87471000	6.73	8.28	11.02	52.86	10.62	33.04	84.54	8.13	8.23	6	7.13 - 7.23; 8.18 - 8.28
87	X87471000	10.33	10.99	22.27	48.25	11.2	29.12	92.99	10.73	10.83	7	10.33 - 10.43
87	X87005000	5.45	5.81	31.13	51.73	15.26	28.63	170.02	5.45	5.55	8	
87	X87170000	0.17	0.37	42.99	49.01	9.72	27.92	72.24	0.17	0.27	9	
District 7												
10	X10190000	1.48	1.74	160.75	208.97	22.15	159.77	377.8	1.48	1.58	1	1.58 - 1.68; 1.64 - 1.74
14	X14140000	2.58	4.53	14.18	116.84	11.66	77.61	112.26	4.08	4.18	2	2.58 - 2.68; 3.08 - 3.18
10	X10002000	9.62	10.73	16.63	123.06	5.11	68.23	28.87	10.42	10.52	3	9.82 - 9.92
10	X10470000	2.73	3.42	16.05	99.67	9.76	63.67	80	3.03	3.13	4	
10	X10190000	2.3	2.51	84.81	88.61	21.32	57.39	329.6	2.4	2.5	5	
10	X10320000	9.49	15.08	8.03	78.68	7.4	56.08	44.54	11.79	11.89	6	9.79 - 9.89; 10.79 - 10.89; 12.79 - 12.89; 13.79 - 13.89; 14.79 - 14.89
10	X10190000	2.09	2.3	73.06	81.82	21.75	51.31	341.46	2.09	2.19	7	
10	X10075000	36.94	39.85	9.97	76.44	10.28	50.55	82.87	37.24	37.34	8	37.14 - 37.24; 38.24 - 38.34; 39.24 - 39.34
10	X10075000	34.16	35.3	17.05	61.5	10.28	39.71	80.66	35.16	35.26	9	34.16 - 34.26; 35.06 - 35.16
15	X15170000	4.44	8.05	7.84	60.48	7.64	35.71	47.5	7.04	7.14	10	6.94 - 7.04; 7.94 - 8.04

Table 6-13: List of High Crash Locations on Urban Freeways – 6 Lanes (Site Subtype 156)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
all-state												
10	X10190000	0	1.48	91.08	515.75	37.15	433.84	1003.53	0.7	0.8	1	0.0 - 0.1; 1.1 - 1.2; 1.2 - 1.3
87	X87200000	4.52	5.14	211.01	374.91	50.69	300.63	1754.28	4.82	4.92	2	4.62 - 4.72; 4.72 - 4.82; 4.92 - 5.02; 5.02 - 5.12
87	X87200000	4.17	4.4	201.19	341.39	42.15	275.56	1223.74	4.27	4.37	3	4.3 - 4.4
87	X87200000	5.14	5.47	134.32	341.79	50.84	269.81	1757.18	5.24	5.34	4	
87	X87200000	4.4	4.52	270.81	312.17	49.62	243.26	1669.7	4.42	4.52	5	4.4 - 4.5
87	X87200000	5.94	7.41	105.87	283.88	48.67	217.76	1602.25	6.24	6.34	6	6.04 - 6.14; 6.14 - 6.24; 6.34 - 6.44; 6.44 - 6.54; 6.84 - 6.94
87	X87200000	9.84	10.03	133.13	227.16	47.21	166.42	1497.73	9.93	10.03	7	
87	X87200000	10.41	10.53	222.39	227.16	47.21	166.42	1497.73	10.43	10.53	8	10.41 - 10.51
87	X87200000	8.09	9.84	88.74	225.35	49.7	162.75	1655.64	9.39	9.49	9	8.39 - 8.49; 9.09 - 9.19; 9.49 - 9.59; 9.69 - 9.79
86	X86470000	16.35	18.21	40.06	211.4	22.11	162.44	355.4	16.95	17.05	10	16.55 - 16.65; 16.65 - 16.75; 17.95 - 18.05
10	X10190000	23.45	25.54	32.19	201.84	42.52	144.07	1224.54	23.65	23.75	11	
87	X87200000	7.41	7.72	118.38	188.75	46.73	131.29	1460.16	7.41	7.51	12	
10	X10075000	23.57	24.91	21.14	172.63	11.31	129.87	103.34	23.87	23.97	13	24.57 - 24.67
86	X86470000	12.36	15.28	23.79	155.36	22.11	114.97	344.8	14.56	14.66	14	12.56 - 12.66; 13.56 - 13.66; 15.06 - 15.16
86	X86470000	8.81	11.31	30.03	145.14	22	106.29	339.83	10.51	10.61	15	9.51 - 9.61; 11.01 - 11.11
10	X10075000	27.96	30.1	18.84	137.86	11.31	105.12	97.6	28.06	28.16	16	29.06 - 29.16
10	X10190000	19.65	22.02	36.82	157.59	42.52	104.08	1213.88	20.05	20.15	17	
77	X77160000	6.09	7.34	20.24	149.31	34.96	102.89	825.77	7.24	7.34	18	7.19 - 7.29
93	X93470000	0	2.47	17.63	145.19	16.73	102.22	208.34	1.7	1.8	19	0.7 - 0.8
93	X93470000	3.75	7.73	15.55	144.84	14.73	102.05	165.15	7.63	7.73	20	4.65 - 4.75; 5.65 - 5.75; 6.55 - 6.65; 7.55 - 7.65

Table 6-13: List of High Crash Locations on Urban Freeways – 6 Lanes (Site Subtype 156) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
District 1												
13	X13075000	0.73	2.94	12.58	92.67	23.88	57.97	390.78	1.03	1.13	1	
16	X16320000	12.9	14.61	7.93	69.45	10.63	45.4	82.25	13.3	13.4	2	
16	X16320000	9.51	11.79	6.94	68.41	10.9	44.49	86.08	11.31	11.41	3	
16	X16320000	3.45	4.38	10.55	68.65	14.79	42.92	153.48	4.05	4.15	4	
16	X16320000	16.12	16.94	11.45	44.07	10.63	26.18	78.94	16.62	16.72	5	
17	X17075000	37.1	38.16	4.54	29.23	5.8	18.74	23.74	38	38.1	6	38.06 - 38.16
17	X17075000	34.89	35.43	5.45	27.86	5.8	17.32	23.77	35.33	35.43	7	
17	X17075000	39.69	41.67	3.59	24.02	5.8	14.63	23.41	40.09	40.19	8	
District 2												
26	X26260000	11.76	13.93	11.65	87.74	9.19	58.2	65.34	11.96	12.06	1	12.06 - 12.16; 13.46 - 13.56
26	X26260000	18.94	19.41	22.33	88.61	9.19	57.12	66.03	19.14	19.24	2	
26	X26260000	17.85	18.47	15.29	86.28	9.19	55.45	65.75	18.15	18.25	3	
26	X26260000	15.77	16.36	14.26	73.34	9.19	47.13	63.83	16.07	16.17	4	
72	X72001000	12.4	14.69	10.74	73.28	19.47	44.59	260.2	12.7	12.8	5	
72	X72280000	0	2.6	5.89	63.65	17.56	40.05	209.04	2.3	2.4	6	
72	X72002000	6.9	9.34	17.87	65.27	11.14	39.79	90.49	7.3	7.4	7	6.9 - 7.0; 7.9 - 8.0; 9.2 - 9.3
26	X26260000	15.28	15.77	13.93	62.56	9.19	39.21	62.58	15.58	15.68	8	15.48 - 15.58
29	X29180000	19.88	22.72	5.43	66.23	5.7	36.94	27.25	21.48	21.58	9	20.48 - 20.58; 22.48 - 22.58
72	X72001000	15.99	16.24	34.73	62.02	19.47	35.58	257.73	16.09	16.19	10	
District 3												
55	X55320000	6.04	8.32	14.57	87.55	9	51.81	64.74	8.04	8.14	1	6.44 - 6.54; 7.44 - 7.54
55	X55320000	2.78	4.58	6.36	38.82	6.34	19.95	30.34	3.18	3.28	2	

Table 6-13: List of High Crash Locations on Urban Freeways – 6 Lanes (Site Subtype 156) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
48	X48260000	16.72	19.18	3	23.93	4.39	11.88	14.35	17.52	17.62	3	
District 4												
86	X86470000	16.35	18.21	40.06	211.4	22.11	162.44	355.4	16.95	17.05	1	16.55 - 16.65; 16.65 - 16.75; 17.95 - 18.05
86	X86470000	12.36	15.28	23.79	155.36	22.11	114.97	344.8	14.56	14.66	2	12.56 - 12.66; 13.56 - 13.66; 15.06 - 15.16
86	X86470000	8.81	11.31	30.03	145.14	22	106.29	339.83	10.51	10.61	3	9.51 - 9.61; 11.01 - 11.11
93	X93470000	0	2.47	17.63	145.19	16.73	102.22	208.34	1.7	1.8	4	0.7 - 0.8
93	X93470000	3.75	7.73	15.55	144.84	14.73	102.05	165.15	7.63	7.73	5	4.65 - 4.75; 5.65 - 5.75; 6.55 - 6.65; 7.55 - 7.65
93	X93220000	41.2	43.22	18.34	157.43	50.14	98.01	1675.6	41.3	41.4	6	
86	X86470000	0	2.07	22.48	135.32	23.96	96.63	397.92	1.8	1.9	7	1.7 - 1.8
86	X86470000	3.2	5.96	27.16	132.67	25.6	93.3	451.33	5.7	5.8	8	3.9 - 4.0
93	X93220000	45.1	45.66	23.83	147.66	50.14	88.78	1674.4	45.2	45.3	9	
94	X94001000	5.11	6.93	18.93	130.26	10.23	84.18	86.74	5.31	5.41	10	6.71 - 6.81
District 5												
77	X77160000	6.09	7.34	20.24	149.31	34.96	102.89	825.77	7.24	7.34	1	7.19 - 7.29
36	X36210000	5.72	12.94	10.14	126.54	14.28	87.83	153.23	6.92	7.02	2	5.92 - 6.02; 7.92 - 8.02; 8.92 - 9.02; 9.92 - 10.02; 10.92 - 11.02; 11.92 - 12.02
36	X36210000	12.94	13.26	35.51	108.46	14.28	73.68	150.37	12.94	13.04	3	
79	X79002000	43.84	44.88	11.32	83.25	11.31	51.74	96.12	44.74	44.84	4	44.78 - 44.88
73	X73001000	5.81	10.09	9.45	72.17	10.68	44.84	84.64	6.21	6.31	5	7.21 - 7.31; 9.01 - 9.11; 9.99 - 10.09
79	X79002000	31.6	31.79	39.63	71.33	12.29	43.03	110.1	31.6	31.7	6	
36	X36210000	2.91	4.33	9.57	66.86	10.76	42.54	84.3	3.91	4.01	7	2.91 - 3.01
36	X36210000	18.44	21.42	7.17	65.29	13.92	39.1	137.32	18.84	18.94	8	19.84 - 19.94

Table 6-13: List of High Crash Locations on Urban Freeways – 6 Lanes (Site Subtype 156) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
79	X79002000	35.87	36.72	8.27	64.45	11.86	38.11	102.08	36.27	36.37	9	
36	X36210000	14.66	15.78	10.3	62.9	13.92	37.98	136.41	14.96	15.06	10	
District 6												
87	X87200000	4.52	5.14	211.01	374.91	50.69	300.63	1754.3	4.82	4.92	1	4.62 - 4.72; 4.72 - 4.82; 4.92 - 5.02; 5.02 - 5.12
87	X87200000	4.17	4.4	201.19	341.39	42.15	275.56	1223.7	4.27	4.37	2	4.3 - 4.4
87	X87200000	5.14	5.47	134.32	341.79	50.84	269.81	1757.2	5.24	5.34	3	
87	X87200000	4.4	4.52	270.81	312.17	49.62	243.26	1669.7	4.42	4.52	4	4.4 - 4.5
87	X87200000	5.94	7.41	105.87	283.88	48.67	217.76	1602.2	6.24	6.34	5	6.04 - 6.14; 6.14 - 6.24; 6.34 - 6.44; 6.44 - 6.54; 6.84 - 6.94
87	X87200000	9.84	10.03	133.13	227.16	47.21	166.42	1497.7	9.93	10.03	6	
87	X87200000	10.41	10.53	222.39	227.16	47.21	166.42	1497.7	10.43	10.53	7	10.41 - 10.51
87	X87200000	8.09	9.84	88.74	225.35	49.7	162.75	1655.6	9.39	9.49	8	8.39 - 8.49; 9.09 - 9.19; 9.49 - 9.59; 9.69 - 9.79
87	X87200000	7.41	7.72	118.38	188.75	46.73	131.29	1460.2	7.41	7.51	9	
87	X87200000	7.72	7.99	129.05	154.3	46.92	99.28	1464.9	7.82	7.92	10	
District 7												
10	X10190000	0	1.48	91.08	515.75	37.15	433.84	1003.5	0.7	0.8	1	0.0 - 0.1; 1.1 - 1.2; 1.2 - 1.3
10	X10190000	23.45	25.54	32.19	201.84	42.52	144.07	1224.5	23.65	23.75	2	
10	X10075000	23.57	24.91	21.14	172.63	11.31	129.87	103.34	23.87	23.97	3	24.57 - 24.67
10	X10075000	27.96	30.1	18.84	137.86	11.31	105.12	97.6	28.06	28.16	4	29.06 - 29.16
10	X10190000	19.65	22.02	36.82	157.59	42.52	104.08	1213.9	20.05	20.15	5	
10	X10075000	12.55	15.75	11.57	99.45	11.31	71.7	94.49	13.25	13.35	6	14.25 - 14.35; 14.45 - 14.55; 15.45 - 15.55
10	X10075000	7.15	7.92	10.71	82.46	10.76	57.07	84.97	7.45	7.55	7	
10	X10075000	10.66	11.35	11.34	71.7	10.76	48.51	83.75	11.16	11.26	8	
10	X10075000	7.92	8.61	12.13	69.91	10.76	47.08	83.54	8.42	8.52	9	

Table 6-13: List of High Crash Locations on Urban Freeways – 6 Lanes (Site Subtype 156) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
10	X10075000	4.38	5.57	7.01	53.39	7.02	35.87	36.44	4.38	4.48	10	5.38 - 5.48

Table 6-14: List of High Crash Locations on Urban Freeways – 8+ Lanes (Site Subtype 157)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
all-state												
87	X87200000	5.47	5.94	76.52	329.87	32.13	272.18	917.69	5.77	5.87	1	
86	X86070000	19.05	19.63	66.58	331.08	56.73	259.37	2726.1	19.35	19.45	2	
93	X93220000	10.64	13	32.13	297.02	33.07	241.58	962.21	12.74	12.84	3	10.94 - 11.04
93	X93220000	0.15	0.92	51.04	276.95	36.27	221.12	1143.8	0.45	0.55	4	
86	X86070000	17.19	17.59	69.93	271.63	56.73	203.18	2711.8	17.29	17.39	5	
87	X87270000	13.66	14.11	108.71	245.99	43.6	187.74	1622.4	13.76	13.86	6	14.01 - 14.11
86	X86070000	11.97	12.89	55.51	232.12	56.73	166.19	2700.2	12.37	12.47	7	12.27 - 12.37
93	X93220000	3.53	4.33	52.68	202.83	36.17	153.09	1121.5	3.73	3.83	8	4.13 - 4.23
87	X87005000	0.97	1.2	108.08	188.83	14.39	145.12	201.91	0.97	1.07	9	1.07 - 1.17
86	X86070000	22.38	22.99	39.98	207.86	56.73	142.65	2697.8	22.58	22.68	10	
14	X14140000	0.29	0.88	40.14	185.21	18.65	139.03	325.83	0.59	0.69	11	
93	X93220000	29.04	30.67	24.9	177.42	31.86	133.2	870.83	30.24	30.34	12	29.44 - 29.54
15	X15190000	16.64	19.65	18.85	164.64	23.39	125.66	481.31	19.34	19.44	13	17.34 - 17.44; 18.34 - 18.44
15	X15190000	14.69	16.64	24.47	152.71	23.39	115.05	479.06	15.29	15.39	14	14.79 - 14.89; 16.29 - 16.39
72	X72001000	5.12	8.28	19.76	151.98	23.01	112.53	467.72	5.82	5.92	15	7.52 - 7.62
10	X10075000	17.07	18.84	12.9	130.44	12.67	100.32	149.41	17.47	17.57	16	18.47 - 18.57
87	X87003000	3.32	3.75	63.02	130.27	17.45	95.48	275.16	3.62	3.72	17	3.42 - 3.52; 3.52 - 3.62; 3.65 - 3.75
75	X75280000	3.31	4.51	18.1	133.75	31.26	94.18	829.45	3.61	3.71	18	
87	X87270000	15.14	15.75	54.35	140.52	43.6	90.25	1595.4	15.34	15.44	19	
93	X93220000	22.36	22.85	41.69	109.59	31.86	71.25	856.63	22.46	22.56	20	
District 1												
No high crash locations were identified												

Table 6-14: List of High Crash Locations on Urban Freeways – 8+ Lanes (Site Subtype 157) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
District 2												
72	X72001000	5.12	8.28	19.76	151.98	23.01	112.53	467.72	5.82	5.92	1	7.52 - 7.62
District 3												
No high crash locations were identified												
District 4												
86	X86070000	19.05	19.63	66.58	331.08	56.73	259.37	2726.1	19.35	19.45	1	
93	X93220000	10.64	13	32.13	297.02	33.07	241.58	962.21	12.74	12.84	2	10.94 - 11.04
93	X93220000	0.15	0.92	51.04	276.95	36.27	221.12	1143.8	0.45	0.55	3	
86	X86070000	17.19	17.59	69.93	271.63	56.73	203.18	2711.8	17.29	17.39	4	
86	X86070000	11.97	12.89	55.51	232.12	56.73	166.19	2700.2	12.37	12.47	5	12.27 - 12.37
93	X93220000	3.53	4.33	52.68	202.83	36.17	153.09	1121.5	3.73	3.83	6	4.13 - 4.23
86	X86070000	22.38	22.99	39.98	207.86	56.73	142.65	2697.8	22.58	22.68	7	
93	X93220000	29.04	30.67	24.9	177.42	31.86	133.2	870.83	30.24	30.34	8	29.44 - 29.54
93	X93220000	22.36	22.85	41.69	109.59	31.86	71.25	856.63	22.46	22.56	9	
District 5												
75	X75280000	3.31	4.51	18.1	133.75	31.26	94.18	829.45	3.61	3.71	1	
75	X75470000	7.12	9.6	10.53	84.64	13.13	58.42	155.82	9.32	9.42	2	8.32 - 8.42
77	X77160000	0.64	0.99	35.48	90.56	28.48	55.9	686.31	0.89	0.99	3	
District 6												
87	X87200000	5.47	5.94	76.52	329.87	32.13	272.18	917.69	5.77	5.87	1	
87	X87270000	13.66	14.11	108.71	245.99	43.6	187.74	1622.4	13.76	13.86	2	14.01 - 14.11
87	X87005000	0.97	1.2	108.08	188.83	14.39	145.12	201.91	0.97	1.07	3	1.07 - 1.17
87	X87003000	3.32	3.75	63.02	130.27	17.45	95.48	275.16	3.62	3.72	4	3.42 - 3.52; 3.52 - 3.62; 3.65 - 3.75
87	X87270000	15.14	15.75	54.35	140.52	43.6	90.25	1595.4	15.34	15.44	5	
87	X87075000	2.55	3.43	10.53	70.97	20.9	44.19	372.07	2.65	2.75	6	
87	X87075000	3.43	3.57	49.06	68.68	20.9	42.17	371.66	3.43	3.53	7	

Table 6-14: List of High Crash Locations on Urban Freeways – 8+ Lanes (Site Subtype 157) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
87	X87471000	14.61	15.32	21.39	49.35	13.4	31.28	153.91	15.11	15.21	8	
87	X87471000	17.01	17.47	22.82	46.68	13.4	29.16	153.32	17.21	17.31	9	
District 7												
14	X14140000	0.29	0.88	40.14	185.21	18.65	139.03	325.83	0.59	0.69	1	
15	X15190000	16.64	19.65	18.85	164.64	23.39	125.66	481.31	19.34	19.44	2	17.34 - 17.44; 18.34 - 18.44
15	X15190000	14.69	16.64	24.47	152.71	23.39	115.05	479.06	15.29	15.39	3	14.79 - 14.89; 16.29 - 16.39
10	X10075000	17.07	18.84	12.9	130.44	12.67	100.32	149.41	17.47	17.57	4	18.47 - 18.57

Table 6-15: List of High Crash Locations on Urban Freeways within Interchange Area – 4 Lanes (Site Subtype 158)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
all-state												
10	X10190000	2.51	3.85	142.01	378.88	55.19	283.39	1190.2	3.71	3.81	1	2.61 - 2.71; 2.71 - 2.81; 3.11 - 3.21; 3.31 - 3.41; 3.51 - 3.61; 3.75 - 3.85
14	X14140000	0.88	1.67	92.48	249.19	26.52	166.1	302.45	1.28	1.38	2	1.08 - 1.18; 1.38 - 1.48
87	X87005000	3.83	4.45	110.73	201.98	37.97	132.24	568.87	3.83	3.93	3	3.93 - 4.03; 4.13 - 4.23
86	X86471000	5.44	7.64	21.13	177.77	11.92	108.62	69.53	6.64	6.74	4	6.94 - 7.04; 7.14 - 7.24
87	X87005000	4.45	5.04	38.94	148.31	26.08	93.5	273.42	4.65	4.75	5	
75	X75008000	1.82	5.12	12.16	99.19	18.69	60.42	140.2	5.02	5.12	6	
10	X10320000	0.17	0.47	74.29	96.37	24.62	58.59	233.59	0.17	0.27	7	
87	X87005000	6.38	7.03	47.71	101.78	26.08	57.91	265.51	6.48	6.58	8	6.93 - 7.03
10	X10470000	3.42	4.99	24.55	101.2	13.99	56.68	83.6	4.42	4.52	9	3.72 - 3.82; 3.82 - 3.92
72	X72020000	2.81	4.22	60.32	90.35	26.24	53.15	262.83	3.01	3.11	10	2.91 - 3.01; 3.31 - 3.41; 3.51 - 3.61; 3.61 - 3.71
72	X72020000	4.22	4.74	58.77	94.52	35.08	50.33	463.4	4.64	4.74	11	
93	X93470000	25.29	25.85	24.89	85.77	17.28	47.99	120.65	25.75	25.85	12	25.69 - 25.79
14	X14140000	4.53	5.18	43	83.09	14.37	45.88	85.39	4.83	4.93	13	4.53 - 4.63; 4.93 - 5.03; 5.03 - 5.13; 5.08 - 5.18
72	X72020000	2.66	2.81	74.73	79.24	25.53	44.44	247.7	2.71	2.81	14	2.66 - 2.76
70	X70220000	30.65	31.87	19.13	81	19.18	43.67	146.41	31.15	31.25	15	
70	X70220000	20.14	21.41	23.93	77.82	12.93	42.74	69.59	20.64	20.74	16	20.54 - 20.64
10	X10075000	30.21	31.94	31.8	69.39	15.56	41.65	95.22	31.01	31.11	17	30.51 - 30.61; 30.81 - 30.91; 30.91 - 31.01; 31.11 - 31.21; 31.21 - 31.31; 31.61 - 31.71
87	X87005000	1.69	2.21	41.33	75.28	18.51	41.33	135.28	2.11	2.21	18	1.99 - 2.09; 2.09 - 2.19
10	X10075000	31.94	33.28	26.05	69.8	15.56	41.19	95.62	31.94	32.04	19	32.04 - 32.14; 32.14 - 32.24; 33.18 - 33.28

Table 6-15: List of High Crash Locations on Urban Freeways within Interchange Area – 4 Lanes (Site Subtype 158) (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
87	X87021000	0.46	1.4	15.73	79.16	8.46	39.7	32.48	0.56	0.66	20	
District 1												
12	X12075000	11.5	12.68	13.16	67.62	16.53	36.05	108.45	11.6	11.7	1	
12	X12075000	7.66	8.37	21.32	51.45	17.35	24.21	116.81	8.26	8.36	2	
12	X12075000	23.48	24.75	15.88	48.11	16.53	22.21	106.06	24.08	24.18	3	
District 2												
72	X72020000	2.81	4.22	60.32	90.35	26.24	53.15	262.83	3.01	3.11	1	2.91 - 3.01; 3.31 - 3.41; 3.51 - 3.61; 3.61 - 3.71
72	X72020000	4.22	4.74	58.77	94.52	35.08	50.33	463.4	4.64	4.74	2	
72	X72020000	2.66	2.81	74.73	79.24	25.53	44.44	247.7	2.71	2.81	3	2.66 - 2.76
72	X72292000	5.26	7.01	19.8	76.56	27.75	37.77	294.38	6.26	6.36	4	
72	X72270000	15.28	16.49	16.27	35.23	8.86	19.94	30.73	15.58	15.68	5	
72	X72270000	10.91	12.05	10.86	33.56	8.86	18.16	30.78	11.41	11.51	6	
72	X72090000	2.91	3.09	26.3	38.99	9.98	16.4	40.28	2.91	3.01	7	
72	X72002000	5.26	6.47	14.73	34.28	11.42	14.74	51.18	5.96	6.06	8	
72	X72090000	2.65	2.91	13.79	27.42	5.63	10.72	13.2	2.75	2.85	9	
72	X72090000	7.38	7.66	10.16	24.39	5.27	9.27	11.51	7.48	7.58	10	
District 3												
55	X55320000	8.63	9.02	33.39	65.11	12.83	31.97	67.88	8.83	8.93	1	
58	X58002000	3.03	4.38	11.48	64.03	10.4	28.34	46.18	3.13	3.23	2	4.13 - 4.23
55	X55320000	8.46	8.63	36.99	53.27	12.83	24.73	66.57	8.53	8.63	3	
48	X48260000	9.88	10.55	16.88	29.83	7	12.81	20.01	10.28	10.38	4	10.18 - 10.28
58	X58002000	7.26	8.75	3.93	33.06	4.92	11.6	10.51	8.36	8.46	5	
58	X58002000	12.61	14.06	4.61	30.42	5.27	10.28	11.84	13.61	13.71	6	
48	X48270000	0	0.54	9.23	21.61	6.12	8.86	15.02	0	0.1	7	
District 4												
86	X86471000	5.44	7.64	21.13	177.77	11.92	108.62	69.53	6.64	6.74	1	6.94 - 7.04; 7.14 - 7.24

Table 6-15: List of High Crash Locations on Urban Freeways within Interchange Area – 4 Lanes (Site Subtype 158) (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
93	X93470000	25.29	25.85	24.89	85.77	17.28	47.99	120.65	25.75	25.85	2	25.69 - 25.79
93	X93470000	26.63	27.67	19.39	62.69	17.28	31.65	117.69	26.93	27.03	3	
93	X93470000	32.8	34.17	18.1	61.31	17.28	30.49	117.61	33.9	34	4	
93	X93470000	19.57	20.78	28.73	58.84	17.28	29.13	117.09	20.37	20.47	5	19.57 - 19.67; 19.97 - 20.07
94	X94001000	23.37	24.9	9.26	38.88	10.69	16.43	45.87	24.17	24.27	6	
89	X89470000	13.22	14.25	5.66	28.87	6.62	11.12	18.04	13.72	13.82	7	
88	X88081000	5.56	6.35	13.02	25.15	6	9.34	14.76	5.86	5.96	8	6.16 - 6.26
District 5												
75	X75008000	1.82	5.12	12.16	99.19	18.69	60.42	140.2	5.02	5.12	1	
70	X70220000	30.65	31.87	19.13	81	19.18	43.67	146.41	31.15	31.25	2	
70	X70220000	20.14	21.41	23.93	77.82	12.93	42.74	69.59	20.64	20.74	3	20.54 - 20.64
75	X75470000	5.16	5.77	18.41	68.73	15.15	37.05	92.15	5.36	5.46	4	
75	X75470000	22.91	24.44	17.63	65.46	15.53	34.09	96.41	23.51	23.61	5	
70	X70220000	40.97	41.5	28.37	63.64	19.18	31.41	143.9	41.27	41.37	6	
75	X75470000	18.24	19.66	18.87	56.84	15.75	28.3	97.93	18.64	18.74	7	18.74 - 18.84
70	X70220000	35.1	36.62	16.67	54.96	19.18	25.28	142.65	36.3	36.4	8	
70	X70220000	15.6	17.1	14.87	44.61	9.98	21.83	40.38	16.6	16.7	9	
79	X79002000	22.65	23.88	12.42	37.88	10.38	16.89	43.07	23.75	23.85	10	23.45 - 23.55; 23.78 - 23.88
District 6												
87	X87005000	3.83	4.45	110.73	201.98	37.97	132.24	568.87	3.83	3.93	1	3.93 - 4.03; 4.13 - 4.23
87	X87005000	4.45	5.04	38.94	148.31	26.08	93.5	273.42	4.65	4.75	2	
87	X87005000	6.38	7.03	47.71	101.78	26.08	57.91	265.51	6.48	6.58	3	6.93 - 7.03
87	X87005000	1.69	2.21	41.33	75.28	18.51	41.33	135.28	2.11	2.21	4	1.99 - 2.09; 2.09 - 2.19
87	X87021000	0.46	1.4	15.73	79.16	8.46	39.7	32.48	0.56	0.66	5	
87	X87260000	2.27	3.42	25.4	64.54	21.87	35.15	181.62	3.32	3.42	6	

Table 6-15: List of High Crash Locations on Urban Freeways within Interchange Area – 4 Lanes (Site Subtype 158) (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
87	X87470000	0.34	0.58	133.52	66.66	17.61	35.01	122.19	0.48	0.58	7	0.44 - 0.54
87	X87470000	0.17	0.34	59.29	64.09	17.61	33.18	121.86	0.24	0.34	8	0.17 - 0.27
87	X87260000	0.68	2.27	13.16	45.14	15.9	23.64	96.13	0.78	0.88	9	1.88 - 1.98
87	X87471000	38.76	39.67	21.85	47.34	16.79	23.31	108.11	39.26	39.36	10	
District 7												
10	X10190000	2.51	3.85	142.01	378.88	55.19	283.39	1190.2	3.71	3.81	1	2.61 - 2.71; 2.71 - 2.81; 3.11 - 3.21; 3.31 - 3.41; 3.51 - 3.61; 3.75 - 3.85
14	X14140000	0.88	1.67	92.48	249.19	26.52	166.1	302.45	1.28	1.38	2	1.08 - 1.18; 1.38 - 1.48
10	X10320000	0.17	0.47	74.29	96.37	24.62	58.59	233.59	0.17	0.27	3	
10	X10470000	3.42	4.99	24.55	101.2	13.99	56.68	83.6	4.42	4.52	4	3.72 - 3.82; 3.82 - 3.92
14	X14140000	4.53	5.18	43	83.09	14.37	45.88	85.39	4.83	4.93	5	4.53 - 4.63; 4.93 - 5.03; 5.03 - 5.13; 5.08 - 5.18
10	X10075000	30.21	31.94	31.8	69.39	15.56	41.65	95.22	31.01	31.11	6	30.51 - 30.61; 30.81 - 30.91; 30.91 - 31.01; 31.11 - 31.21; 31.21 - 31.31; 31.61 - 31.71
10	X10075000	31.94	33.28	26.05	69.8	15.56	41.19	95.62	31.94	32.04	7	32.04 - 32.14; 32.14 - 32.24; 33.18 - 33.28
10	X10470000	0.82	1.71	25.1	58.54	13.13	29.14	69.79	0.92	1.02	8	
10	X10002000	4.4	6.79	9.96	65.36	7.41	28.79	24.82	4.5	4.6	9	4.4 - 4.5
10	X10075000	35.3	36.94	20.27	52.48	15.56	27.47	94.13	36	36.1	10	35.6 - 35.7; 35.9 - 36.0; 36.1 - 36.2

Table 6-16: List of High Crash Locations on Urban Freeways within Interchange Area – 6 Lanes (Site Subtype 159)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
all-state												
10	X10190000	7.57	7.68	349.83	381.86	54.06	289.83	1311.5	7.58	7.68	1	
10	X10190000	3.85	5.63	152.82	376.28	59.64	281.78	1580.7	5.25	5.35	2	4.05 - 4.15; 4.15 - 4.25; 4.35 - 4.45; 4.55 - 4.65; 4.95 - 5.05; 5.35 - 5.45; 5.45 - 5.55
87	X87270000	4.37	5.05	201.23	341.84	76.12	244.69	2502.7	4.87	4.97	3	4.47 - 4.57; 4.67 - 4.77; 4.77 - 4.87
93	X93220000	26.83	27.91	97.02	297.46	55.52	216.9	1353.7	26.93	27.03	4	27.13 - 27.23
75	X75008000	7.64	8.9	49.87	257.76	30.41	183.97	438.67	8.74	8.84	5	
87	X87270000	13.18	13.37	157.33	273.42	86.88	171.2	3232.0	13.27	13.37	6	
10	X10190000	22.02	23.45	27.41	237.21	48	164.31	1019.0	22.12	22.22	7	
15	X15190000	7.41	8.27	50.29	202.23	31.82	142.9	460.68	7.51	7.61	8	
87	X87270000	3.54	4.37	85.67	229.72	76.12	141.44	2476.7	4.27	4.37	9	4.24 - 4.34
10	X10320000	1.55	4.66	91.08	208.61	48.23	139.98	1020.6	2.45	2.55	10	1.65 - 1.75; 1.95 - 2.05; 2.25 - 2.35; 2.35 - 2.45; 2.65 - 2.75; 3.35 - 3.45; 3.45 - 3.55; 3.55 - 3.65; 3.95 - 4.05; 4.45 - 4.55
87	X87260000	6.96	7.18	175.28	212.24	59.11	136.6	1512.7	7.08	7.18	11	7.06 - 7.16
10	X10320000	1.2	1.55	145.03	199.53	48.08	132.15	1012.5	1.3	1.4	12	1.4 - 1.5; 1.45 - 1.55
87	X87270000	12.67	13.18	132.75	227.85	86.88	129.38	3219.5	12.77	12.87	13	
87	X87075000	0.25	0.54	91.92	188.92	37.41	128.94	623.66	0.25	0.35	14	

Table 6-16: List of High Crash Locations on Urban Freeways within Interchange Area – 6 Lanes (Site Subtype 159) (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
10	X10075000	24.91	27.96	36.87	179.24	14.89	128.17	112.34	26.71	26.81	15	25.11 - 25.21; 25.41 - 25.51; 25.51 - 25.61; 25.61 - 25.71; 25.71 - 25.81; 25.81 - 25.91; 25.91 - 26.01; 26.11 - 26.21; 26.51 - 26.61; 26.61 - 26.71; 26.81 - 26.91; 26.91 - 27.01; 27.21 - 27.31; 27.51 - 27.61
87	X87270000	2.98	3.54	105.79	200.1	70.36	119.08	2115.3	3.44	3.54	16	
15	X15190000	2.64	2.74	165.79	165.79	24.25	116.2	271.38	2.64	2.74	17	
87	X87260000	14.93	17.03	58.04	166.08	40.63	109.87	721.73	16.03	16.13	18	
93	X93220000	27.91	29.04	108.57	170.62	55.52	103.08	1326.7	28.31	28.41	19	
10	X10190000	11.72	15.69	28.69	146.35	31.62	98.87	441.67	15.32	15.42	20	15.59 - 15.69
District 1												
13	X13075000	6.58	7.8	23.87	69.42	23.79	35.67	249.49	7.48	7.58	1	
16	X16320000	11.79	12.9	21.33	62.55	14.1	35.13	91.09	12.39	12.49	2	12.29 - 12.39
16	X16320000	14.61	16.02	17.53	46.36	14.1	23.47	89.14	14.61	14.71	3	
District 2												
72	X72001000	9.34	12.4	29.25	96.51	24.07	57.53	259.04	9.64	9.74	1	9.54 - 9.64; 9.74 - 9.84; 11.14 - 11.24; 12.14 - 12.24
72	X72001000	1.89	3.18	32.18	103.01	34.46	56.34	519.77	1.99	2.09	2	
26	X26260000	13.93	14.48	38.81	70.62	12.4	40.45	72.66	14.38	14.48	3	14.13 - 14.23; 14.23 - 14.33; 14.33 - 14.43
26	X26260000	11.07	11.76	27.81	66.07	12.4	37.28	72.16	11.47	11.57	4	11.07 - 11.17; 11.17 - 11.27
72	X72270000	20.66	21.04	35.63	54.7	8.26	36.86	31.72	20.94	21.04	5	20.66 - 20.76; 20.86 - 20.96
72	X72020000	2.48	2.66	39.25	46.7	11.21	28.69	56.11	2.48	2.58	6	

Table 6-16: List of High Crash Locations on Urban Freeways within Interchange Area – 6 Lanes (Site Subtype 159) (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
26	X26260000	9.68	10.98	17.49	53.24	13.32	27.43	81.27	9.98	10.08	7	
26	X26260000	16.36	17.13	16.73	51.54	12.4	26.96	70.65	16.56	16.66	8	
72	X72270000	18.02	20.26	14.53	37.58	8.26	23.17	30.78	20.16	20.26	9	19.02 - 19.12; 19.52 - 19.62; 19.92 - 20.02; 20.12 - 20.22
72	X72270000	21.04	21.34	23.61	35.87	8.26	21.92	30.65	21.04	21.14	10	21.24 - 21.34
District 3												
55	X55320000	4.67	5.86	16.63	53.97	10.92	25.98	56.57	5.67	5.77	1	
48	X48260000	10.91	12.09	5.99	21.75	6.46	9.15	19.12	11.99	12.09	2	
48	X48260000	16.41	16.72	13.96	18.84	6.46	8.92	19.75	16.41	16.61	3	
District 4												
93	X93220000	26.83	27.91	97.02	297.46	55.52	216.9	1353.7	26.93	27.03	1	27.13 - 27.23
93	X93220000	27.91	29.04	108.57	170.62	55.52	103.08	1326.7	28.31	28.41	2	
86	X86472000	17.8	20.43	14.48	121.41	11.24	76.61	65.37	20.2	20.3	3	
86	X86470000	23.36	25.13	15.79	111.79	26.94	68.63	323.83	24.16	24.26	4	
86	X86470000	15.28	16.35	35.82	95.54	26.94	56.08	320.32	15.78	15.88	5	
93	X93470000	7.73	9.67	30.15	85.82	17.4	49.99	139.76	7.83	7.93	6	9.13 - 9.23
89	X89095000	13.14	14.01	18.54	86.71	15.05	49.61	107.26	13.24	13.34	7	
93	X93470000	2.47	3.75	22.41	70.32	19.26	37.84	166.88	2.77	2.87	8	3.65 - 3.75
89	X89095000	11.45	13.01	18.26	57.71	15.05	29.69	103.3	12.65	12.75	9	
86	X86472000	1.5	2.19	19.31	51.66	17.09	25.04	130.32	2	2.1	10	
District 5												
75	X75008000	7.64	8.9	49.87	257.76	30.41	183.97	438.67	8.74	8.84	1	
75	X75008000	11.04	11.88	48.4	115.7	31.21	67.79	432.79	11.24	11.34	2	
75	X75008000	8.9	10.12	31.2	110.9	30.41	65.13	409.84	9.6	9.7	3	
79	X79110000	5.35	5.6	50.92	106.57	24.76	63.61	276.69	5.35	5.45	4	
75	X75008000	5.77	7.09	41.41	86.92	30.41	45.73	405.14	5.77	5.87	5	

Table 6-16: List of High Crash Locations on Urban Freeways within Interchange Area – 6 Lanes (Site Subtype 159) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
75	X75008000	10.12	10.47	29.09	83.92	30.41	43.3	404.55	10.12	10.22	6	
75	X75008000	10.52	11.04	27.09	80.93	30.41	40.87	403.96	10.62	10.72	7	
36	X36210000	17.2	18.44	18.12	57.6	17.89	28.67	143.49	17.8	17.9	8	
73	X73001000	4.6	5.81	17.85	52.61	14.58	26.15	96.63	5.7	5.8	9	5.71 - 5.81
73	X73001000	10.09	11.65	9.65	43.53	13.7	20.22	84.71	10.99	11.09	10	
District 6												
87	X87270000	4.37	5.05	201.23	341.84	76.12	244.69	2502.7	4.87	4.97	1	4.47 - 4.57; 4.67 - 4.77; 4.77 - 4.87
87	X87270000	13.18	13.37	157.33	273.42	86.88	171.2	3232.0	13.27	13.37	2	
87	X87270000	3.54	4.37	85.67	229.72	76.12	141.44	2476.7	4.27	4.37	3	4.24 - 4.34
87	X87260000	6.96	7.18	175.28	212.24	59.11	136.6	1512.7	7.08	7.18	4	7.06 - 7.16
87	X87270000	12.67	13.18	132.75	227.85	86.88	129.38	3219.5	12.77	12.87	5	
87	X87075000	0.25	0.54	91.92	188.92	37.41	128.94	623.66	0.25	0.35	6	
87	X87270000	2.98	3.54	105.79	200.1	70.36	119.08	2115.3	3.44	3.54	7	
87	X87260000	14.93	17.03	58.04	166.08	40.63	109.87	721.73	16.03	16.13	8	
87	X87260000	17.28	22.22	66.25	147	41.28	92.38	741.49	17.88	17.98	9	17.98 - 18.08; 18.88 - 18.98; 19.98 - 20.08; 20.08 - 20.18; 20.98 - 21.08; 21.08 - 21.18; 21.98 - 22.08; 22.08 - 22.18
87	X87300000	1.37	2.65	26.29	109.43	9.25	58.68	46.68	1.77	1.87	10	1.47 - 1.57; 1.87 - 1.97
District 7												
10	X10190000	7.57	7.68	349.83	381.86	54.06	289.83	1311.4	7.58	7.68	1	
10	X10190000	3.85	5.63	152.82	376.28	59.64	281.78	1580.7	5.25	5.35	2	4.05 - 4.15; 4.15 - 4.25; 4.35 - 4.45; 4.55 - 4.65; 4.95 - 5.05; 5.35 - 5.45; 5.45 - 5.55
10	X10190000	22.02	23.45	27.41	237.21	48	164.31	1019.0	22.12	22.22	3	

Table 6-16: List of High Crash Locations on Urban Freeways within Interchange Area – 6 Lanes (Site Subtype 159) - (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
15	X15190000	7.41	8.27	50.29	202.23	31.82	142.9	460.68	7.51	7.61	4	
10	X10320000	1.55	4.66	91.08	208.61	48.23	139.98	1020.6	2.45	2.55	5	1.65 - 1.75; 1.95 - 2.05; 2.25 - 2.35; 2.35 - 2.45; 2.65 - 2.75; 3.35 - 3.45; 3.45 - 3.55; 3.55 - 3.65; 3.95 - 4.05; 4.45 - 4.55
10	X10320000	1.2	1.55	145.03	199.53	48.08	132.15	1012.5	1.3	1.4	6	1.4 - 1.5; 1.45 - 1.55
10	X10075000	24.91	27.96	36.87	179.24	14.89	128.17	112.34	26.71	26.81	7	25.11 - 25.21; 25.41 - 25.51; 25.51 - 25.61; 25.61 - 25.71; 25.71 - 25.81; 25.81 - 25.91; 25.91 - 26.01; 26.11 - 26.21; 26.51 - 26.61; 26.61 - 26.71; 26.81 - 26.91; 26.91 - 27.01; 27.21 - 27.31; 27.51 - 27.61
15	X15190000	2.64	2.74	165.79	165.79	24.25	116.2	271.38	2.64	2.74	8	
10	X10190000	11.72	15.69	28.69	146.35	31.62	98.87	441.67	15.32	15.42	9	15.59 - 15.69
10	X10320000	0.66	1.2	128.08	160.92	47.77	98.69	991.25	0.86	0.96	10	0.66 - 0.76; 0.96 - 1.06; 1.1 - 1.2

Table 6-17: List of High Crash Locations on Urban Freeways within Interchange Area – 8+ Lanes (Site Subtype 160)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
all-state												
10	X10190000	5.63	6.44	188.33	500.59	67.26	397.4	2329.6	5.73	5.83	1	6.23 - 6.33
87	X87270000	5.43	11.04	164.98	471.38	84.56	363.07	3595.6	10.73	10.83	2	6.13 - 6.23; 6.23 - 6.33; 7.13 - 7.23; 7.23 - 7.33; 8.23 - 8.33; 8.33 - 8.43; 8.73 - 8.83; 8.83 - 8.93; 9.23 - 9.33; 9.73 - 9.83; 10.13 - 10.23; 10.83 - 10.93
87	X87270000	11.04	11.84	167.46	444.77	84.56	338.2	3588.8	11.74	11.84	3	
87	X87260000	3.42	4.22	149.29	399.51	46.17	319.36	1117.4	3.82	3.92	4	3.62 - 3.72; 3.72 - 3.82; 3.92 - 4.02; 4.02 - 4.12; 4.12 - 4.22
87	X87270000	15.75	17.26	102.79	360.22	82.25	260.25	3381.8	16.75	16.85	5	
87	X87260000	4.67	5.53	114.46	344.93	62.76	258.45	2000.9	4.87	4.97	6	
87	X87260000	5.53	6.96	138.17	318.02	64.43	232.55	2098.8	6.43	6.53	7	5.83 - 5.93; 5.93 - 6.03; 6.33 - 6.43
87	X87260000	7.18	8.54	140.21	318.32	79.6	220.94	3172.7	8.28	8.38	8	8.38 - 8.48; 8.44 - 8.54
86	X86070000	12.89	14.1	137.13	292.67	110.96	172.87	6070.9	12.89	12.99	9	
87	X87270000	11.84	12.02	203.31	262.57	84.56	167.14	3545.7	11.84	11.94	10	
87	X87260000	4.42	4.67	96.89	236.71	60.39	161.23	1831.9	4.42	4.52	11	
87	X87005000	2.21	2.9	106.87	222.68	34.81	160.49	638.42	2.31	2.41	12	2.21 - 2.31; 2.41 - 2.51; 2.51 - 2.61; 2.71 - 2.81
86	X86070000	1.27	1.86	137.04	240.42	91.24	141.37	4108.0	1.57	1.67	13	
87	X87260000	22.22	23.98	86.59	212.86	69.18	131.63	2387.3	23.52	23.62	14	23.02 - 23.12; 23.42 - 23.52
87	X87260000	13.02	14.93	80.38	201.25	69.18	121.69	2381.1	13.22	13.32	15	
87	X87005000	3.51	3.83	148.11	177.1	46.74	113.94	1110.0	3.71	3.81	16	3.51 - 3.61; 3.73 - 3.83
87	X87260000	8.54	13.02	85.5	185.88	69.18	107.7	2376.5	10.34	10.44	17	11.24 - 11.34; 12.34 - 12.44
93	X93220000	4.52	5.96	88.15	178.89	66.94	103.24	2225.2	5.02	5.12	18	

Table 6-17: List of High Crash Locations on Urban Freeways within Interchange Area – 8+ Lanes (Site Subtype 160) (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
93	X93220000	0.92	3.53	86.58	177.06	69.9	98.99	2423.4	1.52	1.62	19	
72	X72001000	8.28	9.34	33.37	150.18	43.73	93.52	966.66	8.48	8.58	20	
District 1												
No high crash locations were identified												
District 2												
72	X72001000	8.28	9.34	33.37	150.18	43.73	93.52	966.66	8.48	8.58	1	
72	X72270000	21.34	21.66	22.78	62.15	15.43	40.31	121.68	21.34	21.44	2	
District 3												
No high crash locations were identified												
District 4												
86	X86070000	12.89	14.1	137.13	292.67	110.96	172.87	6070.9	12.89	12.99	1	
86	X86070000	1.27	1.86	137.04	240.42	91.24	141.37	4108.0	1.57	1.67	2	
93	X93220000	4.52	5.96	88.15	178.89	66.94	103.24	2225.2	5.02	5.12	3	
93	X93220000	0.92	3.53	86.58	177.06	69.9	98.99	2423.4	1.52	1.62	4	
93	X93220000	20.3	20.84	111.11	157.37	61.18	88.65	1857.6	20.5	20.6	5	
District 5												
No high crash locations were identified												
District 6												
87	X87270000	5.43	11.04	164.98	471.38	84.56	363.07	3595.6	10.73	10.83	1	6.13 - 6.23; 6.23 - 6.33; 7.13 - 7.23; 7.23 - 7.33; 8.23 - 8.33; 8.33 - 8.43; 8.73 - 8.83; 8.83 - 8.93; 9.23 - 9.33; 9.73 - 9.83; 10.13 - 10.23; 10.83 - 10.93
87	X87270000	11.04	11.84	167.46	444.77	84.56	338.2	3588.8	11.74	11.84	2	
87	X87260000	3.42	4.22	149.29	399.51	46.17	319.36	1117.4	3.82	3.92	3	3.62 - 3.72; 3.72 - 3.82; 3.92 - 4.02; 4.02 - 4.12; 4.12 - 4.22

Table 6-17: List of High Crash Locations on Urban Freeways within Interchange Area – 8+ Lanes (Site Subtype 160) (Cont'd)

County	Route	Site Start Location	Site End Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Start Location	End Location	Rank	Additional Windows of Interest
87	X87270000	15.75	17.26	102.79	360.22	82.25	260.25	3381.8	16.75	16.85	4	
87	X87260000	4.67	5.53	114.46	344.93	62.76	258.45	2000.9	4.87	4.97	5	
87	X87260000	5.53	6.96	138.17	318.02	64.43	232.55	2098.8	6.43	6.53	6	5.83 - 5.93; 5.93 - 6.03; 6.33 - 6.43
87	X87260000	7.18	8.54	140.21	318.32	79.6	220.94	3172.7	8.28	8.38	7	8.38 - 8.48; 8.44 - 8.54
87	X87270000	11.84	12.02	203.31	262.57	84.56	167.14	3545.7	11.84	11.94	8	
87	X87260000	4.42	4.67	96.89	236.71	60.39	161.23	1831.9	4.42	4.52	9	
87	X87005000	2.21	2.9	106.87	222.68	34.81	160.49	638.42	2.31	2.41	10	2.21 - 2.31; 2.41 - 2.51; 2.51 - 2.61; 2.71 - 2.81
District 7												
10	X10190000	5.63	6.44	188.33	500.59	67.26	397.4	2329.6	5.73	5.83	1	6.23 - 6.33
10	X10075000	16.71	17.07	43.81	101.94	23.63	67.09	286.94	16.71	16.81	2	
10	X10470000	0	0.82	20.43	53.3	18.72	27.05	179.72	0.7	0.8	3	

Once the lists of HCLs were generated, the GIS system developed in-house could be used to spatially locate the HCLs. Figure 6-1 shows an example of spatial representation of HCLs in District 6.

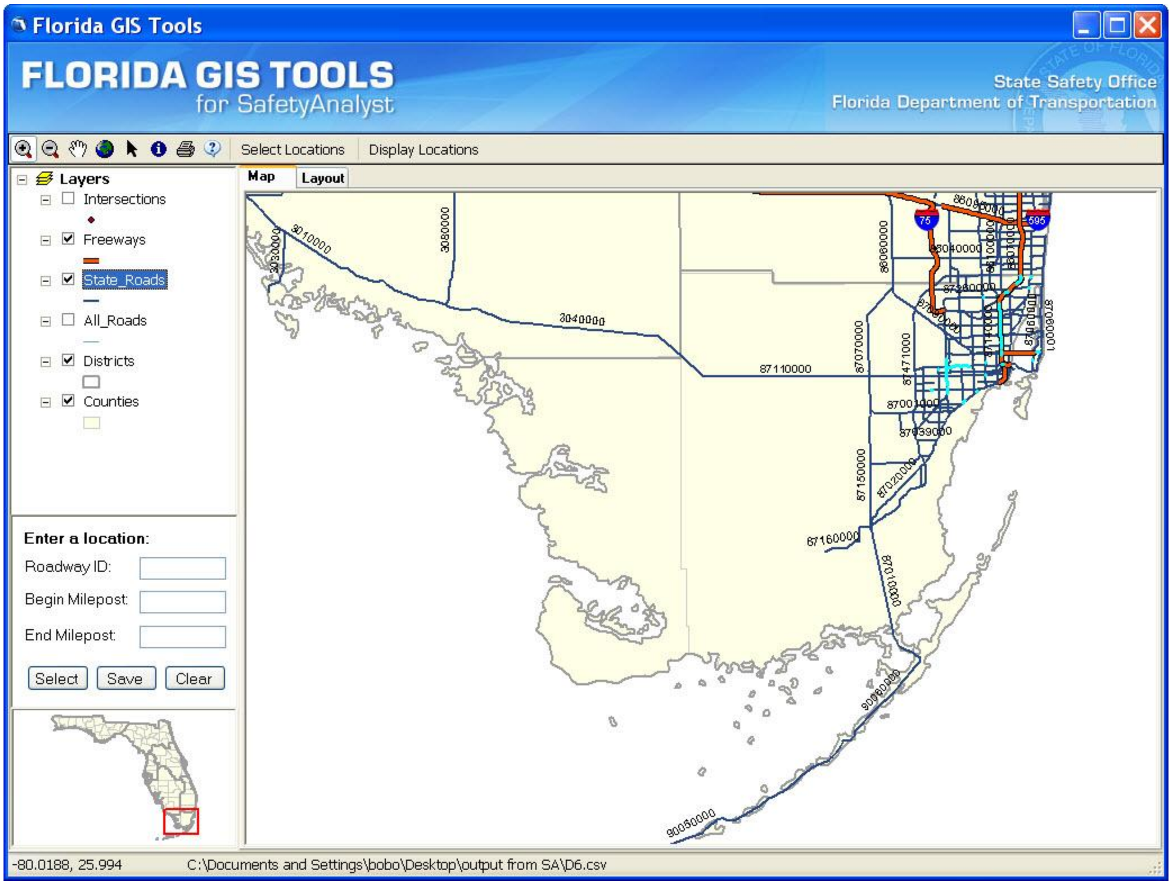


Figure 6-1: Display of High Crash Locations in District 6

<u>*6.1.2 Ramps*</u>

Ramps were analyzed using 2009 RCI data and crash and traffic data from 2008-2010. Traffic data on ramps is complete for only 2010. Therefore, AADT is assumed to be the same for the earlier years (i.e., 2008 and 2009).

SafetyAnalyst reclassifies ramps into 16 site subtypes based on area type, ramp configuration, and ramp type. However, the ramp configurations used within *SafetyAnalyst* were different from the configurations used in Florida. Therefore, ramps were divided into site subtypes using Florida's classification. Table 6-18 lists Florida-specific ramp subtypes used in the analysis.

Table 6-18: Classification of Ramps Based on Florida Data

Site Subtype	Code
Rural Diamond Off ramp	411
Rural Diamond On ramp	412
Rural Partial Diamond Off ramp	413
Rural Partial Diamond On ramp	414
Rural Trumpet Off ramp	415
Rural Trumpet On ramp	416
Rural Parclo Loop Off ramp	417
Rural Parclo Loop On ramp	418
Rural Direct Connection	419
Urban Diamond Off ramp	420
Urban Diamond On ramp	421
Urban Partial Diamond Off ramp	422
Urban Partial Diamond On ramp	423
Urban Trumpet Off ramp	424
Urban Trumpet On ramp	425
Urban Parclo Loop Off ramp	426
Urban Parclo Loop On ramp	427
Urban Direct Connection	428

As the default site subtypes were not used for ramps, import files were generated manually. The following steps were performed to obtain the list of high crash locations:

- Manually generate import files for *SafetyAnalyst*.
- Address a few issues with the generated import files.
- Add the Florida-specific ramp subtypes and Florida-specific SPFs in *SafetyAnalyst* Administration Tool.
- Import, post-process, and calibrate the data files in *SafetyAnalyst* Data Management Tool.
- Open network screening module in *SafetyAnalyst* Analytical Tool and create site lists.
- Perform EB analysis within the network screening module.
- Spatially locate the list of high crash locations in the GIS system.

Basic network screening was performed on the entire state's ramp data. The analysis was performed on ramps with data-set specific distributions and Florida-specific SPFs.

Table 6-19 gives the list of HCLs on ramps. Of the 1,777 ramps that were evaluated, only 90 were ranked. This is because locations should experience a minimum of 1 crash/mile/year to be listed as an HCL. Note that the following table displays only relevant columns from the output.

The following are the additional parameters considered in the analysis:

- Type of analysis: Basic Network Screening
- Accident Severity Level: Total Accidents

• Site Types:	Ramps
• Screening Attribute:	Accident Type and Manner of Collision
• Potential for Safety Improvement Using:	Excess Accident Frequency
• Analysis Period:	From 2008 To 2010
• CV limit:	0.5 (for ramps)
• Area Weights (Rural):	1.0
Area Weights (Urban):	1.0
• Limiting Value:	1.0 crash/mi/yr (for ramps)
• Number of sites in the site list:	2960
• Number of ramps evaluated:	1777
• Number of sites flagged:	90

Table 6-19: List of High Crash Locations on Ramps

Site Subtype	County	Route	Ramp Length (miles)	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Rank
Urban 1-Diamond Off	87	X87260136	0.29	254.7	254.7	15.48	218.74	291.2	1
Urban 2-Partial Diamond Off	12	X12020000	0.06	219.69	219.69	10.68	140.06	160.39	2
Urban 1-Diamond Off	26	X26260026	0.46	125.88	125.88	8.7	106.04	105.44	3
Urban 2-Partial Diamond On	87	X87170355	0.08	99.76	99.76	5.5	61.79	66.48	4
Urban 1-Diamond Off	15	X15190033	0.35	73.17	73.17	10.46	56.26	118.77	5
Urban 1-Diamond Off	26	X26260050	0.42	65.4	65.4	6.28	50.99	53.2	6
Urban 5-Parclo Loop Off	75	X75280081	0.3	66.74	66.74	13.38	48.74	191.72	7
Urban 1-Diamond Off	87	X87260128	0.23	66.17	66.17	12.36	46.87	154.11	8
Urban 1-Diamond Off	10	X10320147	0.27	64.61	64.61	12.96	46.11	167.92	9
Urban 1-Diamond On	87	X87260519	0.03	373.65	373.65	1.49	44.1	4.24	10
Urban 5-Parclo Loop Off	10	X10075336	0.43	55.87	55.87	2.79	40.29	19.34	11
Urban 1-Diamond Off	26	X26260052	0.47	52.12	52.12	9	39.23	87.76	12
Urban 2-Partial Diamond Off	93	X93220085	0.43	50.62	50.62	7.64	39.06	79.65	13
Urban 1-Diamond Off	87	X87260400	0.37	55.17	55.17	13.25	38.61	172.87	14
Urban 2-Partial Diamond Off	87	X87270166	0.33	51.67	51.67	8.72	38.53	99	15
Urban 1-Diamond Off	93	X93220034	0.37	51.16	51.16	9.71	37.11	98.78	16
Urban 2-Partial Diamond Off	10	X10190051	0.39	51.16	51.16	11.58	36.89	163.9	17
Urban 1-Diamond Off	93	X93220038	0.41	51.6	51.6	11.43	36.86	131.87	18
Urban 2-Partial Diamond Off	93	X93220086	0.24	52.91	52.91	4.21	36.72	30.72	19
Urban 5-Parclo Loop On	87	X87260318	0.33	49.71	49.71	8.64	34.65	62	20
Urban 1-Diamond Off	87	X87260132	0.22	53.99	53.99	15.22	34.45	220.8	21
Urban 1-Diamond Off	93	X93220042	0.29	49.92	49.92	11.11	34.33	123.97	22
Urban 1-Diamond Off	93	X93220030	0.36	46.4	46.4	10.32	32.41	108.35	23
Urban 1-Diamond Off	10	X10190090	0.33	44.99	44.99	6.63	32.18	50.95	24
Urban 1-Diamond Off	93	X93220074	0.28	47.72	47.72	13.25	30.96	169.88	25
Urban 1-Diamond On	15	X15190072	0.33	41.4	41.4	4.69	30.2	33.11	26
Urban 1-Diamond Off	93	X93220043	0.24	44.85	44.85	8.78	30.07	80.06	27

Table 6-19: List of High Crash Locations on Ramps - (Cont'd)

Site Subtype	County	Route	Ramp Length (miles)	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Rank
Urban 1-Diamond On	87	X87260518	0.27	40.22	40.22	7.51	28.09	69.93	28
Urban 1-Diamond Off	87	X87260505	0.17	45.85	45.85	12.36	27.91	147.41	29
Urban 5-Parclo Loop Off	10	X10320165	0.18	42.47	42.47	8.73	27.16	83.39	30
Urban 5-Parclo Loop On	10	X10075010	0.42	38.23	38.23	7.58	26.28	48.06	31
Urban 1-Diamond On	14	X14140001	0.26	37.72	37.72	5.48	26.13	40.47	32
Urban 3-Trumpet Off	86	X86470113	0.72	34.53	34.53	6.7	25.79	62.42	33
Urban 2-Partial Diamond On	87	X87140066	0.08	61.75	61.75	2.13	25.33	11.93	34
Urban 1-Diamond Off	72	X72280234	0.23	38.73	38.73	9.85	24.36	96.32	35
Urban 2-Partial Diamond Off	15	X15190012	0.38	33.41	33.41	5.06	24.2	37.28	36
Rural 1-diamond Off	14	X14140007	0.23	38.95	38.95	8.19	23.49	49.92	37
Urban 5-Parclo Loop Off	86	X86070043	0.36	35.39	35.39	9.61	23.23	99.02	38
Urban 2-Partial Diamond On	87	X87270191	0.27	30.97	30.97	5.5	22.04	58.77	39
Urban 1-Diamond Off	70	X70220061	0.28	34.47	34.47	9.85	21.36	95.67	40
Urban 1-Diamond Off	12	X12075004	0.36	32.99	32.99	8.85	21.33	79.07	41
Urban 2-Partial Diamond Off	26	X26260023	0.25	31.92	31.92	4.96	21.3	34.56	42
Urban 1-Diamond Off	15	X15190038	0.3	32.17	32.17	7.14	20.92	53.74	43
Urban 5-Parclo Loop Off	93	X93220124	0.26	32.2	32.2	7.69	20.59	65.2	44
Urban 5-Parclo Loop Off	15	X15190040	0.38	29.7	29.7	6.44	20.13	47.97	45
Urban 1-Diamond On	87	X87200080	0.43	29.33	29.33	7.31	19.91	64.67	46
Urban 5-Parclo Loop Off	15	X15190042	0.32	29.58	29.58	5.5	19.79	36.47	47
Urban 1-Diamond Off	87	X87260133	0.24	30.93	30.93	5.83	19.3	37.17	48
Urban 1-Diamond On	75	X75280075	0.18	31.14	31.14	4.3	18.75	25.02	49
Urban 1-Diamond Off	13	X13075014	0.42	29.16	29.16	8.78	18.3	77.06	50
Urban 1-Diamond On	93	X93220040	0.28	27.52	27.52	5.21	18.16	35.22	51
Urban 1-Diamond On	10	X10075014	0.38	26.73	26.73	5.85	18.16	43.29	52
Urban 5-Parclo Loop Off	93	X93220228	0.41	25.75	25.75	5.92	17.14	40.77	53
Urban 5-Parclo Loop On	93	X93220229	0.48	26.18	26.18	6.04	17.03	30.89	54

Table 6-19: List of High Crash Locations on Ramps - (Cont'd)

Site Subtype	County	Route	Ramp Length (miles)	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Rank
Urban 2-Partial Diamond Off	15	X15190013	0.42	24.19	24.19	3.16	16.84	16.79	55
Urban 1-Diamond On	10	X10190056	0.29	25.37	25.37	5.35	16.47	36.32	56
Urban 2-Partial Diamond On	72	X72002018	0.31	23.29	23.29	4.01	16.26	32.97	57
Urban 2-Partial Diamond On	87	X87170352	0.24	26.92	26.92	1.63	15.88	8.52	58
Urban 1-Diamond On	93	X93220023	0.37	23.67	23.67	5.35	15.68	36.33	59
Urban 2-Partial Diamond On	87	X87270190	0.22	24.18	24.18	5.71	15.6	60.53	60
Urban 1-Diamond On	10	X10320168	0.2	26.27	26.27	3.6	15.49	18.17	61
Urban 5-Parclo Loop On	87	X87270218	0.41	25.54	25.54	7.58	15.35	44.76	62
Urban 1-Diamond On	72	X72020084	0.22	25.48	25.48	3.45	15.3	17.1	63
Urban 1-Diamond On	15	X15190037	0.41	22.21	22.21	3.77	15.17	20.42	64
Urban 2-Partial Diamond Off	93	X93220088	0.34	22.41	22.41	3.38	14.79	17.72	65
Urban 2-Partial Diamond Off	72	X72002015	0.45	20.96	20.96	2.73	14.37	13.08	66
Urban 1-Diamond On	15	X15190034	0.46	21.32	21.32	4.94	14.28	31.52	67
Urban 5-Parclo Loop On	93	X93220019	0.35	23.94	23.94	6.71	14.06	35.63	68
Urban 1-Diamond On	72	X72001031	0.28	22.52	22.52	5.73	13.9	40.17	69
Urban 5-Parclo Loop Off	10	X10190133	0.43	22.01	22.01	6.38	13.73	45.34	70
Urban 2-Partial Diamond Off	72	X72280229	0.26	22.33	22.33	2.88	13.5	13.22	71
Urban 5-Parclo Loop On	72	X72270192	0.33	22.21	22.21	4.12	13.03	15.49	72
Urban 5-Parclo Loop On	93	X93220014	0.3	22.11	22.11	5.81	12.5	27.21	73
Urban 5-Parclo Loop Off	10	X10320164	0.18	22.25	22.25	4.72	12.1	25.5	74
Urban 5-Parclo Loop Off	72	X72001006	0.36	19.21	19.21	4.36	11.95	22.99	75
Urban 1-Diamond Off	10	X10320148	0.31	19.16	19.16	5.05	11.12	27.3	76
Urban 2-Partial Diamond Off	10	X10190063	0.16	20.41	20.41	4.17	10.87	22.81	77
Urban 5-Parclo Loop On	48	X48260005	0.31	18.56	18.56	5.17	9.83	21.85	78
Rural 1-diamond Off	78	X78080002	0.37	17.43	17.43	2.94	9.44	8.22	79
Urban 8-Direct	86	X86095052	0.61	13.11	13.11	2.05	9.11	7.69	80
Urban 1-Diamond On	10	X10190057	0.28	15.01	15.01	3.03	8.6	12.56	81

Table 6-19: List of High Crash Locations on Ramps - (Cont'd)

Site Subtype	County	Route	Ramp Length (miles)	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Rank
Urban 2-Partial Diamond On	87	X87003015	0.24	14.25	14.25	2.17	8.37	10.55	82
Urban 2-Partial Diamond Off	26	X26260022	0.24	15.12	15.12	3.34	8.34	15.27	83
Urban 5-Parclo Loop Off	79	X79110004	0.44	13.24	13.24	3.51	7.8	15.09	84
Urban 1-Diamond On	72	X72001055	0.36	12.65	12.65	3.07	7.36	12.7	85
Urban 2-Partial Diamond Off	72	X72001311	0.31	12.87	12.87	2.58	7.29	9.83	86
Rural 5-Parclo Loop Off	26	X26260015	0.31	26.88	26.88	5.25	6.66	4.91	87
Rural 1-diamond Off	18	X18130016	0.25	12.9	12.9	2.54	5.4	5.44	88
Urban 2-Partial Diamond Off	87	X87021010	0.07	15.55	15.55	1.02	2.58	1.37	89
Urban 5-Parclo Loop On	86	X86070059	0.23	7.59	7.59	0.59	1.43	0.37	90

6.1.3 Signalized Intersections

Intersections were analyzed using 2009 RCI data, and crash and traffic data from 2007-2010. *SafetyAnalyst* reclassifies intersections into 12 site subtypes based on area type, number of intersection legs, and traffic control type. Due to data unavailability, only signalized intersections were analyzed. Table 6-20 gives the list of signalized intersection subtypes that were analyzed. The signalized intersections database included only state road crossing state road intersections and very few state road crossing county road intersections due to limited AADT data on county roads. Only the signalized intersections that have traffic data on all of its approaches are used to generate the HCL list. Hence, the list of HCLs is based on a sample of signalized intersections.

Table 6-20: Classification of Signalized Intersections Based on Florida Data

Site Subtype	Code
Rural Three - Leg Signalized Intersections	203
Rural Four - Leg Signalized Intersections	206
Urban Three - Leg Signalized Intersections	253
Urban Four - Leg Signalized Intersections	256

The following steps were performed to obtain the list of high crash locations:

- Input the required data files into SADC to generate import files for *SafetyAnalyst*.
- Manually add the site subtype information based on area type and number of legs.
- Address a few issues with the generated import files.
- Replace the default SPFs in *SafetyAnalyst* Administration Tool with Florida-specific SPFs.
- Import, post-process, and calibrate the data files in *SafetyAnalyst* Data Management Tool.
- Open network screening module in *SafetyAnalyst* Analytical Tool and create site lists.
- Perform EB analysis within the network screening module.

Basic network screening was performed on the entire state's signalized intersections data using data-set specific distributions and Florida-specific SPFs.

Table 6-21 gives the list of HCLs on signalized intersections. Of the 1,419 signalized intersections that were evaluated, only 48 were ranked. This is because locations should experience a minimum of 1 crash/year to be listed as a high crash location. Note that the following table displays only relevant columns from the output.

The following are the additional parameters considered in the analysis:

- Type of analysis: Basic Network Screening
- Accident Severity Level: Total accidents
- Site Types: Intersections
- Screening Attribute: Accident Type and Manner of Collision
- Potential for Safety Improvement Using: Excess accident frequency

- Analysis Period: From 2007 To 2010
- CV limit: 0.5 (for intersections)
- Area Weights (Rural): 1.0
  Area Weights (Urban): 1.0
- Limiting Value: 1.0 crash/yr (for intersections)
- Number of sites in the site list: 1419
- Number of ramps evaluated: 1145
- Number of sites flagged: 48

Table 6-21: List of High Crash Locations on Signalized Intersections

Site Subtype	County	Route	Site Start Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Rank
Urb; 4-leg	87	SR87270168	0	75.6	75.6	3.2	58.9	21.67	1
Urb; 4-leg	87	SR87281000	0	72.45	72.45	26.23	44.97	338.3	2
Urb; 4-leg	10	SR10030000	2.26	74.09	74.09	29.75	42.53	445.61	3
Urb; 3-leg	14	SR14120000	0	63.24	63.24	19.39	42.22	180.76	4
Urb; 3-leg	87	SR87030000	23.5	69.59	69.59	26.53	41.92	323.43	5
Urb; 4-leg	86	SR86065000	2.03	65.21	65.21	22.9	41.03	260.54	6
Urb; 4-leg	87	SR87090000	19.67	57.05	57.05	13.85	40.91	106.23	7
Urb; 4-leg	87	SR87026000	3.01	65.89	65.89	25.38	39.33	316.92	8
Urb; 4-leg	15	SR15050000	0	48.71	48.71	8.95	36.65	51.35	9
Rur; 4-leg	46	SR46040000	1.12	47.42	47.42	9.88	35.05	55.09	10
Urb; 3-leg	87	SR87140000	0	44.67	44.67	4	34.77	16.56	11
Urb; 4-leg	87	SR87260528	1.02	43.38	43.38	7.11	32.85	35.43	12
Urb; 4-leg	10	SR10330000	2.14	54.47	54.47	20.55	32.76	210.59	13
Rur; 4-leg	12	SR12070000	6.87	50.36	50.36	16.79	32.1	138	14
Urb; 3-leg	46	SR46020000	1.29	53.09	53.09	21.33	30.69	211.72	15
Urb; 4-leg	87	SR87200074	0	40.44	40.44	7.39	30.1	36.33	16
Urb; 3-leg	14	CR14570000	0	50.45	50.45	19.47	29.89	177.67	17
Urb; 4-leg	75	SR75030000	0	36.39	36.39	6.98	26.9	31.54	18
Urb; 4-leg	87	SR87260536	1	32.54	32.54	4.72	24.15	18.44	19
Urb; 4-leg	87	SR87062000	2.03	40.43	40.43	15.97	23.43	129.04	20
Urb; 3-leg	55	SR55060000	6.82	38.44	38.44	14.93	22.46	106.5	21
Rur; 4-leg	46	SR46060000	1.75	36.29	36.29	12.72	22.34	80.31	22
Urb; 3-leg	15	SR15190053	0.2	31.05	31.05	6.66	21.96	27.25	23
Urb; 3-leg	48	SR48020000	14.91	31.52	31.52	7.61	21.87	33.16	24
Urb; 4-leg	26	SR26070068	0.45	35.15	35.15	13.23	20.81	90.59	25
Urb; 4-leg	14	SR14120000	12.43	33.99	33.99	12.12	20.44	79.07	26

Table 6-21: List of High Crash Locations on Signalized Intersections - (Cont'd)

Site Subtype	County	Route	Site Start Location	Average Observed Accidents for Entire Site	Average Observed Accidents	Predicted Accident Frequency	Excess Accident Frequency	Variance	Rank
Urb; 3-leg	75	SR75250000	0	28	28	6.1	19.67	22.88	27
Urb; 4-leg	87	SR87260298	0	31.14	31.14	11.3	18.66	67.73	28
Urb; 4-leg	87	SR87120001	0	30.16	30.16	10.77	18.15	62.21	29
Urb; 4-leg	87	SR87270203	0.09	26.94	26.94	7.15	17.96	31	30
Urb; 3-leg	13	SR13010001	0.12	27.61	27.61	10.45	16.03	54.78	31
Urb; 4-leg	12	CR12000112	0	25.05	25.05	7.41	15.59	34.22	32
Rur; 3-leg	10	SR10110000	19.49	24.29	24.29	8.4	14.74	44.78	33
Urb; 3-leg	55	SR55040000	11.8	24.99	24.99	9.04	14.7	42.39	34
Urb; 4-leg	10	SR10010000	5.69	20.51	20.51	3.64	14.11	10.91	35
Urb; 3-leg	15	SR15140000	6.75	22.18	22.18	6.36	14.07	23.59	36
Urb; 3-leg	55	OS55160000	4.6	19.66	19.66	5.36	12.52	17.48	37
Urb; 4-leg	87	SR87270205	0.07	19.68	19.68	6.94	11.54	27.58	38
Urb; 4-leg	48	SR48100001	0.62	19.46	19.46	6.93	11.27	27.8	39
Urb; 3-leg	75	SR75200000	0	17.19	17.19	5.69	10.15	18.48	40
Urb; 4-leg	87	SR87260600	0	14.61	14.61	3.01	9.39	7.41	41
Urb; 4-leg	27	CR27040000	0	12.91	12.91	3.14	7.98	7.45	42
Urb; 3-leg	87	SR87085000	0	13.78	13.78	4.97	7.63	14.22	43
Urb; 3-leg	46	SR46020000	6.36	11.68	11.68	4	6.63	9.37	44
Rur; 3-leg	76	SR76050000	2.03	8.86	8.86	2.03	5.23	3.99	45
Urb; 4-leg	71	CR71580001	0.05	9.58	9.58	0.69	4.35	1.04	46
Urb; 3-leg	48	SR48010000	2.48	8.07	8.07	0.98	4.02	1.33	47
Rur; 3-leg	35	SR35040000	0	6.61	6.61	1.57	3.66	2.5	48

6.1.4 Investigation of Error Logs in SafetyAnalyst

6.1.4.1 Segments

Segment file, traffic file, and crash file were imported into *SafetyAnalyst* using the Data Management Tool. After importing, post-processing and calibration were performed. At each step of the import process, *SafetyAnalyst* generates error logs to help flag issues with the data.

Detailed investigation of the generated error logs revealed a few issues with the data. About 13,735 segments were excluded from the analysis because of missing traffic data for the entire study period. Over 4,500 segments had either missing or invalid site subtype. These segments were excluded from further analysis. Table 6-22 gives the reason for exclusion, and the number and miles of segments excluded.

Table 6-22: Reasons for Exclusion of Segments in *SafetyAnalyst*

Reason for Exclusion	# of Segments Excluded	Miles of Segments Excluded
Missing or invalid location	3	5.11
Missing or invalid site subtype	4592	6326.23
Missing information on number of lanes	28	6.15

More specifically, over 4,500 segments were marked as invalid. Table 6-23 gives the reasons for missing or invalid site subtype.

Table 6-23: Reasons for Invalid Segments

Reason of Invalid Segment	# of Segments Excluded
Unspecified or unknown operation way	3023
No predefined site subtype	1552
Unspecified or unknown area type	17
Total # of segments with missing or invalid site subtype	**4592**

6.1.4.2 Ramps

Ramp file, traffic file, and crash file were imported into *SafetyAnalyst* using the Data Management Tool. The error logs at each step of the import process were reviewed to address issues, if any, with the import data.

Of the 3,088 ramps that were initially imported into *SafetyAnalyst*, about 1,311 ramps were excluded. Over 1,100 ramps were excluded from the analysis because of missing traffic data for the entire study period. A few ramps were excluded because of missing SPFs. Florida-specific SPFs for a few ramp configurations were not generated due to insufficient sample size. Table 6-24 gives the reason for exclusion, and the number of ramps excluded.

Table 6-24: Reasons for Invalid Ramps

Reason of Invalid Ramp	# of Ramps Excluded
No traffic data	1183
No SPFs for specific ramp configurations due to limited sample size	128
Total # of ramps excluded from the analysis	**1311**

6.1.4.3 Intersections

Intersection file, major road traffic file, minor road traffic file, and crash file were imported into *SafetyAnalyst* using the Data Management Tool. As mentioned earlier, only signalized intersections were analyzed due to missing data on traffic control type for unsignalized intersections. Only 1,419 signalized intersections were successfully imported into *SafetyAnalyst*. Intersection leg information, one of the required data is missing on locations where state roads intersect local roads. Additionally, traffic data on minor roads was also missing for a significant number of intersections.

6.2 Summary

Using *SafetyAnalyst*, segments and signalized intersections were analyzed using 2009 RCI data and 2007-2010 crash and traffic data. Ramps were analyzed using 2009 RCI data and 2008-2010 crash and traffic data. District-wide top 10 and statewide top 20 HCLs on segments were identified for each of the 17 predefined segment subtypes. Top 90 HCLs on ramps were identified using Florida-specific ramp subtype classifications and Florida-specific SPFs. HCLs on signalized intersections were identified using Florida-specific SPFs. In addition to the list of HCLs, the error logs in *SafetyAnalyst* were investigated. It was found that over 4,500 segments were excluded due to either missing or invalid site subtype and over 13,000 segments have no traffic data. About one-third of the entire ramp database has no traffic data for the entire study period. Minor road traffic information is sporadic, forcing to exclude a majority of intersections from further analysis.

CHAPTER 7
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SafetyAnalyst is a state-of-the-art analytical tool for making system wide safety decisions. The software incorporates all the steps in the roadway safety management process and could act as a complete "safety toolbox" for any safety office. As one of the 27 participating state agencies in the development of *SafetyAnalyst*, the Florida Department of Transportation (FDOT) has been proactive in adopting the software.

The main goal of this project is to prepare Florida for state-wide deployment of *SafetyAnalyst.* To achieve this goal, research has been done in the followed areas:

- Generation of Florida-specific Safety Performance Functions
- Acquisition of AADT
- Visualization of *SafetyAnalyst* results
- Generation of import files for *SafetyAnalyst*
- Identification of HCLs

7.1 Florida-specific Safety Performance Functions

To perform network screening, *SafetyAnalyst* implements the empirical Bayes (EB) method, which is data intensive requiring the use of SPFs. *SafetyAnalyst* is equipped with a set of national default SPFs and the software calibrates the default SPFs to represent the agency's safety performance. Agencies are recommended to generate agency specific SPFs whenever possible. It is believed that the agency specific SPFs represent the agency data better than the national default SPFs calibrated to agency data. Further, it is believed that the crash trends in Florida are different from the states whose data were used to develop the national default SPFs.

In this project, Florida-specific SPFs were developed using 2008 Roadway Characteristics Inventory (RCI) data and crash and traffic data from 2007-2010 for both total and F+I crashes. As per the predefined subtypes used in *SafetyAnalyst*, segments were divided into 17 site subtypes based on area type, functional classification, and number of lanes. Florida-specific SPFs were developed for all the 17 predefined subtypes using the procedure similar to the development of national default SPFs. Florida-specific SPFs were then compared to the national default SPFs calibrated to Florida data using Freeman-Tukey R^2 statistic and overdispersion parameter.

Compared to segments, the data requirements to generate intersection SPFs are intense. *SafetyAnalyst* divides intersections into 12 subtypes. One of the required variables, traffic control type is not in the required detail in the RCI database. Therefore, SPFs were developed for only four types of signalized intersections (rural and urban, three-leg and four-leg signalized intersections). At this point, analysis of unsignalized intersections is not possible due to the lack of detailed data on traffic control type.

SafetyAnalyst classifies ramps into 16 subtypes based on ramp configuration, ramp type, area type, etc. This classification could not be used to generate Florida-specific SPFs as Florida has different ramp classifications. Therefore, SPFs for ramps were generated using Florida-specific subtypes.

7.2 AADT Acquisition and Estimation

AADT is one of the required variables to be imported into *SafetyAnalyst*. Nonetheless, AADT is sparsely available for local roads. Review of the segments database identified over 13,000 segments with missing traffic data, forcing these segments to be excluded from the analysis. Therefore, to be able to successfully import local roads into *SafetyAnalyst*, AADT has to be either acquired from local sources or estimated.

Out of the 67 counties, traffic data were successfully obtained from 42 counties. Twenty-five counties provided AADT, 13 provided ADT, while three counties (Broward, Hillsborough, and Indian River) provided both AADT and ADT counts. The data were collected in four different formats (some counties provided information in more than one format). Thirty-two counties provided information by PDF, seven by Excel file, three by maps, and two counties provided their information in GIS format. The data were requested and obtained from the following nine different sources:

1. County Development Division
2. County Engineering Department/Division
3. County Highway and Transportation Department
4. County Planning Department
5. County Traffic Operations Department
6. County Transportation Department
7. Metropolitan Planning Organization (MPO)
8. Public Works Department
9. Transportation Planning Organization (TPO)

To estimate AADT values on local roads, a number of existing AADT estimation methods were reviewed, and a parcel-level travel demand model method was proposed. The advantage of this method is that it optimizes the traditional four-step travel demand model method at the parcel level, and the trips between the parcels and the traffic count sites are distributed and assigned to get AADTs for local roads. The method was applied to study areas in Broward County, Florida and compared with the USF method and the URS method. The results show that the parcel-level travel demand method produces lower estimation errors than the two existing methods. However, the evaluation was based on relatively limited traffic count data that were available to this project and further evaluation of the method with additional actual traffic counts will be needed to derive at a more definite conclusion of its performance.

While the evaluation results show the advantages of the parcel-level travel demand model method, it has a few limitations. Firstly, it requires enough traffic count site data to evenly cover the study area. Secondly, due to the fact that the maximum zone number supported by Cube is 32,000, the method cannot cover an area with more than 32,000 parcels and traffic counts. Lastly, the process of building the Cube network file from roadway shape file and creating centroid connectors is performed by using Cube instead of programming. In spite of the above-mentioned limitations, adopting the parcel-level travel demand modeling method to explore the detailed DOR parcel data and the traffic count site data is still an innovate and prospective approach to estimate AADTs for local roads.

7.3 Visualization of *SafetyAnalyst* Results

SafetyAnalyst provides only the data interface needed to exchange GIS data. Given the spatial nature of crash analysis, a GIS component to allow the user to graphically select locations and to display results from *SafetyAnalyst* would be an asset to Florida's application of *SafetyAnalyst*.

The following two major functions are served in the developed GIS system:

1. Provide an alternate method for selecting locations for analysis by *SafetyAnalyst* using a graphical display and to create new input file from graphical selections.
2. Provide a graphical display of the output from network screening module of *SafetyAnalyst*.

This GIS application comprises of four major GIS tools to implement the above identified functions:

1. A basic GIS toolbox: Zoom In, Zoom Out, Pan, and Identify the geographic feature on which the user clicks;
2. A selection tool: assist the user in selecting roadway locations by routes, counties, or districts spatially;
3. A display tool: display specific roadway locations with potential for safety improvement and label the major attributes of the *SafetyAnalyst* output files on the map;
4. A Google Map tool: overlay the user's selected roadway locations on Web-based Google Map.

The developed GIS system presents an intuitive way to visualize both the input data and output data of *SafetyAnalyst*. With this application, the user will be able to perceive data in relation to space.

In the long run, this project has the capability to extend selection and display functions. For example, the interface of selection function could be improved to provide a more convenient way for the user to select locations on the map. The display function could allow the user to define the display attributes on the map.

7.4 Generation of Import Files for *SafetyAnalyst*

SafetyAnalyst has stringent data requirements and a steep learning curve, often hindering its extensive adoption. In 2008, University of South Florida had developed a software program, *SafetyAnalyst* Data Converter (SADC), to automate the process of generating import files. The program was able to generate *SafetyAnalyst* import files for roadway segments using a sample data set based on the 2007 crash data. However, the program is not able to generate data sets for intersections and ramps.

Review of SADC source code and the generated import files revealed a few mapping issues. Fewer and fixable issues were found with the segments file. The major problem lies with intersections and ramps. Import files for unsignalized intersections cannot be generated because of the lack of detailed information on traffic control type. Ramps present a different issue. The predefined classification of ramps used in *SafetyAnalyst* could not be used with Florida data as Florida uses an entirely different ramp configuration types.

In summary, SADC generated import files for segments along with their corresponding crash and traffic data files. The import files for intersections are incomplete, requiring updated data mapping and complete attributes for traffic control type. The import files generated for ramps are unusable as the predefined subtypes used in *SafetyAnalyst* are different from Florida-specific categories.

7.5 Identification of High Crash Locations (HCLs)

SafetyAnalyst was used to perform network screening (i.e., identify and prioritize locations with greatest potential for safety improvement) on the entire segment (i.e., both state and local roads), ramp, and signalized intersection databases in Florida. Statewide and district-wide lists of HCLs for each of the 17 segment subtypes from *SafetyAnalyst* were presented. Top 90 HCLs on ramps were identified using Florida-specific ramp subtypes and Florida-specific SPFs. Top HCLs on signalized intersections were identified using Florida-specific SPFs.

Detailed investigation of the generated error logs revealed a few issues with the data. About 13,735 segments were excluded from the analysis because of missing traffic data for the entire study period. Over 4,500 segments had either missing or invalid site subtype. About one-third of the entire ramp database had no traffic data for the entire study period. Only 1,419 signalized intersections were analyzed due to data constraints.

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APPENDIX A
INFORMATION ON LOCAL AADT DATA ACQUISITION

Table A-1: Contact Information of Counties with Available Traffic Data

County	Contact Person	Job Title	E-mail	Phone Number
Alachua	Christopher M. Zeigler	Senior Engineering Technician	czeigler@alachuacounty.us	352-548-1271
Gadsden	Willie Brown	Principal Planner	WBrown@gadsdencountyfl.gov	(850) 875-8663
Highlands	Eddie Cardona	Traffic Operations Supervisor	ecardona@hcbcc.org	863 402-6536
	Justin A. Williams	CADD Technician/County Engineering Department	Jwilliam@hcbcc.org	(863) 402-6877 x4239
Leon	Chris Muehlemann	Senior Design Engineer	MuehlemannC@leoncountyfl.gov	(850) 606-1500
	Willie Brown	Principal Planner	WBrown@gadsdencountyfl.gov	(850) 875-8663
Martin	Inti Bryon	Senior Systems Analyst /Programmer	inti@miamidade.gov	(305) 375-2030
Miami-Dade	Carlos Roa	MPO Transportation System Manager	rcf@miamidade.gov	(305) 375-1833
Okaloosa	Edwin S. Sanguyo	Engineer III Public Works Department	esanguyo@co.okaloosa.fl.us	(850) 689-5772
Okeechobee		County	thancock@co.okeechobee.fl.us	(863) 763-5548
Santa Rosa	Joshua Dault	Planner III	joshuad@santarosa.fl.gov	850-981-7079
	Nancy Model	Transportation Planner	nancym@santarosa.fl.gov	(850) 981-7080
Sarasota	Mike Maholtz	Transportation Planner/IT Coordinator'	Mike@MyMPO.org	941-359-5772
Sumter	Pamela Richmond	MPO Project Manager	prichmond@lakesumtermpo.com	(352) 315 0170
Taylor	Kenneth Dudley	Department of Engineering Director	county.engineer@ taylorcountygov.com	850-838-3500

Table A-2: Internet Information of Counties with Available Traffic Data

County	Information Site	Data Site
Bay	http://www.co.bay.fl.us/traffic.php	http://new.co.bay.fl.us/uploads/documents/408/file/BayCoTransportationConcurrency090110.pdf
Brevard	http://www.brevardmpo.com/Traffic%20Counts.html	http://www.spacecoasttpo.com/TRAFFIC%20COUNTS/2010%20Traffic%20Counts%20May%205%202011.pdf
Broward	http://www.browardmpo.org/mpo/trafficcounts.htm	http://www.browardmpo.org/mpo/traffic_count_map_aadt.pdf
		http://www.browardmpo.org/mpo/traffic_count_report.pdf
Charlotte	http://charlottecountyfl.com/PublicWorks/transportation/	http://charlottecountyfl.com/PublicWorks/transportation/trafficcounts.pdf
Citrus	http://www.citruscountyfl.org/devservices/landdev/traffic/traffic_counts.htm	http://www.citruscountyfl.org/devservices/landdev/traffic/traffic_counts_2009.pdf
		http://www.citruscountyfl.org/devservices/landdev/traffic/traffic_count_map.pdf
Clay	http://www.firstcoastmpo.com/traffic_counts/	http://www.firstcoastmpo.com/images/uploads/general/Clay%20County%20Local%20Roads%20Report%20%20-%202008.pdf
Collier	http://www.hendryfla.net/engineering/Traffic%20Counts.htm	http://www.hendryfla.net/engineering/2008_FDOT_Collier_AADT.pdf

Table A-2: Internet Information of Counties with Available Traffic Data – (Cont'd)

County	Information Site	Data Site
Collier	http://www.colliergov.net/Index.aspx?page=813#253	http://www.colliergov.net/Index.aspx?page=2471
Duval	http://www.firstcoastmpo.com/traffic_counts/	http://www.firstcoastmpo.com/images/uploads/general/Duval%20County%20Local%20Roads%20Report%20%20-%202008.pdf
Hendry	http://www.hendryfla.net/	http://www.hendryfla.net/engineering/2006%20TRAFFIC%20COUNT%20REPORT.pdf
	http://www.hendryfla.net/engineering/Traffic%20Counts.htm	http://www.hendryfla.net/engineering/2008_FDOT_Hendry_AADT.pdf
Hernando	http://www.co.hernando.fl.us/mpo/MPOTraffic.asp	http://www.co.hernando.fl.us/mpo/reports/traffic_counts/2010%20TRAF.pdf
Hillsborough	http://www.hillsboroughcounty.org/pgmftransportation/transreview	http://www.hillsborough cou nty.org/ pgm/transportation/transreview/ pdf/20 I OM PO trafficcountdocume nt.pdf
	http://www.hillsboroughcounty.org/pgm/transportation/resoun:es/publications/	http://www.hillsborough cou nty.org/ pgm/transportation/resou n:es/ publication silos/ 20 I 1/losreport.pdf
Indian River	http://www.in:gov.com/departments/public_works/Traffle_Division/lndex.htm	http://www.ircgov.com/ departments/public_works/Traffic_Division/Traffic_Volum e Report.pdf
Jefferson	http://www.co.jefferson.co.us/highways/highways_T48_R I 6.htm	http://www.co.jefferson .co.u s/jeffco/highways_u pleads/ Countywide_Report.pdf
Lake	http://www.lakesumtermpo.com/	http://www.lake sumtermpo.com/pdfs/re soun:es/20 I 0_LC_Armual_Traffic_Count. Pdf
Lee	http://www3.1eegov.com/Public Works/Trafficpage5.htm	http://www3.1eegov.com/Pu blicWorks/Traffic/20 I 0%20Traffic%20Cou nt% 20Repor t.pdf
Leon	http://www.talgov.com/pu bworks/traffic_counts.cfm	http://www.talgov.com/pu bworks/traffic_cnts/in dex.cfm
Madison	http://www.co.madison.al.us/about/org/CoDepts/PubWorks.shtml	http://www.co.madison.al.us/roads/
Manatee	http://www.mymanatee.org/home/governmenridepartments/public-works/divisions_programs/traffic-engine ering/traffic-e ngin eering-traffic-cou nts.html	http://public.myman atee .org/gis/arcims/ downloads/ pdfs/traffic/TrafficCounts.pdf
Marion	http://www.ocalafl.org/tpo/TPO.aspx1id=691	http://www.ocalafl.org/u ploadedFiles/TPO_Services/FINAL%20TP0%20TCTM.pdf
Martin	http://www.martin .fl.us/portal/ page1_page id=73,246044&_dad=portal& schema=PORTAL	http://www.martin.fl.us/web_docs/eng/web/traffic/aid_important_docs/06_Roadway LOS Inventory 20 I O.pdf
Nassau	http://W\o'IIW.firstcoastmpo.com!traffic_counts/	http1/www.flrstcoastmpo.com/images/uploads/generai/Nassau%20County%20Locai%20Roads%20Report%20-%202008.pdf
Nassau	http://W\o'IIW.firstcoastmpo.com!traffic_counts/	http://www.flrstcoastmpo.com/images/uploads/generai/Nassau%20County%20Loc ai%20Roads%20Report%20-%202008.pdf

Table A-2: Internet Information of Counties with Available Traffic Data – (Cont'd)

County	Information Site	Data Site
Orange	http://www.orangecountyfl.nerJYourLocaiGovernmenrJCountyDepartments/PublicWorks/TrafficEngineering/TrafficCounts.aspx	http://www.orangecouncyfl.nerJPortals/O/Library/Public%20Works/20 I 0%20Traffle%20Counts.pdf
Osceola	http://www.osceola.org/public_works/226-3832-0/traffic reports.cfm	http://www.osceola.org/flles/Websites/PublicWorks/00003832_traffic_re ports/20O?TrafficCountRe port.pdf
Palm Beach	http://www.pbcgov.com/mpo/library/dataftraffic.htm	http://www.pbcgov.com/mpo/library/data/pdf/FDOT_2004_AADTs.pdf http1/www.pbcgov.com/engineering/traffic./
		http://www.pbcgov.com/engineering/traffic/pdf/Traffic_Counts_20 I O.pdf
Pasco	http://portal.pascocountyfl.net/portal/server.pricommunity/metropolitan_planning_organization/246/documents_and_forms/21 07	http://portal.pascocountyfl.neriportal/server.pt/gateway/PTARGS_0_2_23 1679_0_0_18/M P0%20REPORT%201997%20T0%205-20 I O.pdf
Pinellas	http://www.pced.org/redevelopme nrlsubpage.asp?Pian ning	http://www.pced.org/download/docume nt/20 I 00729_I 5 2556_24362.pdf
	http://www.pced.org/demographics data/su bpage.asp?data	
Polk	http:/I polktpo.com/ contact us	http://polktpo.com/downloads/844-2009-Traffic-Counts
Putnam	http://www.putnam-fl.com/bocc./index.ph pioption=com_conte nt&view=category&layou t=blog&id=5?&lte mid=?4	http://www.putnam-fl.com/putnam_uploads/uploads/20 I 0-2025_comp_plan .gops_maps/GOP_4_-_2008-2009_AADTs_-_08-182.04.pdf
Santa Rosa	http:/Idata2.santarosa.fl.gov/developmentse rvices/	http://data2.santarosa.fl.gov/developme ntse rvices/documents/roadsegme nts.pdf
Seminole	http://www.seminolecountyfl.gov/pw/traffic./counts.aspx	http://www.seminolecouncyfl.gov/pw/traffic./pdf/trafftc counts.pdf
St Johns	http://W\o'IIW.firstcoastmpo.com!traffic_counts/	http://www.flrstcoastmpo.com/images/uploads/generai/St%20Johns%20County%20Locai%20Roads%20Report%20-%202008.pdf
St. Lucie	http://www.stluciempo.org/roadways.htm	http://www.stluciempo.org/pdf/Spring 2009 PDF 07 19 IO.pdf
Volusia	http://volusia.org/traffic./	http://volusia.org/traffic/20 I OAADTs.pdf

APPENDIX B
LAND USE TYPES BASED ON DOR PARCEL DATA AND ITE TRIP GENERATION REPORT

Table B-1: Land Use Types Based on DOR Parcel Data and ITE Trip Generation Report

Parcel Code	Parcel Land Use	ITE Code	ITE Land Use	Independent Variable Used	Average Rate / Equation
000	Vacant Residential		N/A		
001	Single Family	210	Single-Family Detached Housing	Dwelling Unit	Average Rate
002	Mobile Homes	240	Mobile Home Park	Dwelling Unit	Average Rate
003	Multi-family	220	Apartment	Dwelling Unit	Average Rate
004	Condominiums	230	Residential Condominium/ Townhouse	Dwelling Unit	Average Rate
005	Cooperatives	265	Timeshare	Dwelling Units	Average Rate
006	Retirement Homes	255	Continuing Care Retirement Community	Occupied Units	Average Rate
007	Boarding Homes (Institutional)	254	Assisted Living	Occupied Beds	Average Rate
008	Multi-family less than 10 units	220	Apartment	Dwelling Units	Average Rate
009	Undefined reserved for DOR		N/A		
010	Vacant Commercial		N/A		
011	Stores One-Story	850	Supermarket	Gross Floor Area	Average Rate
012	Mixed Use, i.e., Store and Office	710	General Office Building	Gross Floor Area	Average Rate
013	Department Stores	875	Department Store	Gross Floor Area	Average Rate
014	Department Stores	875	Department Store	Gross Floor Area	Average Rate
015	Regional Shopping Malls	820	Shopping Center	Gross Leasable Area	Average Rate
016	Community Shopping Centers	820	Shopping Center	Gross Leasable Area	Average Rate
017	One-Story Non-Professional Offices	710	General Office Building	Gross Floor Area	Average Rate
018	Multi-Story Non-Professional Offices	710	General Office Building	Gross Floor Area	Average Rate
019	Professional Service Buildings	710	General Office Building	Gross Floor Area	Average Rate
020	Airports, Marinas, Bus Terminals, and Piers	010	Waterport/Marine Terminal	Acres	Average Rate
		090	Park-and-ride Lot with Bus Service	Acres	Average Rate
		420	Marina	Acres	Average Rate
021	Restaurants, Cafeterias	931	Quality Restaurant	Gross Floor Area	Average Rate
		932	High-Turnover(Sit-Down) Restaurant	Gross Floor Area	Average Rate
		933	Fast-Food Restaurant without Drive-Through Window	Gross Floor Area	Average Rate
		934	Fast-Food Restaurant with Drive-Through Window	Gross Floor Area	Average Rate

Parcel Code	Parcel Land Use	ITE Code	ITE Land Use	Independent Variable Used	Average Rate / Equation
		937	Coffee/Donut Shop with Drive-Through Window	Gross Floor Area	Average Rate
022	Drive-in Restaurants	932	High-Turnover(Sit-Down) Restaurant	Gross Floor Area	Average Rate
023	Financial Institutions	912	Drive-in Bank	Gross Floor Area	Average Rate
024	Insurance Company Offices	710	General Office Building	Gross Floor Area	Average Rate
025	Repair Service Shops	814	Specialty Retail Center	Gross Leasable Area	Average Rate
026	Service Stations	853	Convenience Market with Gasoline Pumps	Gross Floor Area	Average Rate
027	Automotive Repair, Service, and Sales	843	Automobile Parts Sale	Gross Floor Area	Average Rate
028	Parking Lots, Mobile Home Sales	814	Specialty Retail Center	Gross Leasable Area	Average Rate
029	Wholesale, Manufacturing, and Produce Outlets	823	Factory Outlet Center	Gross Floor Area	Average Rate
030	Florist, Greenhouses	814	Specialty Retail Center	Gross Leasable Area	Average Rate
031	Drive-in Theaters, Open Stadiums	443	Movie Theater without Matinee	Gross Floor Area	Average Rate
032	Enclosed Theaters, Auditoriums	443	Movie Theater without Matinee	Gross Floor Area	Average Rate
033	Night Clubs, Bars, and Cocktail Lounges	435	Multipurpose Recreational Facility	Acres	Average Rate
034	Bowling Alleys, Skating Rings, Enclosed Arenas	435	Multipurpose Recreational Facility	Acres	Average Rate
035	Tourist Attractions	415	Beach Park	Acres	Average Rate
036	Camps		N/A		
037	Race Horse, Auto, and Dog Tracks	435	Multipurpose Recreational Facility	Acres	Average Rate
038	Golf Courses	430	Golf Course	Acres	Average Rate
039	Hotels, Motels	310	Hotel	Rooms	Average Rate
		320	Motel	Rooms	Average Rate
040	Vacant Industrial		N/A		
041	Light Manufacturing	110	General Light Industrial	Acres	Average Rate
042	Heavy Manufacturing	120	General Heavy Industrial	Acres	Average Rate
043	Lumber Yards, Sawmills, Planning Mills,	812	Building Materials and Lumber Store	Gross Floor Area	Average Rate
044	Fruit, Vegetables, and Meat Packing	110	General Light Industrial	Acres	Average Rate
045	Canneries, Distilleries, and Wineries	110	General Light Industrial	Acres	Average Rate
046	Other Food Processing	110	General Light Industrial	Acres	Average Rate
047	Mineral Processing	120	General Heavy Industrial	Acres	Average Rate
048	Warehouses, and Distribution Centers	150	Warehousing	Acres	Average Rate

Parcel Code	Parcel Land Use	ITE Code	ITE Land Use	Independent Variable Used	Average Rate / Equation
049	Industrial Storage (Fuel, Equip, and Material)	110	General Light Industrial	Acres	Average Rate
050	Improved Agriculture		N/A		
051	Cropland Soil Class 1		N/A		
052	Cropland Soil Class 2		N/A		
053	Cropland Soil Class 3		N/A		
054	Timberland		N/A		
055	Timberland		N/A		
056	Timberland		N/A		
057	Timberland		N/A		
058	Timberland		N/A		
059	Timberland		N/A		
060	Grazing Land Soil Class 1		N/A		
061	Grazing Land Soil Class 2		N/A		
062	Grazing Land Soil Class 3		N/A		
063	Grazing Land Soil Class 4		N/A		
064	Grazing Land Soil Class 5		N/A		
065	Grazing Land Soil Class 6		N/A		
066	Orchard, Groves, Citrus		N/A		
067	Poultry, Bees, Tropical Fish, Rabbits, etc.		N/A		
068	Dairies, Feed Lots		N/A		
069	Ornamentals, Misc. Agriculture		N/A		
070	Vacant Institutional		N/A		
071	Churches	560	Church	Gross Floor Area	Average Rate
072	Private Schools	520	Elementary School	Gross Floor Area	Equation
		522	Middle School/Junior High School	Gross Floor Area	Average Rate
		530	High School	Gross Floor Area	Average Rate
073	Private Hospitals	610	Hospital	Gross Floor Area	Equation
074	Homes for Aged	251	Senior Adult Housing - Detached	Dwelling Units	Average Rate
		252	Senior Adult Housing - Attached	Occupied Dwelling Units	Average Rate
075	Orphanages		N/A		
076	Mortuaries, Cemeteries	566	Cemetery	Acres	Average Rate
077	Clubs, Lodges, and Union Halls	435	Multipurpose Recreational Facility	Acres	Average Rate
078	Sanitariums, Convalescent, and Best Homes	253	Congregate Care Facility	Dwelling Units	Average Rate
079	Cultural Organizations	590	Library	Gross Floor Area	Average Rate and Equation
080	Undefined		N/A		
081	Military		N/A		
082	Forest, Park, and Recreational Areas	411	City Park	Acres	Average Rate
		412	County Park	Acres	Average Rate
		413	State Park	Acres	Average Rate
		415	Beach Park	Acres	Average Rate
		417	Regional Park	Acres	Average Rate
083	Public Schools	520	Elementary School	Gross Floor Area	Equation

Parcel Code	Parcel Land Use	ITE Code	ITE Land Use	Independent Variable Used	Average Rate / Equation
		522	Middle School/Junior High School	Gross Floor Area	Average Rate
		530	High School	Gross Floor Area	Average Rate
084	Colleges	540	Junior/Community College	Gross Floor Area	Average Rate
085	Public Hospitals	610	Hospital	Gross Floor Area	Average Rate
086	Other Counties		N/A		
087	Other State		N/A		
088	Other Federal		N/A		
089	Other Municipal		N/A		
090	Gov. Owned Leased by Non-Gov. Lessee		N/A		
091	Utilities	170	Utilities	Gross Floor Area	Average Rate
092	Mining, Petroleum, and Gas Lands		N/A		
093	Subsurface Rights		N/A		
094	Rights-of-Way Streets, Roads, and Canals		N/A		
095	Rivers, Lakes, and Submerged Lands		N/A		
096	Sewage Disposal, Borrow Pits, and Wetlands		N/A		
097	Outdoor Recreational		N/A		
098	Centrally Assessed		N/A		
099	Acreage not Zoned for Agricultural		N/A		