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Development of Criteria to Identify Pedestrian High Crash Locations in Nevada

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16. Abstract

Highway safety funds need to be allocated efficiently to enhance safety. Identification of pedestrian high crash locations is an important component to help use such funds to produce maximum benefits by reducing the number and severity of crashes in a cost effective way. High crash locations identify the areas that would potentially receive the largest benefit if safety funds were allocated. Unlike analysis of motor related crashes using Geographic Information Systems (GIS), limited research has been done on identifying pedestrian high crash locations in the past. Studies in recent years have focused on the issue of safety analysis using GIS techniques as they have great potential to improve crash location evaluation. The main objective of this research project is to develop criteria to identify pedestrian high crash locations in order to allocate recourses including Federal Safety Funds, for safety improvements.

The tasks involved to accomplish the objective are: (1) a review of the existing literatures that focuses on methodologies / techniques used to analyze pedestrian crashes, compute crash rates, and identify pedestrian high crash locations; (2) geocode (addressmatch) / digitize the pedestrian crashes over corresponding street center lines in order to do analyses using GIS; (3) identify crash concentrations by building crash density maps; (4) identify potential high crash locations according to FHWA Zone Guide for Pedestrian Safety (1998); (5) develop criteria using crash frequency, crash severity and crash rate methods to rank the pedestrian high crash locations.

The study area comprises of five counties in Nevada (Clark, Washoe, Carson, Elko, and Douglas) and crash data provided by Nevada Department of Transportation (NDOT) is used for the analyses. Pedestrian high crash locations were identified for each of the study area. Methods to rank pedestrian high crash locations were then evaluated using data for the identified high crash locations. Results obtained using the sum of the ranks method and crash score method were observed to be relatively more consistent than when individual methods such as crash frequency, crash density or crash rates were used.

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EXECUTIVE SUMMARY

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CHAPTER 1
INTRODUCTION

Nevada has experienced over 40 pedestrian fatal crashes per year over the last six years. Likewise, Nevada also has experienced over 800 pedestrian injury crashes per year during the same period. More than 70 percent of these pedestrian fatal crashes and pedestrian injury crashes are in Clark County, Nevada. There is a critical pedestrian safety issue on many urban streets in Nevada, in general, and in the Las Vegas metropolitan area in Clark County, Nevada, in particular. The Las Vegas metropolitan area is ranked among the worst urban areas in terms of pedestrian safety. Crashes in such environment also result in adverse publicity, which can linger long after the incidents themselves. Besides the adverse publicity, these crashes result in severe health and human life consequences, and monetary impacts.

The main objective of this research project is to develop criteria to identify "pedestrian high crash location" in order to allocate recourses including Federal Safety Funds, for safety improvements. The criteria will help in the development of a "Pedestrian Safety Program", as a part of Nevada Department of Transportation's (NDOT) Federal Highway Safety Improvement Program (HSIP). The developed criteria will assist the system managers not only in Las Vegas and Nevada, but also nationally, in better understanding the cause of the crashes and identifying appropriate operating strategies to enhance pedestrian safety.

The proposed research is divided into the following main tasks:

1. Task 1: Literature Research
2. Task 2: Data Collection and Geocoding
3. Task 3: Analysis of Pedestrian Data
4. Task 4: Develop Criteria to Identify "High Crash Locations"
5. Task 5: Recommendations and Scope for Further Research.

CHAPTER 2
LITERATURE RESEARCH

Pedestrian safety studies involve data collection and spatial analysis. These studies, in general, include analysis of pedestrian crash data to identify pedestrian crash problems, identifying pedestrian high crash locations based on spatial analysis, ranking of pedestrian high crash locations, and, analysis of crashes at each crash location to identify suitable pedestrian safety countermeasures to enhance pedestrian safety. The basic data needs for this analysis are crash reports, street centerline coverage, traffic data, and demographic data. The spatial analyses include use of zone guide for pedestrian safety, and integration of statistical methods.

A literature review was conducted on analysis of pedestrian crashes to identify pedestrian crash problems, tools and techniques such as use of Geographic Information Systems (GIS) software to geocode data and identify pedestrian high crash locations, and rank pedestrian high crash locations. They are discussed next.

Analyses of Pedestrian Crashes

Pedestrian crashes can be categorized in to three major areas (Baltes 1998). They are:

1. Pedestrian characteristics - which explains characteristics of persons involved in these crashes (gender, age and ethnicity)
2. Crash types – which explains elements that lead to crashes (for example, alcohol related, failed to yield and stepped into the path of an oncoming vehicle, disregarded a traffic signal, or made some improper action that contributed to the crash like crossing not at intersection, walking along road with traffic, walking along road against traffic, working on vehicle in road, standing / playing in road, standing in pedestrian island, etc), and
3. Crash event – which explains when and where did these crashes occur (date, time of the day, day of the week, location (urban or rural), weather and lighting conditions, roadway number of lanes, road system identifier, and road surface conditions).

This way of categorizing the pedestrian crashes helps develop effective and practical countermeasures to reduce the pedestrian injuries and fatalities. It is important that crash types are analyzed for different pedestrian age groups. For example, studies have shown that alcohol impaired pedestrian problem is high among some racial and ethnic groups (NHTSA 1998; Leaf and Preusser).

Analysis based on the number of pedestrian crashes in a particular age group, ethnicity, or gender group is useful, but insufficient for determining whether a specific group is more or less prone to be in a crash. This can only be obtained by considering crash rate per capita (from census data) and crash rate per miles walked (from Nation Wide Personal Transportation Survey, NTPS information). These crash rates by different age groups will show which age group are most likely to involve in a crash.

Analysis of crashes based on severity is another critical element. Higher vehicle speeds are strongly associated with both a greater likelihood of pedestrian crash occurrence and more serious resulting pedestrian injury (Leaf et al. 1999; IIHS 2000).

The population density is not a good replacement for pedestrian exposure as it does not account for the amount of walking people do (Qin and Ivan 2001). The number of lanes, area type and sidewalk system are some of the factors that affects the pedestrian exposure.

Schneider et al. (2001) explains the importance of methods to identify where the pedestrian crash problem exists so that a greater number of pedestrian crashes can be prevented in the future. However, crash studies are generally based on reported crash records. Schneider, Khattak, and Ryznar (2002) state that reported crash data alone may not be a good predictor of future crash locations, especially for infrequently - occurring pedestrian crashes. To solve this problem, Schneider, Khattak, and Ryznar presented the idea of combining the crash data with perception survey method. The study concluded that perception survey data helps improve site selection and recommendations for pedestrian safety treatment (for example, gather large quality of data about locations that may have pedestrian problems, and study differences in the perceptions of people with specific traits). However, surveying method may not be appropriate for large study areas such as city or metropolitan areas as it is a time consuming and expensive process.

Tools and Techniques

Several analytical tool and techniques are available to analyze crash data. However, questions such as "where are most of the crashes occurring and why?" is difficult to answer. These questions can be easily addressed in a GIS environment. Using GIS to geocode crash locations and plot the locations is the most common first step (Anadaluz, Robers, and Tina 1997).

GIS techniques are being extensively used in the safety field as they have a greater potential to improve crash location evaluation. Several studies have cited the benefits for using GIS to plot automobile crash locations and identify high-risk areas for motorized-vehicle crashes, though fewer have applied the technique to analyze pedestrian or bicycle crashes. Simple crash plotting, or geocoding crash locations, is the most common GIS technique used for safety studies. GIS turns statistical data, such as crashes, and geographic data, such as roads and crash locations, into meaningful information for spatial analysis and mapping. Using GIS, it is relatively simple to combine crash data and study its correlation with on-network characteristics (traffic volumes, pedestrian volumes, number of lanes, etc.) and off-network characteristics (land-use, demographic characteristics, etc.). GIS also assists in identifying factors that were the cause of those crashes and/or potential solutions to reduce those crashes. GIS-based crash data analysis can influence the four E's of traffic safety: engineering, enforcement, education, and emergency response.

In order to ensure a reasonable stable measure, research has shown that a minimum of one year's data or at least 100 crash records should be available for establishing pedestrian safety zones (NHTSA, 1998). For data analysis, various techniques were used to create zones, identify hotspot locations, and rank the study locations. NHTSA (1998) recommended the guide to identify study zones for pedestrian safety. The zone process provides a systematic method for targeting pedestrian safety improvements in a cost effective manner. Zoning identifies a subset of a jurisdiction containing as much of the pedestrian problem of interest in as little land area as possible. The first step is to select an initial shape for the zones and to define the target rate i.e., the number of events that must fall in an area for it to be defined as a zone. The approach suggested is to search for circular zones, then to search for linear zones, then to determine their final shape. The initial circular zones could be created by using one mile radius, as generally pedestrian crashes occur within one mile of the victim's home or work place. Risk zones could be identified using a target rate of 10 crashes per zone if the total number of crashes in the study area is 200. For linear zones, it could be determined for the segments where six or more crashes occur in a two mile segment. In addition, if total crash data that are used in analysis is higher, the target rate should be adjusted upward as necessary. The final step is to identify the final zone shape, as it may be useful to combine zones, add more radiuses, change zones' shape, or reduce zones' size. Finally, to define zones, areas with some clustering and some dispersion throughout a land area should be identified. However, such a methodology may not work if no clustering is apparent in the study area.

One of the most common macroscopic applications of GIS is the determination of high crash locations, HCLs (Roche 2000). South East Michigan Council of Government (SEMCOG) Crash Analysis Manual (SEMCOG 2001) explains ways of locating high crash locations. Spot map method, the simplest method of identifying high-crash locations, is to examine a map showing clusters of symbols at those spots and on those segments in the road network having the greatest numbers of total crashes. Braddock, Lapidus, Cromly, Burke, and Banco (1994) identified two high pedestrian crash locations which account for 30 percent of all pedestrian crashes in Hartford County, Connecticut based on address matched crash data for analysis. In a different context, three-mile buffer zones were created around 3 clustered areas using GIS to study moped safety in Hawaii. The temporal variations, environmental characteristics, and crash characteristics of these spatially distributed moped crashes were then studied (Kim, Takeyama, and Nitz 1995).

A GIS based crash analysis tool developed by FHWA (1999) uses five different types of analysis to evaluate crashes. The Spot/Intersection Analysis program is used to evaluate crashes at a user-designated spot or an intersection within a given search radius. The Strip Analysis program is used to study crashes along a designated length of roadway as opposed to a spot or an intersection. The Cluster Analysis program is used to study crashes clustered around a given roadway feature such as a bridge, railroad crossing, or traffic signal. The Sliding-Scale Analysis program is used to identify roadway segments with a high crash occurrence. The Corridor Analysis program is used to locate high crash concentrations within a corridor. Using traditional methods, segments along a specific route could be examined, but multiple routes within a corridor could not be easily linked and analyzed as a group, which is possible using this tool.

A simple method, called nearest neighborhood analysis, was used to identify hot spot locations in a mid-block pedestrian safety study (Cui 2000) The analysis used grid cells with a dimension of 100 feet per site and a circular radius of 500 feet. The resultant scores were grouped and ranked based on the distribution of number of pedestrian crashes.

Steiner et al. (2002) discusses a method which involves (1) identification and collection of data (both crash data and the map data layer); (2) selection of a program for processing of crashes; and (3) analysis of data collected by the system.

Most GIS packages have very sophisticated database operations. However, they do not have statistical methods other than means and standard deviations of variables. A statistical spatial method is needed when a more sensitive quantitative method is required (Levine 1999). Schneider, Khattak, and Ryznar (2002) adopted statistical methods on their cluster analysis in order to integrate and evaluate data from two different sources (crash reports and survey data). CrimeStat, a spatial statistics software package, was used to perform the cluster analysis. In addition, several other spatial statistics such as Chi-squared, Ripley's K-function, and G-function tests were also computed.

Rank High Crash Zones

Literature did not document any research exclusively comparing methods to rank pedestrian high crash zones. However, several methods were proposed and used in the past to rank high risk zones based on motor vehicle crashes. The most widely used methods are listed and discussed next.

1. Crash frequency based on number of crashes (CF_N) method
2. Crash frequency based on severity of crashes (CF_S) method
3. Crash density (CD) based on severity of crashes
4. Crash rate (CR) method
5. Sum of ranks (SR) method

Crash Frequency Based on Number of Crashes (CF_N) Method

The crash frequency based on number of crashes (CF_N) method is used to rank zones based on the number of reported crashes. The zones are listed in descending order of crash frequencies. This can be mathematically represented using the below equation.

$$CF_N = F + A + B + C$$

where,

CF_N is crash frequency based on number of crashes,

F is number of fatal crashes,

A is number of injury type "A" crashes,

B is number of injury type "B" crashes, and

C is number of injury type "C" crashes.

The zones having crash frequencies greater than or equal to a critical crash frequency are considered as high risk zones. The critical crash frequency is determined based on system wide average value.

The advantage of this method is that it is simple and ranking is based on the number of crashes in the zone. All types of crashes (F, A, B, and C) are given equal weight. Unlike motor vehicle crashes, pedestrian crashes do not have property-damage-only (PDO) crashes.

Crash Frequency Based on Severity of Crashes (CF_S) Method

An extension to CF_N method is to give different weights to different types of crashes. This extension is preferred to the simple method as inclusion of severity enables agencies to allocate more of their safety resources to zones with greater exhibited potential for injury or loss of life, thereby allowing the treatment of these zones for reducing overall system severity. Thus, in this method, fatal crashes and crashes with severe injuries are given more relative weight than those for crashes with less severe injuries. The crash frequency based on severity of crashes (CF_S) can be mathematically represented using the following equation.

$$CF_S = X \times F + Y \times A + Z \times B + C$$

where,

CF_S is crash frequency based on severity,

F is number of fatal crashes,

A is number of injury type "A" crashes,

B is number of injury type "B" crashes,

C is number of injury type "C" crashes, and

X, Y, and Z are weights for F, A, and B.

As shown in the above equation, fatal crashes (F) and injury crashes (A and B) are given a weight that is compared against injury level "C", which is given a weight of 1. (Note that in case of motor vehicle crashes, fatal and injury crashes F, A, B, and C are given a weight that is compared against PDO crashes which is given a weight of 1.) The resultant CF_S is equal to equivalent number of injury type "C" crashes.

The weight coefficients are based on the relative average crash costs by severity. F-type and A-type crashes often have the same weight. This method is similar to relative severity index (RSI) method in which the computed severity-specific costs are summed and divided by the total crash frequency. Note that if X, Y, and Z are all equal to 1, the CF_S is equal to CF_N.

Using CF_S method would be ideal if the objective is to allocate safety funds to zones based on the number of crashes. The method is frequently biased towards zones with major injuries and fatalities (McMillen 1999) as it may rank zones with a single fatal crash or a severe injury crash higher than zones with numerous less severe crashes. This could be critical if one compares a zone with single fatal crash due to driver or pedestrian error with a zone with numerous minor injury crashes due to a poor design.

Also, the method may not be appropriate if one would like to allocate funds considering critical elements such as pedestrian activity or exposure to on-network and off-network characteristics of the zone in the computations. On-network characteristics, in general, include length or area of the zone, vehicular volumes, and pedestrian volumes. Off-network characteristics include population living within a proximal area.

Considering on-network and off-network characteristics in the computations could have a significant impact in the selection and ranking of high risk zones. In cities such as Las Vegas, zones along the resort corridor are in the top selected pedestrian high risk zones. Pedestrian activity in such zones is also very high. These zones along the resort corridor may not be critical when one considers the ratio of the number of crashes in the zone to the pedestrian activity of the zone. However, the CF_S method would rank such zones high as it is based on the number of crashes. As an example, the CF_S method ranks a zone with 10 pedestrian crashes per year and 1,000 pedestrians per day higher compared to a zone with 5 pedestrian crashes per year and 100 pedestrians per day. Thus, as also stated by other authors (McMillen 1999; Layton 1996), the CF_S method tends be biased towards zones with high pedestrian volumes or traffic volumes. It is generally recommended that the CF_S method be used along with on-network or off-network characteristics to rank pedestrian high risk zones.

Crash Density (CD) Method

The crash density (CD) method is a method to rank zones based on crash frequency based on severity per length in miles or area in square miles. This can be mathematically represented using the below equation.

$$CD_L = \frac{CF_S}{L}$$

$$CD_A = \frac{CF_S}{A}$$

where,

CD_L is crash density based on length,

CD_A is crash density based on area,

CD_S is crash frequency based on severity,

L is length in miles, and

A is area in square miles.

The locations are ranked in the descending order of crash density. The zones with more than a critical crash density are classified as high risk zones. The critical crash density is determined based on system wide average value.

The CD method is most commonly used as obtaining data pertaining to on-network characteristics such as length or area of each zone is easy. Considering length or area also plays a key role in the ranking process. For example, CD method will rank a zone with 5 pedestrian crashes in a 0.5 square mile in area higher when compared to a zone with 10 pedestrian crashes in 2 square miles in area unlike the CF method which will rank the zone with 10 pedestrian crashes higher than the zone with 5 pedestrian crashes.

As zones in the study area comprise of both linear and circular zones which in general are treated same, crash density based on area is recommended. The area of linear zones is identified by generating buffers around each zone so as to capture crashes along the linear segment. However, the CD method does not take into account vehicular volumes and pedestrian volumes which truly represent traffic activity in any given zone.

Crash Rate (CR) Method

The crash rate (CR) method is used to rank zones based on the number of crashes when compared to a measure of exposure. The number of crashes could be with or without considering the severity of crashes. In this study, the number of crashes is based on severity of crashes (CF_S). Typical measures of exposure are vehicular volumes, pedestrian volumes, or population in the proximal area.

a) Crash Rate Based on Vehicular Volume

The crash rate based on vehicular volumes is the ratio of crash frequency based on severity to the vehicular volume. The vehicular volumes are measured either as the number of vehicles crossing a spot in a given time period, or as the number of vehicle-miles of travel along a segment in that period. Rates are given in crashes per million vehicles (crashes/MV) for spot locations and crashes per million vehicle-miles of travel (crashes/MVMT) for sections. This can be mathematically represented using the below equation.

$$CR_{VV} = \frac{CF_S}{VV}$$

where,

CR_{VV} is crash rate based on vehicular volume,

CF_S is crash frequency based on severity, and

VV is MV or MVMT.

The zones are then arranged in the descending order and ranked. The zones with more than a critical crash rate are classified as high risk zones. The critical crash rate is determined based on system wide average values.

The CR method based on vehicular volumes is also commonly used as obtaining data pertaining to vehicular volumes using technologies such as loop detectors is easy. Also, considering MV or MVMT is important as vehicles or drivers play as much of a significant role as pedestrians in pedestrian crashes. However, the vehicular volumes may not be a true representation of pedestrian activity when compared to pedestrian volumes. In addition, the CR method based on vehicular volumes may be biased towards zones with a few crashes and low vehicular volumes as the resulting crash rate will be high (McMillen 1999; Layton 1996).

b) Crash Rate Based on Pedestrian Volume

The crash rate based on pedestrian volume is the ratio of crash frequency based on severity to the pedestrian volume. The pedestrian volumes are measured as the number of pedestrians using the facility in a given time period. The equation can be mathematically represented as shown below.

$$CR_{PV} = \frac{CF_S}{PV}$$

where,

CR_{PV} is crash rate based on pedestrian volume,

CF_S is crash frequency based on severity, and

PV is pedestrian volume.

The zones are then arranged in the descending order and ranked. The zones with more than a critical crash rate are classified as high risk zones. The critical crash rate is determined based on system wide average values.

The CR method based on pedestrian volumes is more appropriate compared to other methods as pedestrian volumes truly represent pedestrian activity in a zone. However, pedestrian crashes involve both motor vehicles and pedestrians. Hence, considering vehicular volumes in the ranking process is as important as considering pedestrian volumes.

Also, obtaining pedestrian volumes during the study period is an expensive and time consuming process compared to other methods. Even data collected using simple low cost video technologies need lot of post processing. An alternative to this is to use surrogate data such as population in proximal area to represent pedestrian activity of the zone.

c) Crash Rate Based on Population

The crash rate based on population is the ratio of crash frequency based on severity to population in the proximal area of the zone. The populations include those who reside or work within a proximal area.

$$CR_{PP} = \frac{CF_S}{PP}$$

where,

CR_{PP} is crash rate based on population,

CF_S is crash frequency based on severity, and

PP is population in the proximal area of the zone.

Census data or data from local agencies in a GIS format could be used to estimate population in the proximal area of a zone. The procedure to extract the population data includes the following steps.

1. Create a half-mile buffer around selected high risk zone. This is based on the assumption that pedestrians would at most walk for 10 minutes. Considering an average walking speed of 4 feet per second, the distance that a pedestrian would walk would be half-a-mile.
2. Overlay this buffer over the population data layer.
3. Clip the buffer with the census data layer to obtain the census blocks within the high risk zone.
4. Compute the area ratio of each census block.

$$\text{Area Ratio} = \frac{\text{Area Census Block}_{\text{High Risk Zone}}}{\text{Area Census Block}_{\text{Census Layer}}}$$

5. Multiply the population data of each census block with the area ratio to obtain the resultant population data of the census blocks within the high risk zone.
6. Add all the resultant populations of the census blocks to obtain the population of the high risk zone.

Once the rates are estimated, the zones are then arranged in the descending order and ranked. The zones with more than a critical crash rate are classified as high risk zones. The critical crash rate is determined based on system wide average values.

The CR method based on population is inexpensive and can be implemented in a short time. This method should be used carefully in places such as Las Vegas. For example, pedestrian activity is very high in zones along the resort corridor in Las Vegas. A very few people live in such zones. These zones along the resort corridor will be ranked higher when one considers the ratio of number of crashes in the zone to the population in the proximal area of the zone whereas the same zones may not be critical when one consider the ratio of the number of crashes in the zone to pedestrian volumes of the zone.

d) Crash Rate Based on Population by Age Group

In the previous method, crash rate was computed using crash frequency based on severity and total population. However, the number of crashes and population differ by age group. As vulnerability to crashes differ by age group, it is important to compute crash rates based on population by age group and then sum them to compute the overall crash rate. Also, in the previous method, equal weights are given to pedestrians of all age group. An extension to this is to give different weights to pedestrians in different age groups.

In this method, crash rates are computed for each population sub-group as in the previous method. More weight is given to crash rates of certain groups of population such as children (pedestrian below the age of 18) and elderly (pedestrians above the age of 64) in determining the combined weighted crash rate.

$$CR_{PA,\ Age<18} = \frac{CF_{S,\ Age<18}}{PP_{Age<18}}$$

$$CR_{PA,\ Age\ 18\text{-}64} = \frac{CF_{S,\ Age\ 18\text{-}64}}{PP_{Age\ 18\text{-}64}}$$

$$CR_{PA,\ Age>64} = \frac{CF_{S,\ Age>64}}{PP_{Age>64}}$$

$$CR_{PA} = X \times CR_{PA,Age<18} + Y \times CR_{PA,Age18\text{-}64} + Z \times CR_{PA,Age>64}$$

where,

CR_{WP} is combined weighted crash rate,

$CR_{PA\_Age<18}$ is crash rate based on population for age group less than 18 years,

$CR_{PA\_Age\ 18\text{-}64}$ is crash rate based on population for age group 18 - 64 years,

$CR_{PA\_Age>64}$ is crash rate based on population for age group greater than 64 years,

$CF_{S,\ Age<18}$ is crash frequency based on severity for age group less than 18 years,

$CF_{S,\ Age\ 18\text{-}64}$ is crash frequency based on severity for age group 18-64 years,

$CF_{S,\ Age>64}$ is crash frequency based on severity for age group greater than 64 years,

$PP_{Age<18}$ is population in proximal area for age group less than 18 years,
$PP_{Age\ 18\text{-}64}$ is population in proximal area for age group 18 - 64years,
$PP_{Age>64}$ is population in proximal area for age group greater than 64 years, and
X, Y, Z are weights for population groups < 18, 18 – 64, and > 64 years.

The zones are then arranged in the descending order and ranked. The zones with more than a critical crash rate are classified as high risk zones. The critical crash rate is determined based on system wide average values.

The disadvantage with this method is the difficulty with obtaining weights for different populations groups. A simplified approach could be to compute crash rates for each age group but give equal weights for all age groups.

As stated before, since pedestrian crashes involve both motor vehicles and pedestrians, it is important that one consider vehicular volumes and pedestrian exposure in the ranking of high risk zones. As obtaining pedestrian counts is an expensive and time consuming process, and estimating weights for different population groups is difficult, it is recommended that crash rate based on vehicular volumes and crash rate based on population by age group (with equal weights for each age group) be combined with other methods to estimate a composite rank or score to rank high risk zones. If pedestrian counts data are available, the crash rate based on population could be replaced by crash rate based on pedestrian counts.

The sum of ranks (SR) method and crash score (CS) method are two methods in which methods discussed above are combine to eliminate the disadvantages.

Sum of Ranks (SR) Method

The sum of ranks (SR) method combines the previous methods in the calculation of a single rank value for each zone. A ranked list is prepared for each of the selected methods, and then the ranks for each zone within these lists are summed to produce a composite rank. The list thus created is then ranked based on the composite rank or composite rank divided by the number of considered methods. For example, a composite rank which is a sum of ranks of CF method, CR method, and value loss rank method (based on cost value of crashes based on severity) divided by the total number of methods considered (3 in this case) was proposed by CTRE (2002).

Different weights can be given to different methods, though many times the composite rank is created by giving equal weight to all the methods. Idaho DOT (?) computes composite ranks using 0.25, 0.25, and 0.50 as weights for CF method based on number of crashes, CR method, and CF method based on severity. The results in this case may be biased towards zones with lower rank for the method with lower weight if the weights are not established using a good logical procedure.

The principle of the sum of ranks method is to capture benefits from each of the different methods and eliminate or minimize the disadvantages that limit the effectiveness of the selected methods.

Based on the advantages and disadvantages of each method, it is recommended that ranks obtained using crash density based on area, crash rate based on vehicular volume, and crash rate based on population by age group be used to estimate the composite rank for the SR method.

$$SR = \frac{CD_A + CR_{VV} + CR_{PA}}{3}$$

Crash Score (CS) Method

In this report, a new method called crash score (CS) method, to rank high risk zones is introduced. The CS method is based on normalizing the values to the same scale so as to obtain a score for each category. Such a normalizing procedure is used to address the challenge of combining disparate components. The individual scores for each component are normalized to a 0-100 scale. Thus, the highest score for a category is equal to 100. The individual scores for each category are then summed to estimate the crash score for the zone.

Different weighted scores can be given for different categories in the estimating the overall crash score. However, as in the case of SR method, the results may be biased towards zones with lower score for the method with lower weight if the weights are not established using a good logical procedure.

Based on the advantages and disadvantages of each method, it is recommended that scores obtained using crash density based on area, crash rate based on vehicular volume, and crash rate based on population by age group be used to estimate the overall crash scores for the CS method.

$$\text{Score CD}_{A} = \frac{\text{CD}_{A}}{\text{Maximum CD}_{A}} \times 100$$

$$\text{Score CD}_{VV} = \frac{\text{CD}_{VV}}{\text{Maximum CD}_{VV}} \times 100$$

$$\text{Score CD}_{PA} = \frac{\text{CD}_{PA}}{\text{Maximum CD}_{PA}} \times 100$$

$$\text{CS} = \text{Score CD}_{A} + \text{Score CR}_{VV} + \text{Score CR}_{PA}$$

The maximum CD_A, maximum CD_{VV}, and maximum CD_{PA} are the maximum CD_A, CD_{VV}, and CD_{PA} values considering all the high risk zones in the study area, respectively.

CHAPTER 3
DATA COLLECTION AND GEOCODING

A discussion on data collection and geo-coding pedestrian crash data is presented in this chapter.

Data Collection

The street network and pedestrian crash data are most critical data elements required for pedestrian safety studies. The data collection efforts for these elements are discussed next.

Street Network

Digitizing crashes on a digital map with street network is not only inaccurate but a time consuming process. On the other hand, the process of automatically creating map features based on address, or similar information exploring the capabilities afforded by GIS software is called geocoding. Crashes can be geocoded using one of the three reference systems (street name / reference street name, mile-post and address). The street name / reference street name reference system and address are most commonly used in urban areas. The advantage of geocoding is that it lets one map locations from crash data that is readily available.

However, a street network in a GIS format with street name and address information is extremely important to geocode crash data. Street centerline (SCL) network in a GIS format are generally developed by public and private agencies. A few of these are commercially available. SCL network attributes include street name, street type (Avenue, Boulevard, and so on), and directional prefixes and suffixes necessary to avoid ambiguity in address location. Each street feature is divided into segments that have beginning and ending addresses, as seen on neighborhood street signs. This makes it possible to estimate the position of an address along the length of a street segment. There may be separate address ranges for each side of the street, so that an address can be geocoded on the correct side of the street.

The Transportation Research Center, UNLV has the SCL coverage for the Clark County developed and maintained by the Clark County Department of Public Works GIS Managers Office (GISMO). The 2003 SCL coverage for the Clark County has 61,573 street segments. Street name and address information is available for all these streets. However, data is not available for other counties in Nevada. A search was conducted to obtain data from other sources. The other common sources for the street network data are: 1) Tiger/Line data from the United States Census Bureau, 2) Geographic Data Technology (GDT) Dynamap U.S Street Data, and 3) Tele Atlas MultiNet.

Census 2000 TIGER/Line data can be downloaded in a shapefile format from United States Census Bureau website free of cost. For the state of Nevada TIGER/Line data contains 345,124 street segments out of which 157,355 are named street segments (45.6%).

GDT Dynamap/2000 United States Street Data can be purchased online in variety of formats including the shapefile format. For the state of Nevada Dynamap/2000 data contains 446,844 street segments out of which 238,716 are named street segments (53.4%). The cost for perpetual use of the data for a 1-5 user internal license, for the state of Nevada, is $10,500.00. However, for a 1-5 user internal license annual use of the data, the cost is $7,875.00.

Tele Atlas, a private provider of digital maps, offers a product called Tele Atlas MultiNet which has 40,000 street network segments for the state of Nevada out of which 38,000 are named segments. The cost for up to 5 users of the Tele Atlas MultiNet product without driving directions (routing attributes) in a shapefile format for use on PCs is $7,030.00. With routing attribute information the cost is $14,440.00.

The number of street segments and percent of named street segments in the Tiger/Line data and GDT databases for each County in the State of Nevada are summarized in Table 1. As can be seen from the table, percentage of named street segments is less than 70 percent for most of the counties in the State of Nevada. This might limit the number of crashes that could automatically be geo coded using GIS software. Though, GDT has more percent of named street segments, it is very expensive compared to Tiger/Line data which is available free of cost. Considering cost constraints, Tiger/Line Street network is used to geocode the pedestrian crashes.

Pedestrian Crash Data

Crash reports filed by law enforcement agencies provide the basis for a statewide crash database maintained by NDOT. The crash reports are filed with the Department of Motor Vehicles (DMV), who extracts limited driver data from each report and forwards a paper copy of the report to NDOT. The system is maintained primarily to serve the needs of engineers and planners in determining high crash locations and driver problem areas.

Pedestrian crash detail is severely restricted. The system does not provide details such as how far from the crosswalk the pedestrian was, the direction the pedestrian was traveling, or whether a vehicle was turning left or right at the intersection. The data can be manipulated to extract some additional detail, such as causal factor by age, but most of this must be done manually from the actual reports recorded by the investigating officer. The TRC has worked extensively with data from NDOT, and it has been successful in geo-referencing (in a GIS environment) crash data extracted from the NDOT files. Pedestrian crashes over a five-year period (1998 to 2002) were considered for this study. This information was provided in five files, requiring extensive data processing and formatting.

The system contains spatial and temporal characteristics of pedestrian crashes. The spatial characteristics includes pedestrian crashes by locations such as signalized intersection, unsignalized intersection, mid-block, near bust stops, etc., and pedestrian crashes by street type, i.e. functional classification of the road (major arterial, minor arterial, collector streets, local roads, etc.) and road class (divided or undivided highway, number of lanes, etc.). The temporal characteristics of the pedestrian crashes includes time of the day, day of the week, month of the year, age and gender of the pedestrian, etc. The system also contains data for the pedestrian action during the crashes such as crossing not at intersection, crossing at intersection with signal, ran in to roadway, etc.

The evaluation and identification of high pedestrian crash sites is thus primarily based on crash data maintained by NDOT. Table 2 shows the number of pedestrian crashes in each county from 1998 to 2002. Data show that there were 4,844 pedestrian crashes in the state of Nevada between 1998 and 2002. Of the 4,844 pedestrian crashes, 3,627 and 877 pedestrian crashes occurred in Clark County and Washoe County, respectively. These pedestrian crashes in Clark County and Washoe County account for 75 percent and 18 percent of the total pedestrian crashes in Nevada, respectively. The top five counties account 97% of the total pedestrian crashes. So only these counties are considered for evaluation and identification of high pedestrian crash sites. Figure 1 shows the number of pedestrian crashes for the selected counties during the study period.

Geocoding

The method of deriving spatial coordinates for a specific location based on street name / reference street name, street address or mile-post is called geocoding. The information in the attribute table of the street network is used to locate the addresses in case of geocoding based on street name / reference street name or street address. A street network with mile-post data is required to geocode crashes based on mile-post. The more detailed the street data, the more accurately addresses can be located. The output of a geocoding process is either a shapefile or a geodatabase feature class of points.

Issues with geocoding

In order to geocode using ArcMap, a geocoding service has to be created using ArcCatalog. To build a geocoding service appropriate geocoding style has to be selected. The majority of the styles available in ArcMap support the street address reference system, which contains a street name attribute and beginning and ending address ranges for each side of a street. Similarly, geocoding service style called "ZIP" is used with reference data that has a ZIP code attribute. But the pedestrian crash database provided by the NDOT has crashes recorded mainly using Intersection reference system and milepost reference systems, for which there is no specific style available.

Crashes occurring at the intersections are recorded using a street name and a reference street name while those occurring at midblock are done using street address reference system. In order to geocode the crashes at the intersections based on street name / reference street name, the intersection connector feature available in ArcCatalog is used. The main idea behind this feature is to separate the main street name and reference street name using some connectors such as "& @ , /". So an additional field is created on the crash database with the main street and reference street name and separated by "&" in order to geocode the intersections.

Geocoding service is created for each county separately with the input parameters such as the location of the county street network and the name of the respective fields required in the crash database. Each county is separately considered in order to possibly avoid conflict of same street name in different counties. Likewise, a separate database was created for each year for each county.

Another issue while geocoding was the discrepancies on the naming convention adopted in the street center line and crash database. For example, the crash database has the street name "US 50" and the same street is denoted as "United States Highway 50" in the street center line coverage. The problem with crash database naming style is that, while geocoding it searches for the street with name "US 50" and type "Hwy". Similarly the street center line does not have the street type for "United States Highway 50". So in order to resolve these issues the naming style of both the records are changed, so that consistency is ensured. The street name on the crash database is changed to "US50 Hwy". Similarly, the name on the street center line is updated to "US50" with the street type as "Hwy".

A few crashes were not geocoded because their corresponding street addresses were missing or misspelled or different name is used on the corresponding reference street network. For example, within the Carson City, crashes on the United States Highway 50 could not be geocoded because a local street name is used in the reference data instead of United States Highway 50. Crashes which are not geocoded due to such issues were digitized manually with the help of a map.

Geocoding Results

Table 3 shows number of crashes, number of crashes geocoded, number of crashes digitized, total geocoded (sum of crashes geocoded and digitized), and the percent of crashes of crashes geocoded by year for Clark County, Washoe County, Carson City, Elko County, and Douglas County. Figures 2 to 6 shows pedestrians crashes overlaid on the street network for Clark County, Washoe County, Carson City, Elko County, and Douglas County.

Table 1 Number of Street Segments and Segments with Street Name by County

County	No. of Street Segments		% of Named Street Segments	
	Tiger/Line	GDT	Tiger/Line	GDT
Clark	75,072	108,735	85.36	95.80
Carson City	4,785	6,560	81.73	90.41
Washoe	34,122	54,110	69.86	78.77
Douglas	7,732	8,211	66.04	86.97
Lyon	10,991	14,332	56.91	59.06
Storey	1,947	2,053	42.32	50.66
Churchill	12,736	15,860	33.26	34.57
Nye	41,824	53,144	30.80	34.32
Elko	41,870	47,038	26.92	24.94
Eureka	7,096	9,746	25.20	39.08
White Pine	26,095	31,624	24.84	25.29
Humboldt	19,809	20,431	24.36	35.02
Mineral	10,573	13,178	22.63	22.08
Lander	11,150	11,505	19.64	25.61
Pershing	13,787	18,176	18.74	24.90
Lincoln	17,617	22,157	18.63	14.13
Esmeralda	7,918	9,984	17.71	14.21
Total	**345,124**	**446,844**	**45.59**	**53.42**

Table 2 Number of Pedestrian Crashes by County (1998-2002)

County	1998	1999	2000	2001	2002	Total	Rank
Carson	30	28	28	19	21	126	**3**
Churchill	1	6	9	7	1	24	8
Clark	749	790	685	728	675	3,627	**1**
Douglas	7	6	5	11	7	36	**5**
Elko	15	8	15	10	12	60	**4**
Esmeralda	0	0	0	0	0	0	17
Eureka	0	1	0	0	1	2	12
Humbolt	4	7	2	7	6	26	7
Lander	0	0	0	1	0	1	15
Lincoln	1	0	0	0	0	1	16
Lyon	5	5	4	5	8	27	6
Mineral	0	2	2	3	2	9	10
Nye	2	6	4	1	4	17	9
Pershing	1	1	0	0	0	2	13
Storey	0	0	0	2	0	2	14
Washoe	152	180	175	168	202	877	**2**
White Pine	3	2	1	0	1	7	11
Total	**970**	**1,042**	**930**	**962**	**940**	**4,844**	

Table 3 Pedestrian Crashes Geocoding/Digitizing Results

1998					
County	**No. of Crashes**	**No. Geocoded**	**No. Digitized**	**Total Referenced**	**% Referenced**
Clark	749	720	0	720	**96%**
Washoe	152	131	0	131	**86%**
Carson	30	18	8	26	**87%**
Elko	15	8	0	8	**53%**
Douglas	7	5	0	5	**71%**
Total	953	882	8	890	**93%**
1999					
County	**No. of Crashes**	**No. Geocoded**	**No. Digitized**	**Total Referenced**	**% Referenced**
Clark	790	754	0	754	**95%**
Washoe	180	144	0	144	**80%**
Carson	28	11	9	20	**71%**
Elko	8	6	1	7	**88%**
Douglas	6	1	3	4	**67%**
Total	1,012	916	13	929	**92%**
2000					
County	**No. of Crashes**	**No. Geocoded**	**No. Digitized**	**Total Referenced**	**% Referenced**
Clark	685	646	0	646	**94%**
Washoe	175	150	0	150	**86%**
Carson	28	11	13	24	**86%**
Elko	15	7	4	11	**73%**
Douglas	5	1	0	1	**20%**
Total	908	815	17	832	**92%**
2001					
County	**No. of Crashes**	**No. Geocoded**	**No. Digitized**	**Total Referenced**	**% Referenced**
Clark	728	691	0	691	**95%**
Washoe	168	135	0	135	**80%**
Carson	19	9	10	19	**100%**
Elko	10	7	1	8	**80%**
Douglas	11	6	2	8	**73%**
Total	936	848	13	861	**92%**
2002					
County	**No. of Crashes**	**No. Geocoded**	**No. Digitized**	**Total Referenced**	**% Referenced**
Clark	675	645	0	645	**96%**
Washoe	202	168	0	168	**83%**
Carson	21	13	8	21	**100%**
Elko	12	7	2	9	**75%**
Douglas	7	1	2	3	**43%**
Total	917	834	12	846	**92%**
Total (1998-2002)					
County	**No. of Crashes**	**No. Geocoded**	**No. Digitized**	**Total Referenced**	**% Referenced**
Clark	3,627	3,456	0	3,456	**95%**
Washoe	877	728	0	728	**83%**
Carson	126	62	48	110	**87%**
Elko	60	35	8	43	**72%**
Douglas	36	14	7	21	**58%**
Total	4,726	4,295	63	4,358	**92%**

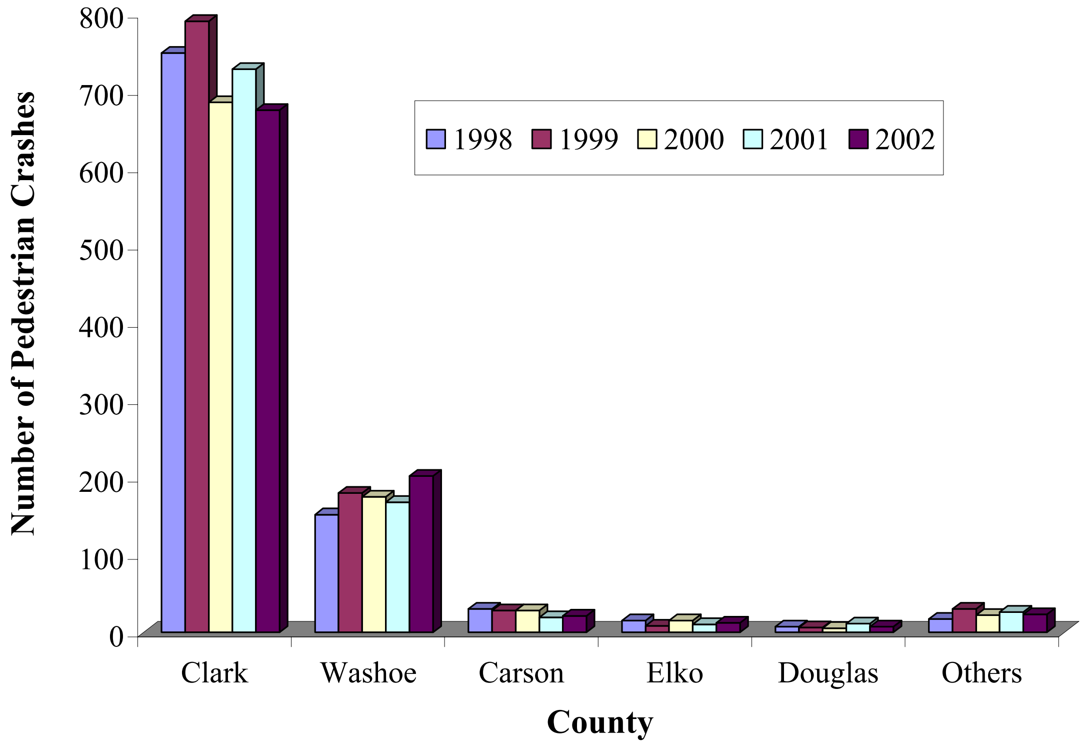

Figure 1 Number of Pedestrian Crashes for Selected Counties (1998-2002)

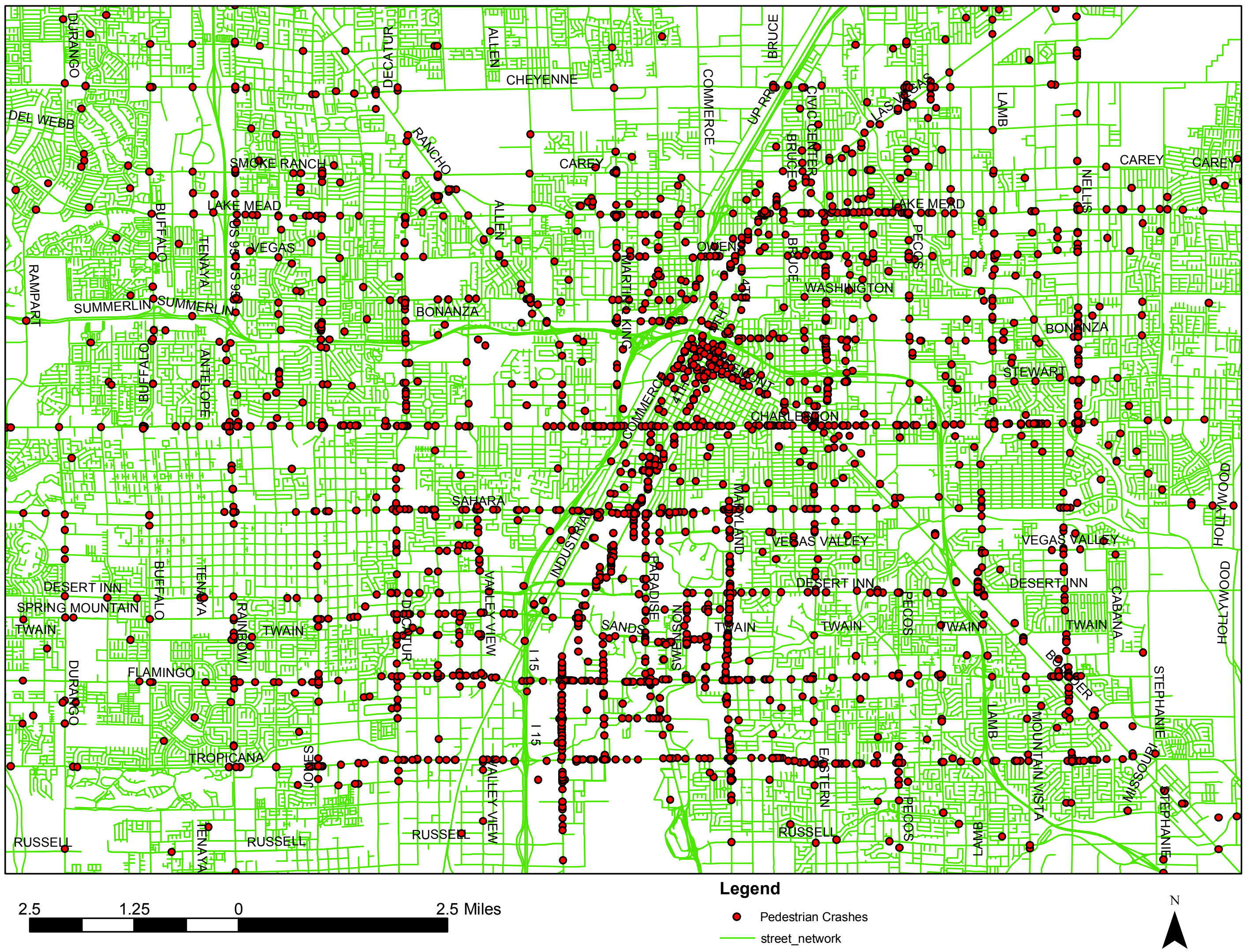

Figure 2 Spatial Distributions of Pedestrian Crashes in the Las Vegas Metropolitan (1998-2002)

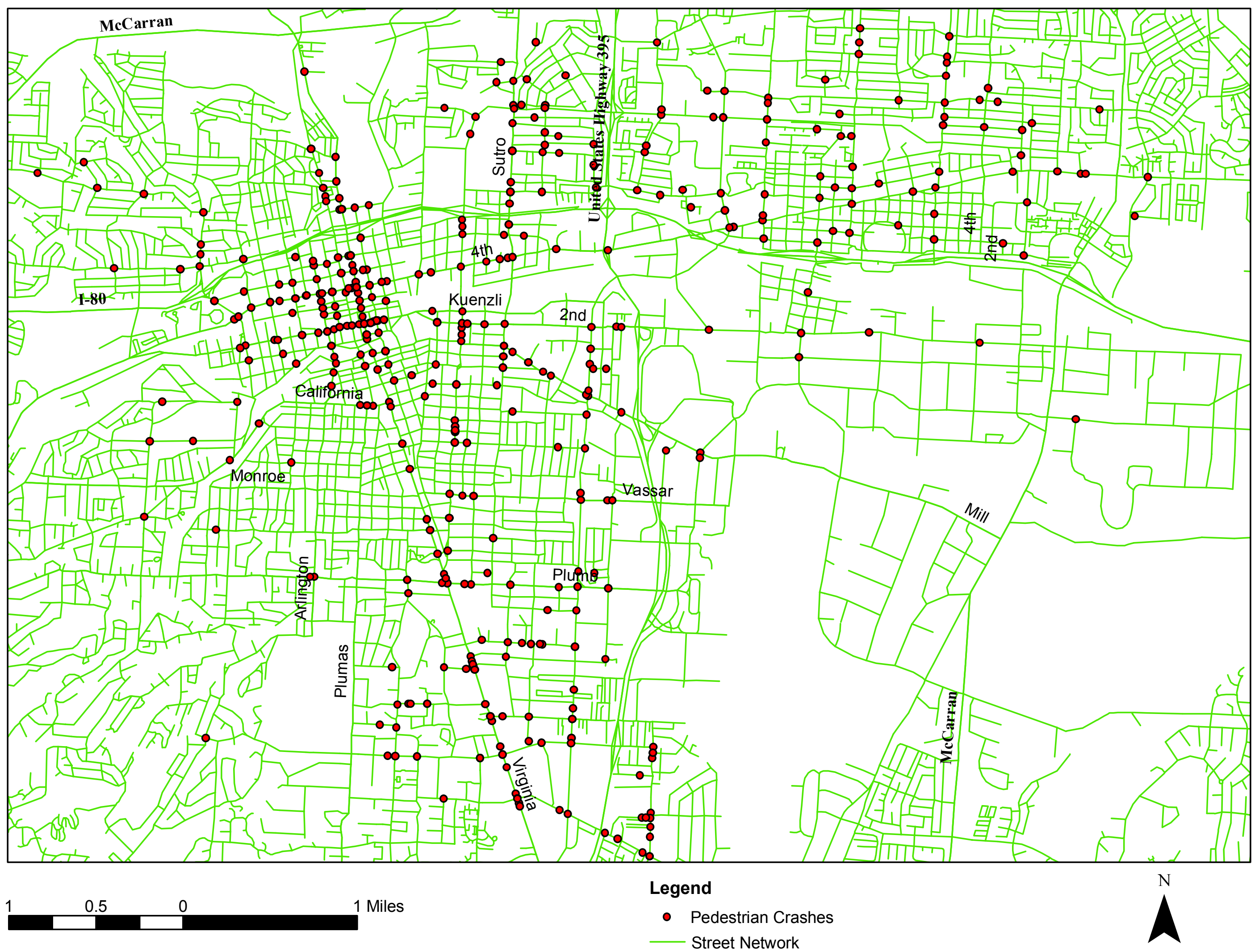

Figure 3 Spatial Distributions of Pedestrian Crashes in Washoe County (1998-2002)

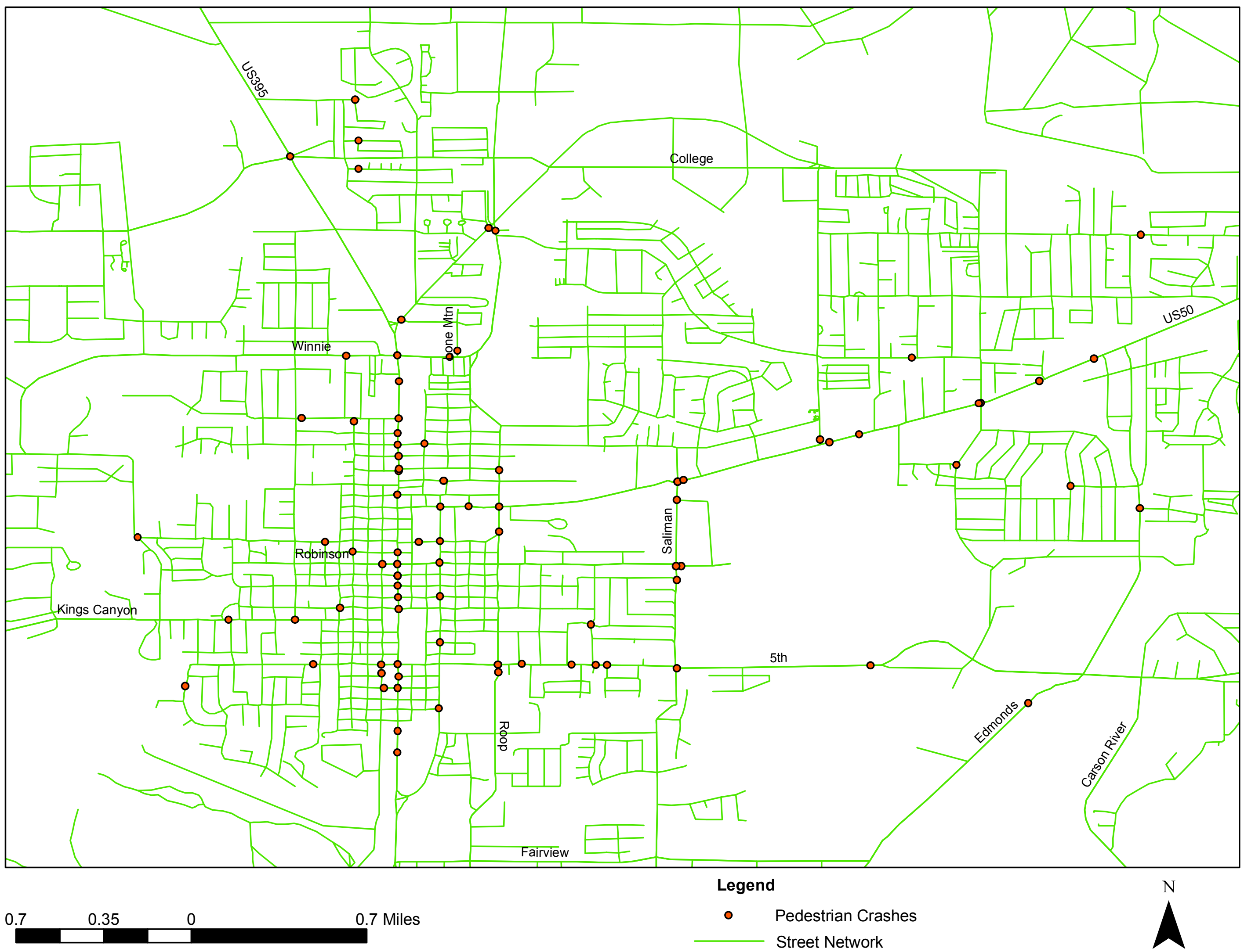

Figure 4 Spatial Distributions of Pedestrian Crashes in Carson City (1998-2002)

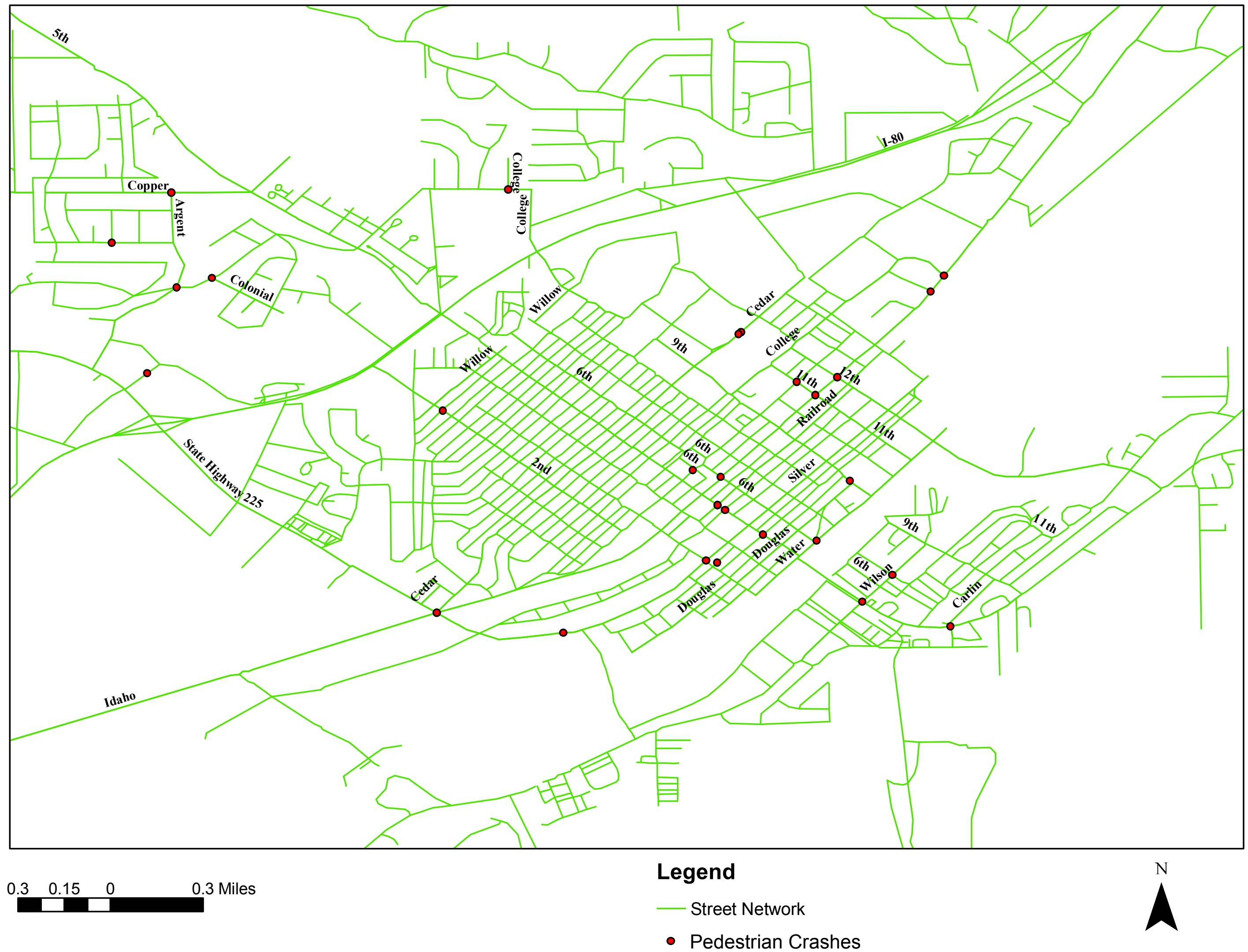

Figure 5 Spatial Distributions of Pedestrian Crashes in the City of Elko (1998-2002)

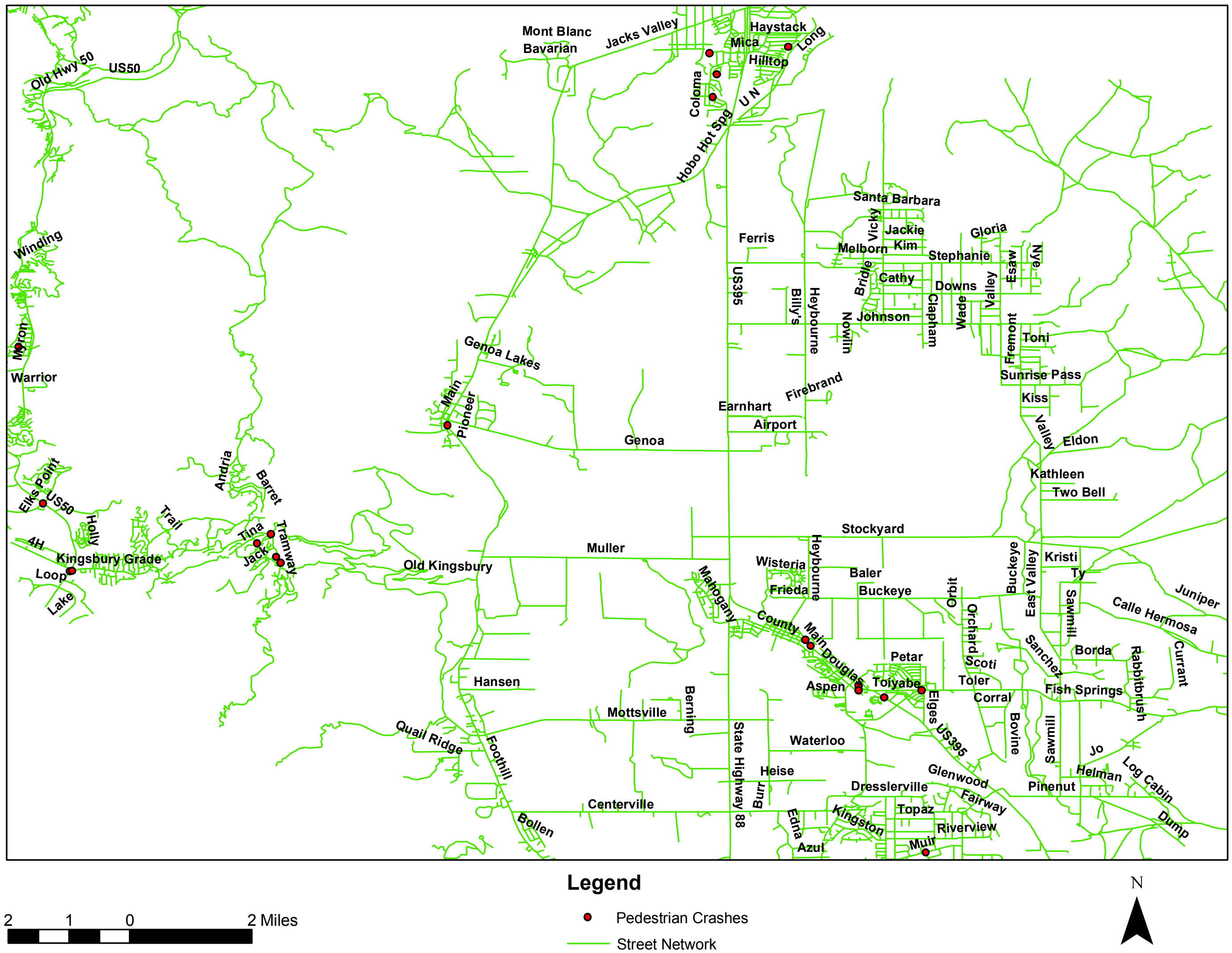

Figure 6 Spatial Distributions of Pedestrian Crashes for Douglas County (1998-2002)

CHAPTER 4
ANALYSIS OF DATA

The crash data provided by the NDOT are used to analyze the spatial and temporal characteristics of pedestrian crashes in Nevada. Analysis of the pedestrian crashes that occurred from 1998 to 2002 indicated that about five percent of the crashes are fatal. Observations have shown that the probability of pedestrian involvement in a crash between 1998 and 2002 was about the same on all days of a week, though it is marginally higher on Fridays and lower on Sundays. Approximately, 40 percent of crashes were under dark light conditions, and about 45 percent of crashes are between 12:00 Noon and 6:00 PM and. About 20 percent of crashes occurred between 6:00 PM and 12:00 AM. Similarly, 14 percent of crashes occurred during cloudy and raining conditions.

About 75 percent of pedestrian crashes occurred on principal arterial and minor arterial streets (Figure 7). Approximately 50 percent of the crashes occurred on streets with undivided four lanes and undivided six lanes (Table 4). About 60 percent of the pedestrian crashes were in “speed control zones” and seven percent of pedestrian crashes at stop signs (Table 5). About 55 percent of crashes were due to pedestrian failure to yield and about 40 percent due to motorist failure to yield, driving under the influence of alcohol or inattentive driving.

Analysis of pedestrian crashes that occurred from 1998 to 2002 indicates that male pedestrians are involved in twice as many pedestrian crashes as female pedestrians. During the same period, children under 18 years of age were involved in about 27 percent of pedestrian crashes (Figure 8). Similarly, citizens in the age group of 50 to 64 years and 65 years and over were involved in about 14 percent and 9 percent of total pedestrian crashes, respectively. About 38 percent of the pedestrians who die each year had consumed alcohol or drugs.

An analysis of the pedestrian action field in all the pedestrian crash records shows the following to be the top six causal factors (Figure 9):

1) Crossing not at intersection – no pedestrian crosswalk (28 percent)
2) Crossing at intersection with signal (20 percent)
3) Ran into roadway (7 percent)
4) Not in roadway (8 percent)
5) Crossing at intersection – no signal (8 percent)
6) Crossing at intersection – against signal (7 percent)

The percent of crashes for each causal factor is indicated in parenthesis besides the causal factor.

Analysis of the pedestrian crashes with respect to each county shows that the characteristics of the crashes were similar. But some variations do exist. About 20 percent of the pedestrian crashes occurred during cloudy and raining conditions in Washoe County and Carson City, and 30 percent of the pedestrian crashes occurred during cloudy and raining conditions in Elko County.

About 75 percent of pedestrian crashes occurred on principal arterial rural and local rural streets in Douglas County and approximately 65 percent of the crashes occurred on streets with two lanes marked and unmarked streets. About 80 percent of the pedestrian crashes were in "speed control zones" in Elko and Douglas Counties, and ten percent of pedestrian crashes at stop signs in Washoe County and Carson City.

About 44 percent of the pedestrians who were involved in the crashes were female in Elko County. Children under 18 years of age were involved in about 45 percent of pedestrian crashes in Carson City and Elko County. Approximately 25 percent of the crashes were due to pedestrian crossing at intersection without signal in Carson City and Elko County, and only about three percent of the crashes were during pedestrian crossing at intersection with signal in Elko and Douglas Counties.

Table 4 Percent of Pedestrian Crashes by Road Class

Road Class	Percent of Crashes				
	1998	1999	2000	2001	2002
2L- Marked (One Each Direction)	11	9	12	8	8
2L- Unmarked (One Each Direction)	14	15	15	13	10
4L - Divided	18	12	10	11	13
4L - Undivided	25	26	27	28	25
6 Lanes - Divided	22	27	25	23	23
6 Lanes - Undivided	7	7	7	10	12
Others	3	4	4	7	8

Table 5 Percent of Pedestrian Crashes by Traffic Control

Traffic Control	Percent of Crashes				
	1998	1999	2000	2001	2002
Speed Control Zone	64.64	57.77	59.46	58.32	60.21
Signal Lights - In Operation	27.63	33.01	30.86	32.22	30.32
Stop Sign	4.85	7.20	6.88	7.17	6.81
Others	2.89	2.02	2.80	2.29	2.66

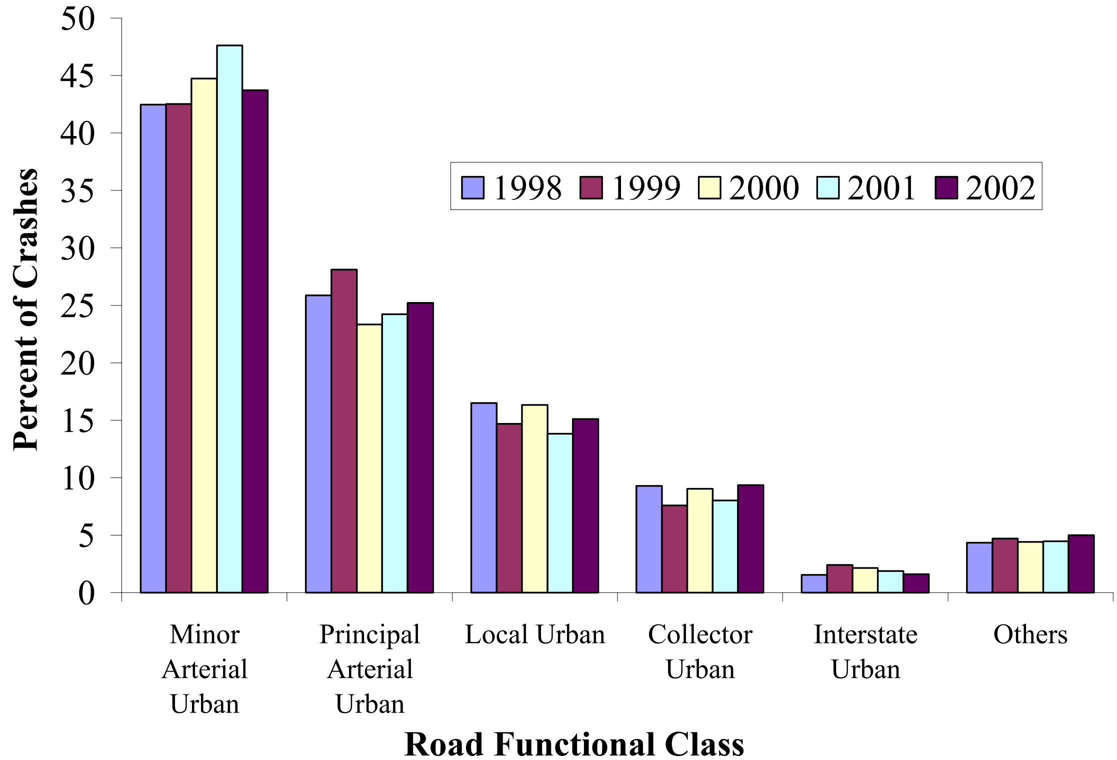

Figure 7 Percent of Pedestrian Crashes by Functional Class

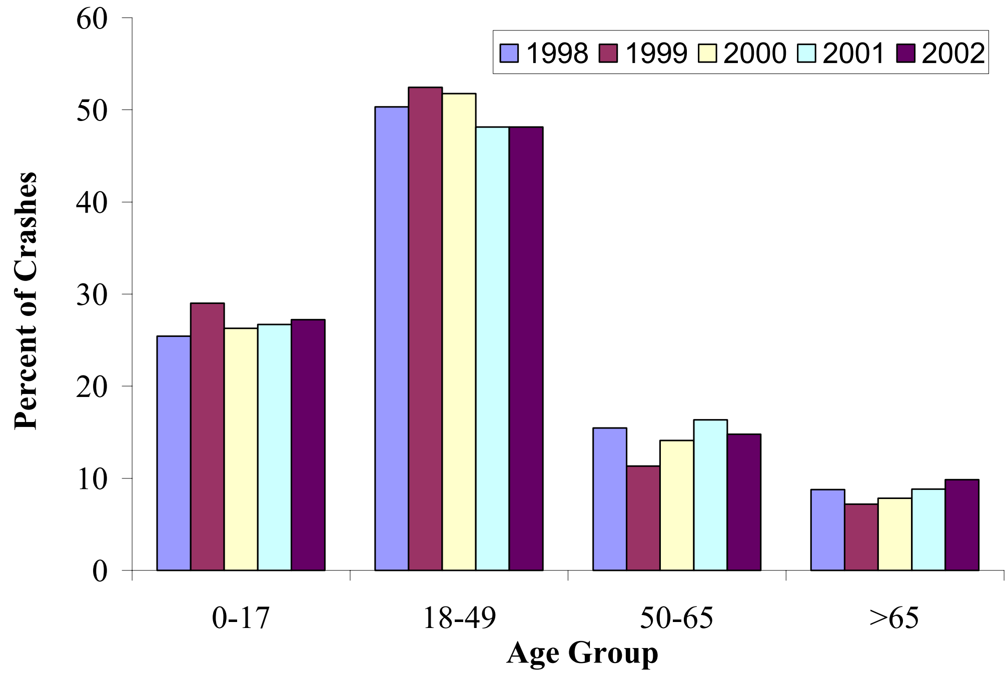

Figure 8 Percent of Pedestrian Crashes by Age Group

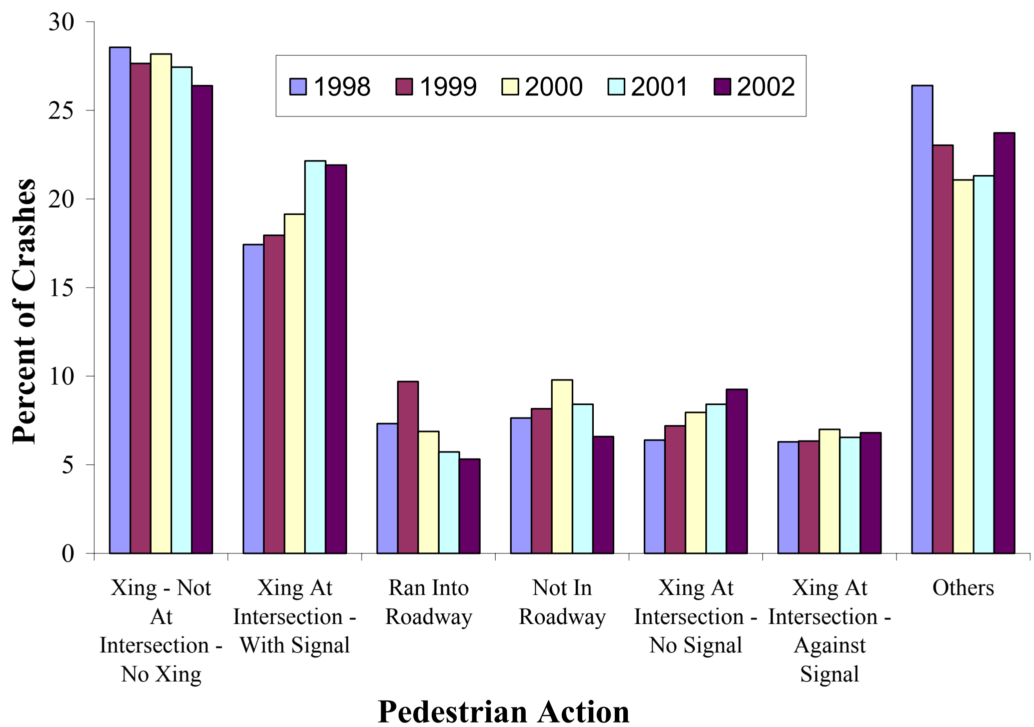

Figure 9 Percent of Pedestrian Crashes by Pedestrian Action

CHAPTER 5
IDENTIFY CRASH CONCENTRATIONS

The geocoded pedestrian crashes show some clustering and some dispersion throughout the study area. Several crashes occur at one single point, so the presence of a dot does not necessarily equal one crash. For example, Figure 10 shows the spatial distributions of pedestrian crashes in the City of Reno and the map does not exactly reflect the crash concentrations of locations having more than one crash. Virginia Street and 4th Street intersection in the map actually has 9 crashes, where as Virginia Street and Plaza Street intersection has only one crash. But the map does not make any difference in representing these crash concentrations. In order to identify the concentration and pattern of crashes, which is important to locate pedestrian high crash locations, density map feature available in ArcMap is used.

Density surfaces are used to demonstrate concentrations of point or line locations. For example, if on an annual basis higher number of pedestrian crashes occurs at an intersection than other locations, then the density of pedestrian crashes will be concentrated near the intersection. Density is a measure of the quantity of something per unit of area, such as the number of pedestrian crashes per square mile or people per square mile. Density can be calculated using two methods: simple method and kernel method. A circular search area is used by both methods to calculate density.

Simple Density

The simple method divides the entire study area to predetermined number of cells and draws a circular neighborhood around each cell to calculate the individual cell density values, which is the ratio of number of features that fall within the search area to the size of the area (Figure 11). Radius of the circular neighborhood affects the resulting density map. If the radius is more, higher is the possibility that the circular neighborhood include more feature points which results in a smoother density surface.

Kernel Density

Kernel method uses a mathematical procedure to estimate the density compared to the simple method. The kernel method divides the entire study area to predetermined number of cells. Rather than considering a circular neighborhood around each cell (simple method), kernel method draws a circular neighborhood around each feature point and then a math function is applied that goes from 1 at the position of the feature point to 0 at the neighborhood boundary. Radius of the circular neighborhood affects the resulting density map. If the radius is more, the flatter is the kernel. ArcMap 8.2 uses a Quadratic function to do the kernel density estimation. Density at a distance of r from sample point is

$$= \mathbf{K * (1 - (\frac{r}{R})^2)^2} \quad \text{if } r < R \text{ and } \mathbf{0} \text{ if } r >= R$$

where,

R = Search Radius

r = Distance from the sample point

$K = \frac{3}{\pi R^2}$

For example for a search radius of 500m the density can be calculated as (Figure 12):

Density at (r=0) i.e. at (0, 0) = $\frac{3}{\pi\, 500^2}\ (1 - (\frac{0}{500})^2)^2$

= 3.82 per sq. km.

This kernel function is applied to each feature point. The individual cell density value is the sum of the overlapping kernel values over that cell divided by the area of the search radius (Figure 13). A smoother looking density surface is created by kernel density calculations than the simple density calculations.

For calculating the crash densities, kernel method is employed with a search radius of 400 feet. The resulting crash densities (corresponding to Figure 10) for the city of Reno are shown in Figure 14. The map makes clear distinction between the crash concentrations of locations having more number of crashes. From Figure 14 it is more apparent that the Virginia Street and 4th Street intersection in the City of Reno has higher crash concentrations compared to other intersections nearby. Figure 15 through Figure 18 shows density maps / pedestrian crash concentrations for the Las Vegas metropolitan area, City of Reno, Carson City, and Elko City, respectively.

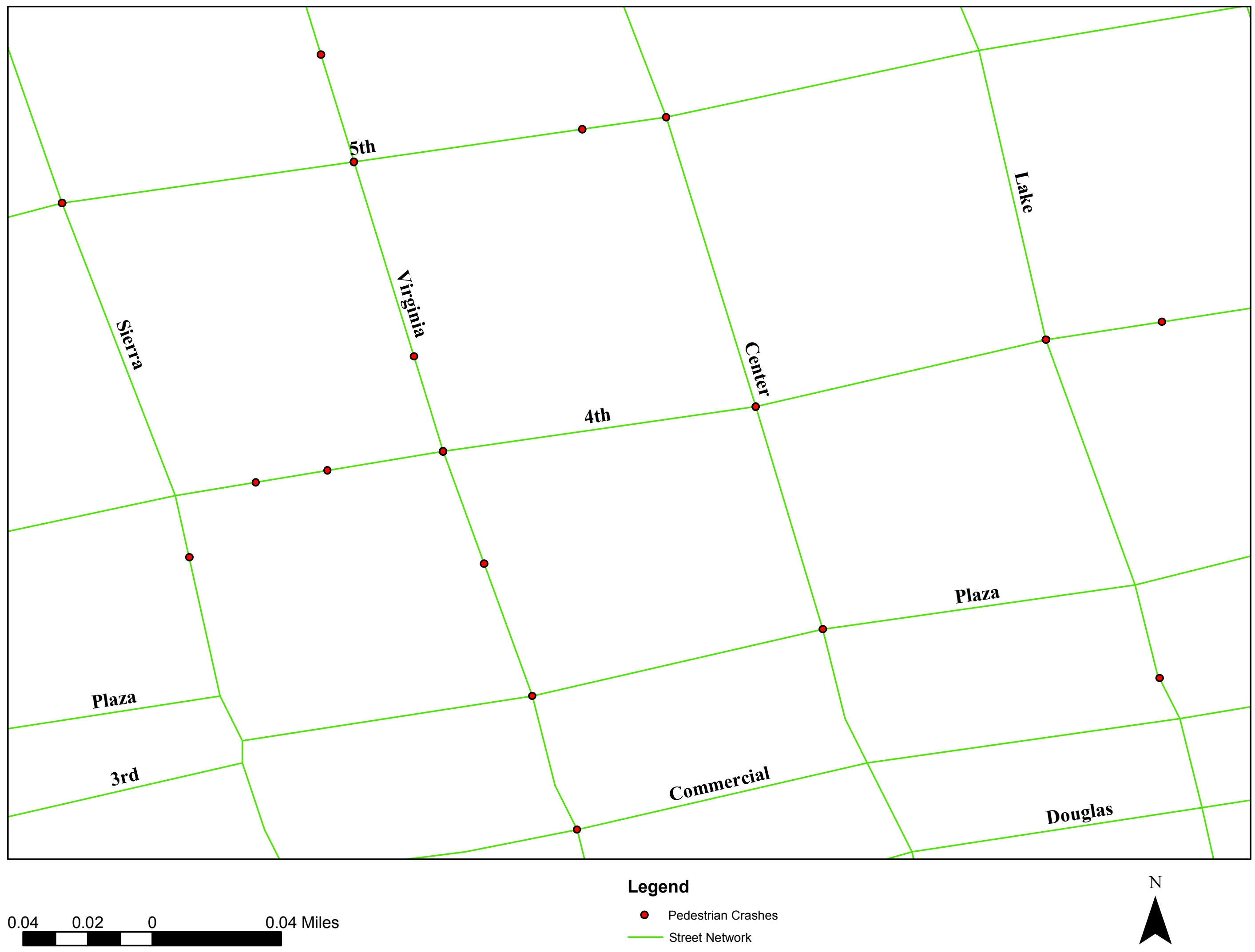

Figure 10 Spatial Distribution of Pedestrian Crashes in the City of Reno (Zoomed in)

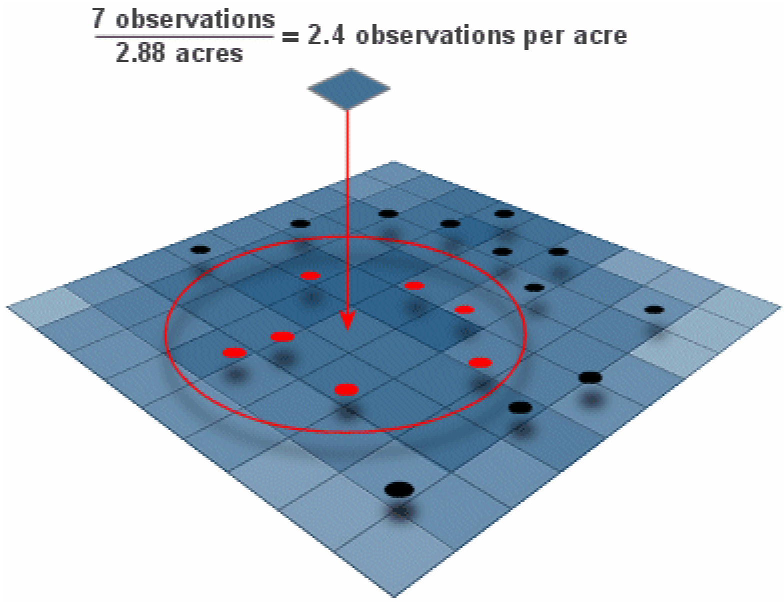

Figure 11 Simple Density Calculations (Source: ESRI VIRTUAL CAMPUS)

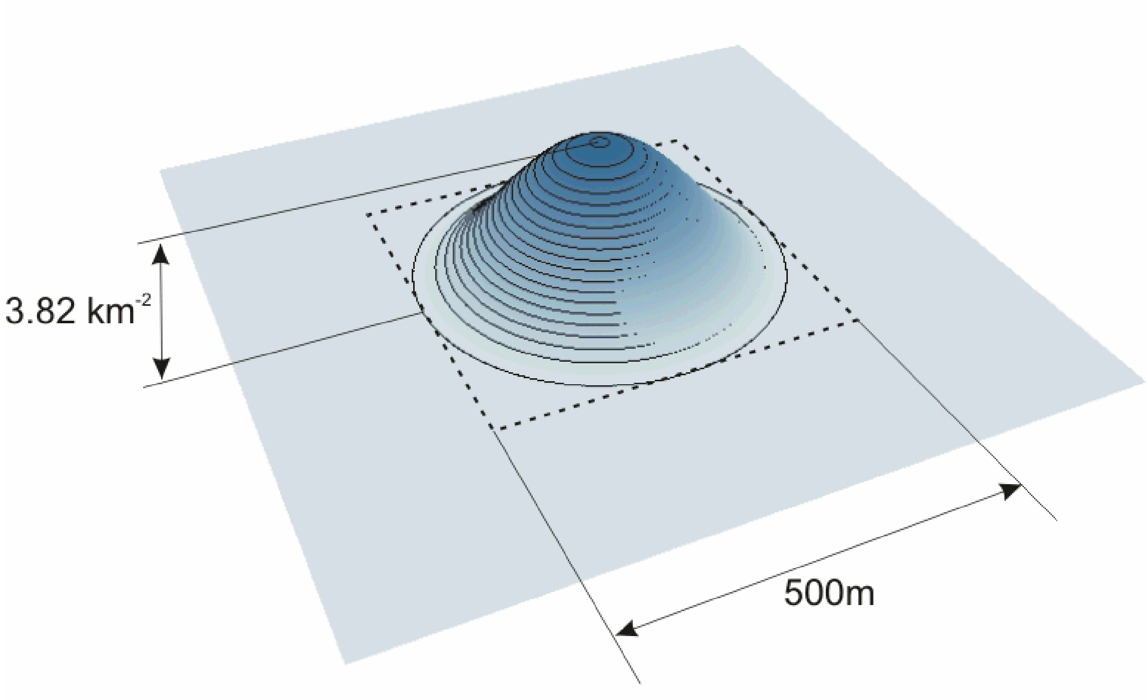

Figure 12 Kernel Density Calculations

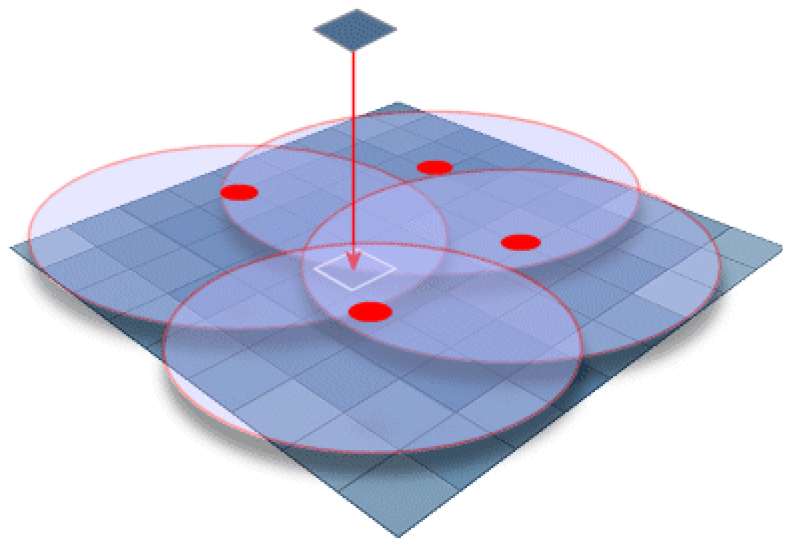

Figure 13 Kernel Density: Calculating the Individual Cell Density Values (Source: ESRI VIRTUAL CAMPUS)

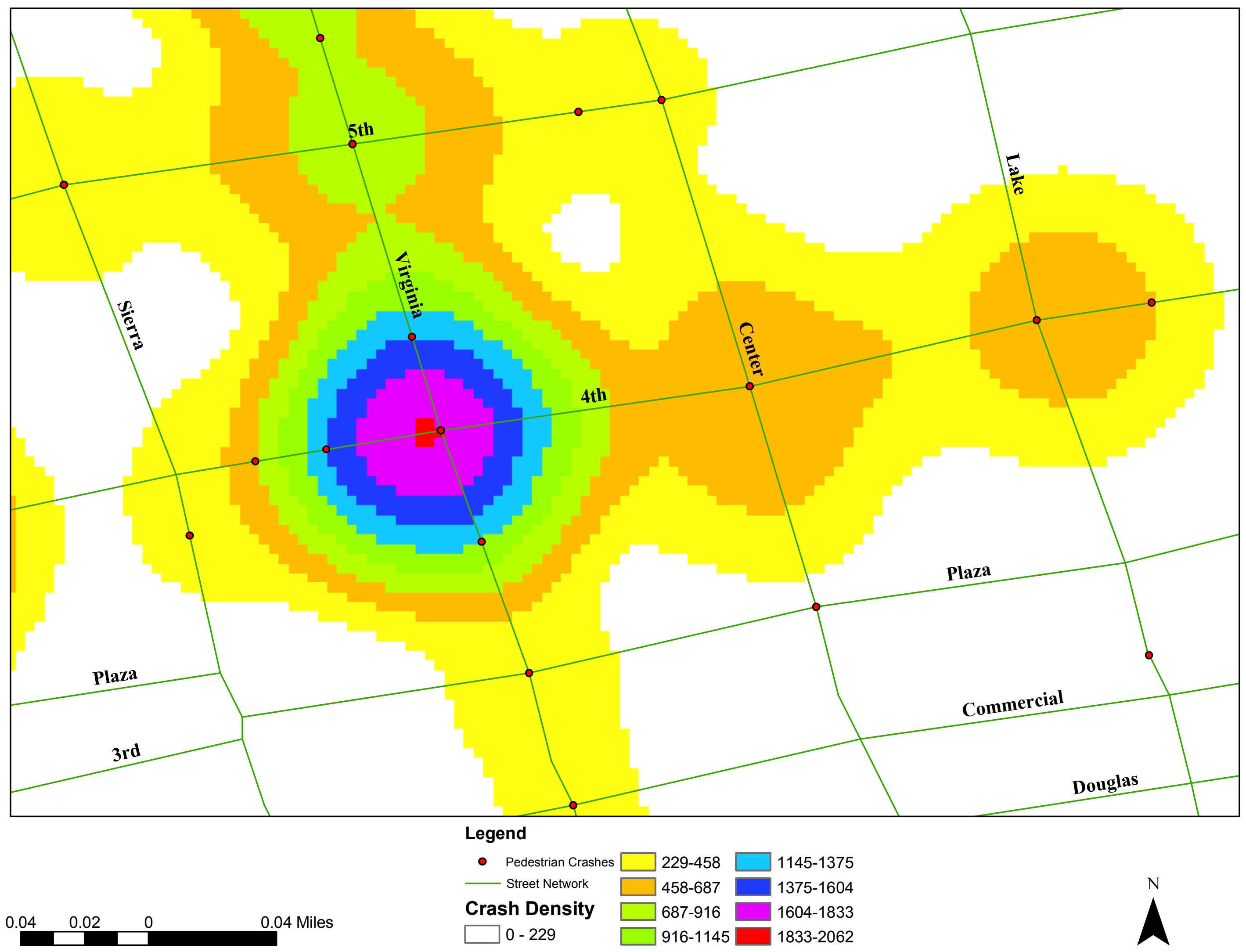

Figure 14 Pedestrian Crash Concentrations in the City of Reno (Zoomed In)

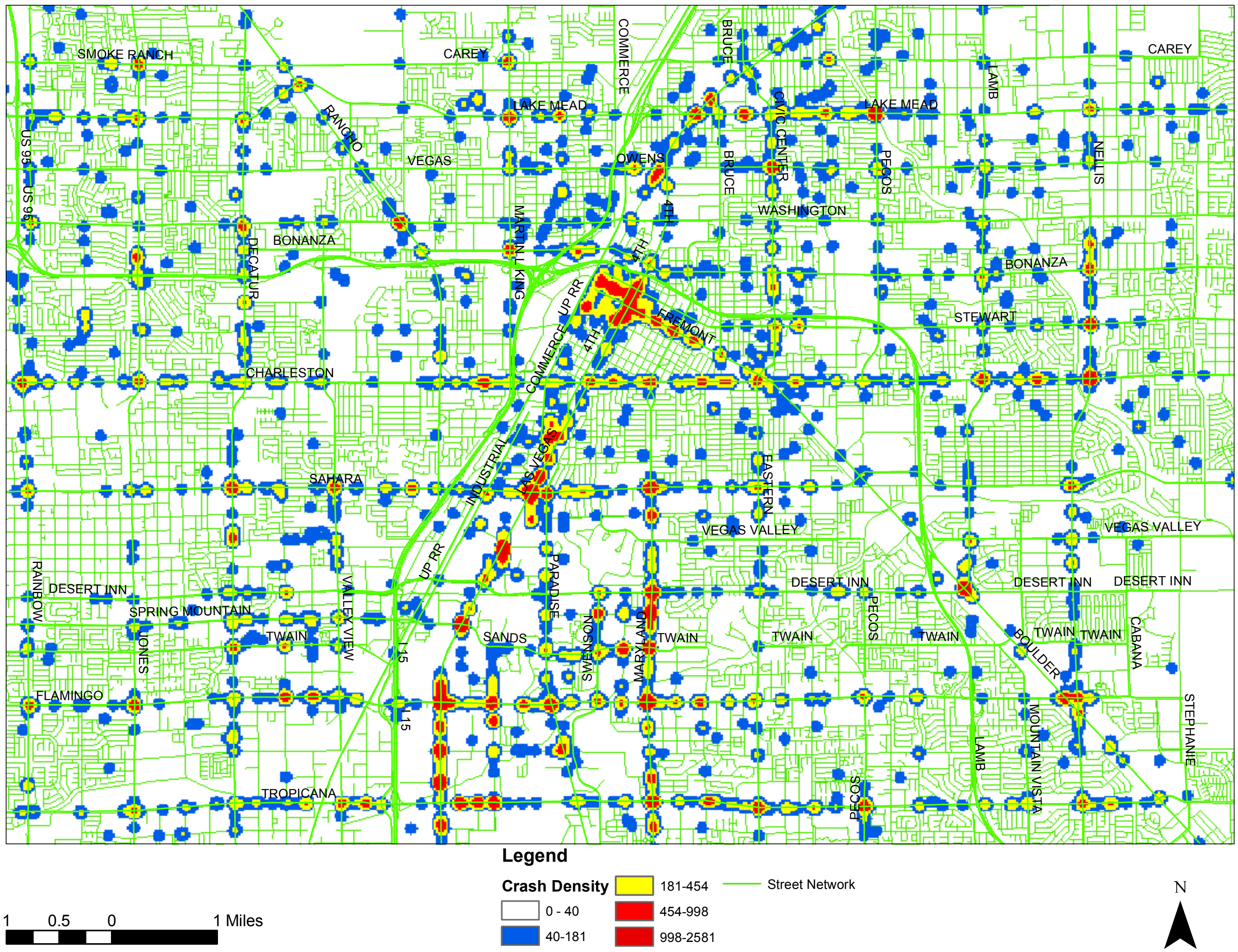

Figure 15 Pedestrian Crash Concentrations in the Las Vegas Metropolitan (1998-2002)

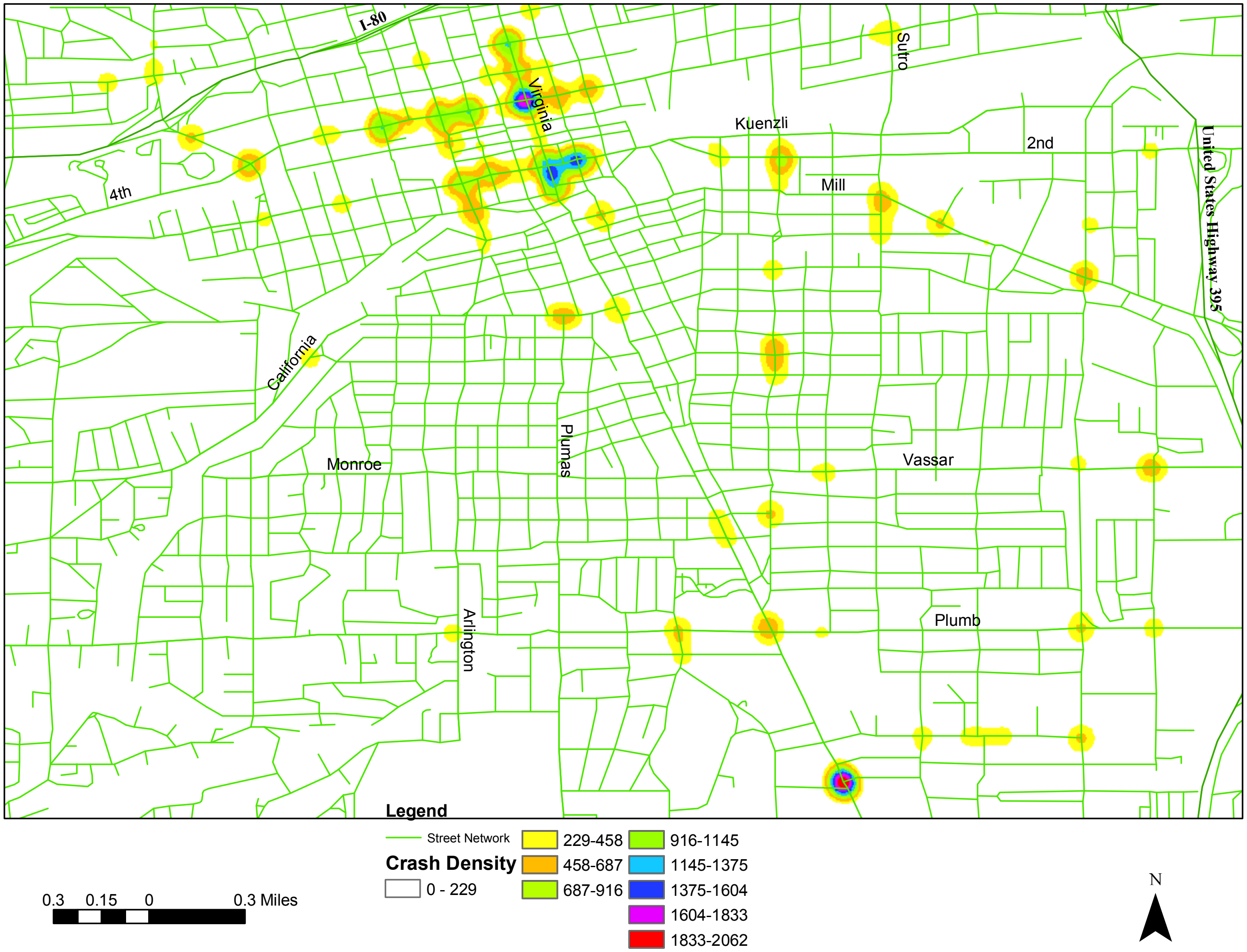

Figure 16 Pedestrian Crash Concentrations in the City of Reno (1998-2002)

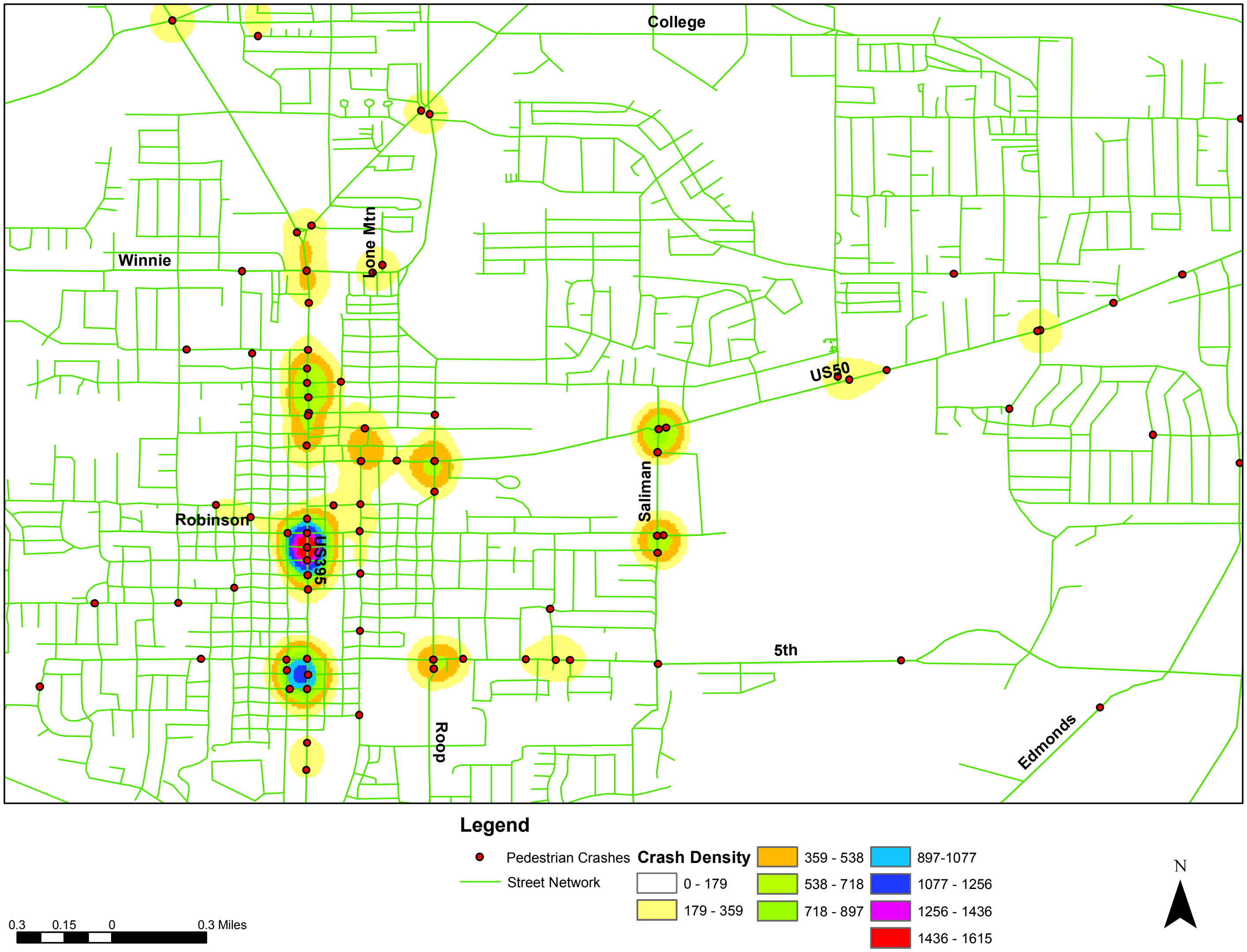

Figure 17 Pedestrian Crash Concentrations in Carson City (1998-2002)

Figure 18 Pedestrian Crash Concentrations in the City of Elko (1998-2002)

CHAPTER 6
IDENTIFY HIGH CRASH LOCATIONS

After identifying crash densities, the next step is to select potential "high crash locations". The FHWA Zone Guide for Pedestrian Safety (1998) provides a systematic method for targeting pedestrian safety improvements in a cost effective manner. Zoning identifies a subset of jurisdiction containing as much of the pedestrian problem of interest in as little land area as possible. The zoning methodology was initially applied to Washoe County, which has seen 762 pedestrian crashes in 187.6 square miles of study area.

The map is examined for high pedestrian crash density that occurs along a single strip of corridor. According to the FHWA Zone guide, for an annual crash rate in order of 200, those roadway segments where six or more crashes occur in a two-mile segment should be identified as linear zones. Thus for a study of 726 crashes, the minimum number of crashes required to qualify as a linear zone is 22 crashes in a two-mile segment. This crash rate is adjusted with respect to the segment length and 28 high risk linear zones are identified for the study area.

The locations which do not fall along a corridor but have higher crash density are selected as individual circular zones with 300 feet radius. Thirty-one high risk circular zones are identified in Washoe County.

For all zones combined, the percentages of both crashes and land area covered are calculated in order to determine program coverage efficiency.

$$\text{Ratio of percent of the problem addressed} = \frac{\text{Number of crashes inside all zones combined}}{\text{Total number of crashes in the study area}}$$

$$= \frac{460}{726} = 60.00\ \%$$

$$\text{Ratio of the land area covered} = \frac{\text{Total Area of Linear Zones+Total area of Circular zones}}{\text{Area of Study Area}}$$

$$= \frac{0.629 sq.miles + 0.313 sq.miles}{187.6 sq.miles} = 0.50\ \%$$

$$\text{Efficiency ratio} = \frac{\text{Ratio of percent of the problem addressed}}{\text{Ratio of the land area covered}}$$

$$= \frac{60}{0.5} = 120$$

Thus, an efficiency ratio of 120 is obtained, which is much higher than the minimum efficiency ratio of 3 specified by FHWA Zone Guide.

The methodology is applied to Clark County, Carson City, Elko County, and Douglas County to identify the "high crash locations / zones". Twenty-two linear zones and 5 circular zones in Clark County, 5 linear zones and 5 circular zones in Carson City, 21 circular zones in Elko County, and 19 circular zones in Douglas County are identified. Table 5-Table 9 provides the details of the selected high crash locations. Figure 19-Figure 23 shows the spatial distributions of the selected high crash locations.

Table 6 Pedestrian High Crash Locations in the Las Vegas Metropolitan Area

Zone #	Location	Length(miles)	Radius(miles)	Type
1	Las Vegas Blvd: Fashion Show Dr to Reno Av	2.16		Linear
2	Las Vegas Blvd: 4th St to Stardust Rd	1.74		Linear
3	Downtown Las Vegas		1.10	Circular
4	Las Vegas Blvd: Cheyenne Av to Foremaster La	3.25		Linear
5	Charleston Blvd: Decatur Blvd to Buffalo Dr	3.15		Linear
6	Charleston Blvd: Main St to Rancho Dr	1.08		Linear
7	Charleston Blvd: Nellis Blvd to Eastern Av	2.39		Linear
8	Sahara Ave: Mcleod Dr to Paradise Rd	2.52		Linear
9	Sahara Ave: Arville Av to Rainbow Blvd	2.42		Linear
10	Sahara Ave: Fairfield Av to Valley View Blvd	1.81		Linear
11	Maryland Pkwy: Karen Av to Hacienda Av	3.25		Linear
12	Tropicana Av: Pecos Rd to Tamarus St	1.76		Linear
13	Tropicana Av: Boulder Av to Sandhill Rd	2.29		Linear
14	Boulder Highway-Pecos Rd		0.75	Circular
15	Boulder Highway-Desert Inn Rd		0.50	Circular
16	Flamingo Rd: Sandhill Rd to Escondido St	2.43		Linear
17	Tropicana Av: Wilbur St to Tropicana CC Bdry	1.64		Linear
18	Flamingo Rd: Claymont St to Las Vegas Blvd	1.59		Linear
19	Harmon Avenue		0.43	Circular
20	Paradise-Twain		0.60	Circular
21	Flamingo Rd: I-15 to Ravenwood Dr	3.91		Linear
22	Tropicana Ave: I-15 to Raibow Blvd	3.37		Linear
23	Desert Inn Rd - Arville St		0.90	Circular
24	Decatur Blvd: Lake Mead Blvd to Dover Pl	2.31		Linear
25	Rancho Dr: Carey Ave to Palomino Ln	3.24		Linear
26	Jones Blvd: Somke Ranch Rd to Chelse Cr	1.88		Linear
27	Martin L King Blvd: Cartier Av to Bonanza Rd	2.04		Linear
28	Lake Mead Blvd-Mojave Rd		0.75	Circular
29	Nellis Blvd: Harris Av to Sahara Av	2.33		Linear

Table 7 Pedestrian High Crash Locations in Washoe County

Zone #	Location	Length (miles)	Radius (feet)	Type
1	4th Street: Lake Street to Keystone Avenue	0.85		Linear
2	Virginia Street: 6th Street to 1st Street	0.49		Linear
3	2nd Street: Lake Street to Keystone Place	0.84		Linear
4	Arlington Avenue: 6th Street to Island Avenue	0.57		Linear
5	California Street: Virginia Street to Hill Street	0.17		Linear
6	Keystone Avenue: Sunnyside Drive to 5th Street	0.37		Linear
7	Sierra Street: College Drive to 10th Street	0.31		Linear
8	Virginia Street: College Drive to 9th Street	0.30		Linear
9	Montello Street: Oliver Avenue to 9th Street	0.50		Linear
10	Sutro Street: Oliver Avenue to 4th Street	0.88		Linear
11	Oddie Blvd: Sullivan Lane to Silverada Blvd	0.61		Linear
12	El Rancho Drive: G Street to Prater Way	0.20		Linear
13	Wells Avenue: Kuenzli Street to Mill Street	0.17		Linear
14	Wells Avenue: Thoma Street to Taylor Street	0.12		Linear
15	Mill Street: Kietzke Lane to Pringle Way	0.39		Linear
16	Kirman Avenue: Mill Street to Ryland Street	0.12		Linear
17	Rock Blvd: Glendale Avenue to Freeport Blvd	0.14		Linear
18	Virginia Street: Pueblo Street to Plumb Lane	0.38		Linear
19	Lakeside Drive: Plumb Lane to Hillcrest Drive	0.08		Linear
20	Virginia Street: Linden Street to Peckham Lane	0.86		Linear
21	Neil Road: Moana Lane to Peckham Lane	0.63		Linear
22	Moana Lane: Kietzke Lane to Lakeside Drive	1.02		Linear
23	Kietzke Lane: Plumb Lane to Gentry Way	0.76		Linear
24	Grove Street: Wrondel Way to Kietzke Lane	0.38		Linear
25	Brinkby Avenue: Robinhood Drive to Lakeside Drive	0.17		Linear
26	Sun Valley Blvd: 7th Avenue to Scottsdale Road	2.57		Linear
27	Baring Blvd: Springland Drive to Sparks Blvd	0.49		Linear
28	Virginia Street: Bailey Drive to Talus Way	0.60		Linear
29	Peckham Lane & Kietzke Lane		300	Circular
30	Vassar Street & Kietzke Lane		300	Circular
31	Vassar Street & Harvard Way		300	Circular
32	Plumb Lane & Harvard Way		300	Circular
33	Terminal Way & Mill Street		300	Circular
34	Vassar Street & Locust Street		300	Circular
35	Wells Avenue & Pueblo Street		300	Circular
36	Stewart Street & Wells Avenue		300	Circular
37	Second Street & Wells Street		300	Circular
38	Mill Street & Center Street		300	Circular
39	7th & Center Street		300	Circular
40	5th Street & Sierra Street		300	Circular
41	Center Street & 5th Street		300	Circular
42	Newland Circle & California Avenue		300	Circular
43	7th Street & Elgin Avenue		300	Circular
44	Silverada Blvd & Orchid Way		300	Circular
45	9th Street & Shone Drive		300	Circular
46	Prater Way & Sullivan Lane		300	Circular
47	Plumb Lane & Arlington Avenue		300	Circular
48	Sulivan Lane & Greenbrae Drive		300	Circular
49	Tyler Way & Pyramid Way		300	Circular
50	Prater Way & I Street		300	Circular
51	Pyramid Way & L Street		300	Circular
52	Shadow Lane & Deep Creek Drive		300	Circular
53	Greg Street & Sparks Blvd		300	Circular
54	Stead Blvd & Silver Lake Road		300	Circular
55	Colling Circle & Newport Lane		300	Circular
56	2nd Street & Reservation Road		300	Circular
57	Prosperity Street & Kietzke Lane		300	Circular
58	Wells Avenue & 6th Street		300	Circular
59	Plumb Lane & Locust Street		300	Circular

Table 8 Pedestrian High Crash Locations in Carson City

Zone #	Location	Length (miles)	Radius (feet)	Type
1	US395 Highway: Hotsprings Road to John Street	0.68		Linear
2	US395 Highway: Caroline Street to 7th Street	0.54		Linear
3	US 50 Highway: Stewart Street to Saliman Road	0.75		Linear
4	US 50 Highway: Lompa Lane to Brown Street	0.95		Linear
5	5th Street: Root Street to Saliman Road	0.55		Linear
6	Robinson Street & Saliman Road		300	Circular
7	Winnie Lane & Lone Mtn Drive		300	Circular
8	Hotsprings Road & Pine Lane		300	Circular
9	College Parkway & US395 Highway		300	Circular
10	US395 & Snyder Avenue		300	Circular

Table 9 Pedestrian High Crash Locations in the City of Elko

Zone #	Zone	Radius (feet)	Type
1	Cedar Street & 12th Street	500	Circular
2	5th Street & Railroad Street	1,000	Circular
3	Water Street & 6th Street	200	Circular
4	9th Street & Douglas Street	200	Circular
5	5th Street & Carlin Court	200	Circular
6	Wilson Avenue & 6th Street	400	Circular
7	Cedar Street & Buns Road	200	Circular
8	Idaho Street & 11th Street	500	Circular
9	Idaho Street & College Avenue	400	Circular
10	Silver Street & Elecart Blvd	200	Circular
11	Idaho Street & Cedar Street	200	Circular
12	Second Street & Willow Street	200	Circular
13	Mittry Avenue & College Court	200	Circular
14	Argent Avenue & Copper Street	200	Circular
15	Antimony Road & Carlson Avenue	200	Circular
16	Chris Avenue & Colonial Drive	400	Circular
17	Spruce Road & Noodle Lane	200	Circular
18	Kittridge Canyon Road & Lupine Street	200	Circular
19	Spring Valley Pardway & Cedarlawn Drive	200	Circular
20	Berry Creek Place & Berry Creek Drive	200	Circular
21	Tres Cartes Avenue & Berry Creek Drive	200	Circular

Table 10 Pedestrian High Crash Locations in Douglas County

Zone #	Zone	Radius (feet)	Type
1	US 50 Highway & Elks Point Road	300	Circular
2	US 50 Highway & Kingsbury Grade Road	300	Circular
3	Tahoe Drive & Lynn Way	300	Circular
4	Benjamin Drive & Tina Court	300	Circular
5	Kingsbury Grade Road & Tramway Drive	300	Circular
6	Tramay Drive & Jacks Circle	600	Circular
7	Main Street & County Road	300	Circular
8	Main Street & First Street	300	Circular
9	Meadow Lane & Douglas Avenue	300	Circular
10	Main Street & Eddy Street	300	Circular
11	US395 Highway & Kingslane Court	300	Circular
12	Waterloo Lane & Toler Lane	300	Circular
13	Muir Drive & Lyell Way	300	Circular
14	Main Street & Mill Street	300	Circular
15	Heritage Lane & Tillman Lane	300	Circular
16	Mica Drive & Calcite Drive	300	Circular
17	Tourmaline Drive & Granite Court	300	Circular
18	Somerset Way & Plymouth Drive	300	Circular
19	Sunridge Drive & Starshine Court	300	Circular

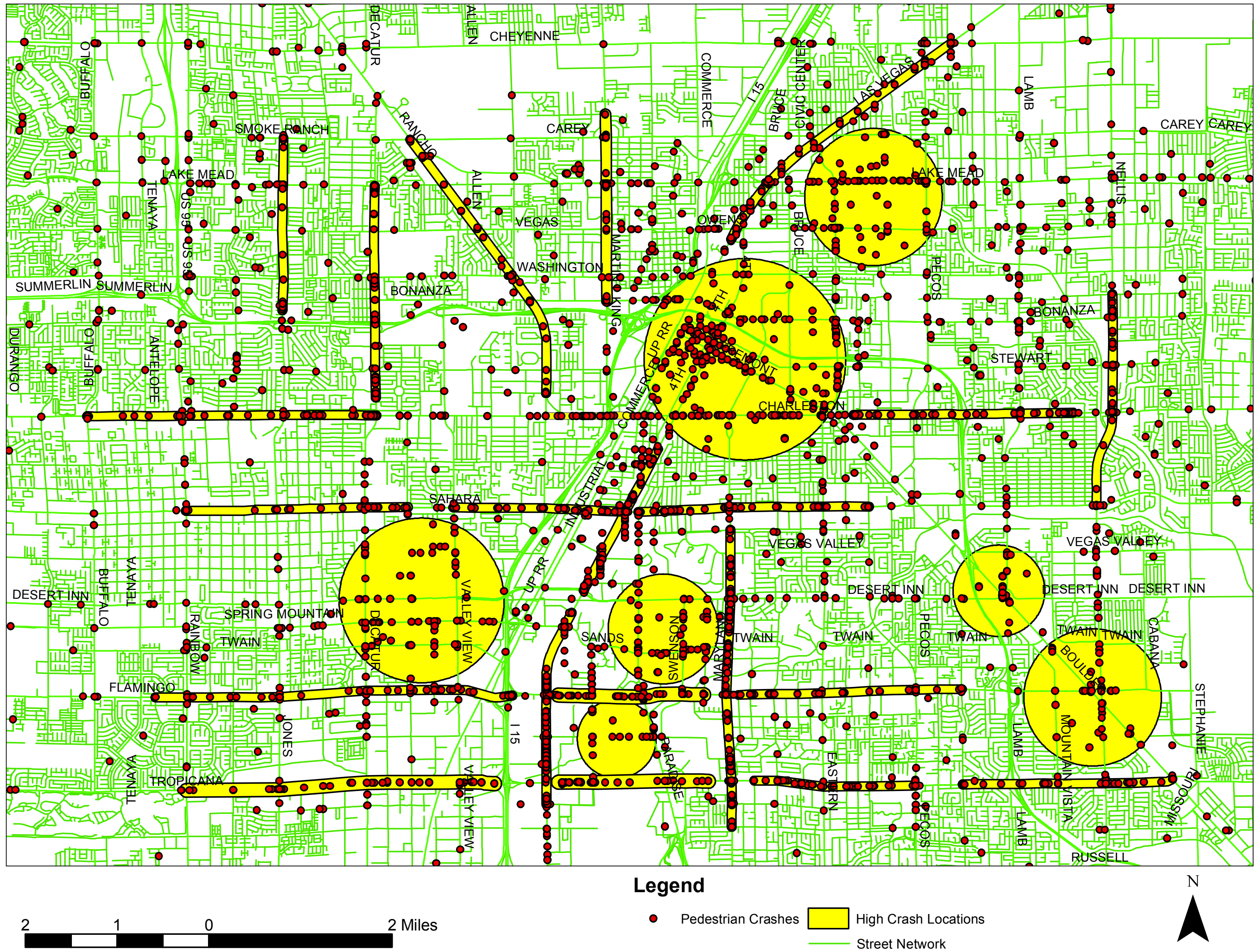

Figure 19 Pedestrian High Crash Locations in the Las Vegas Metropolitan area

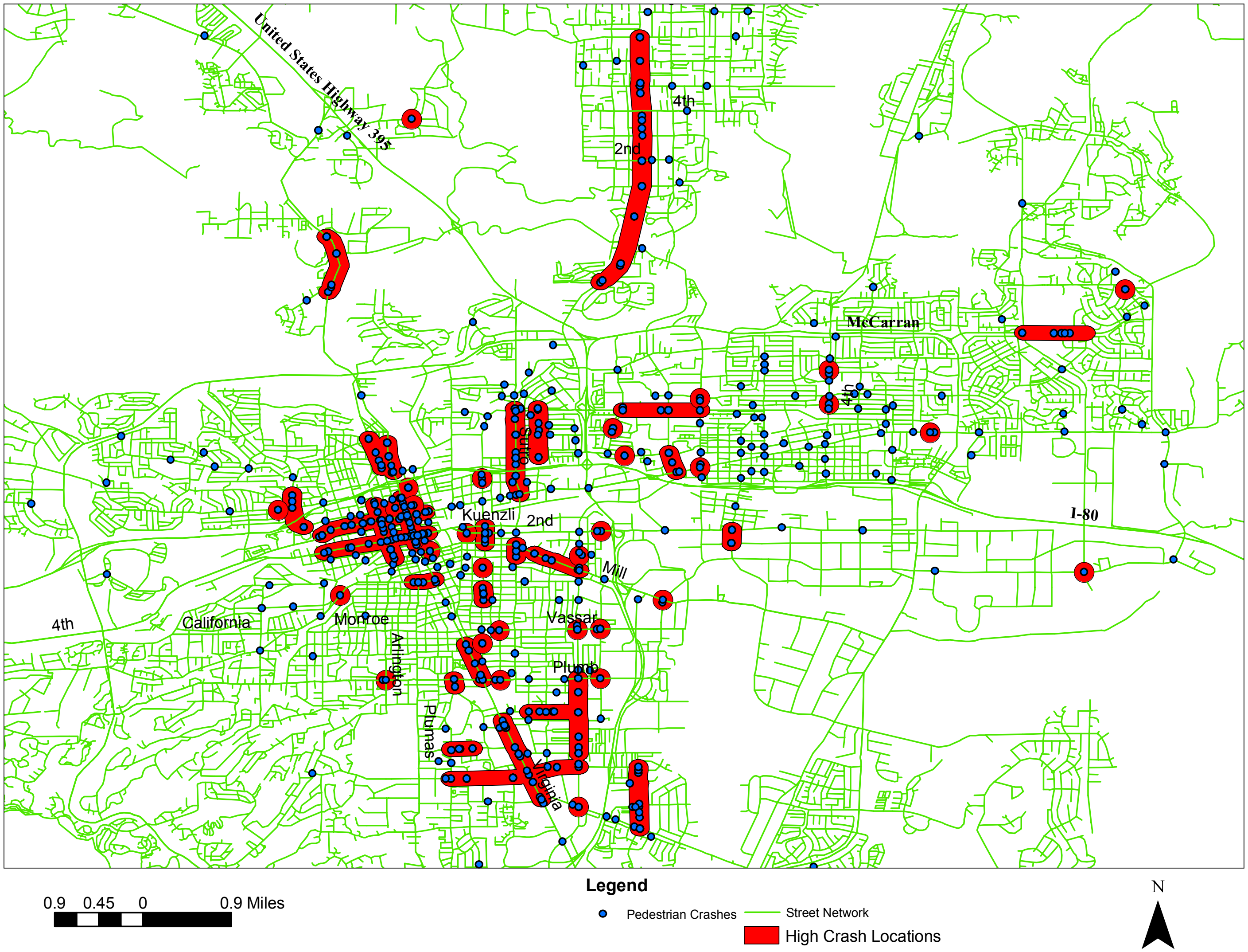

Figure 20 Pedestrian High Crash Locations in Washoe County

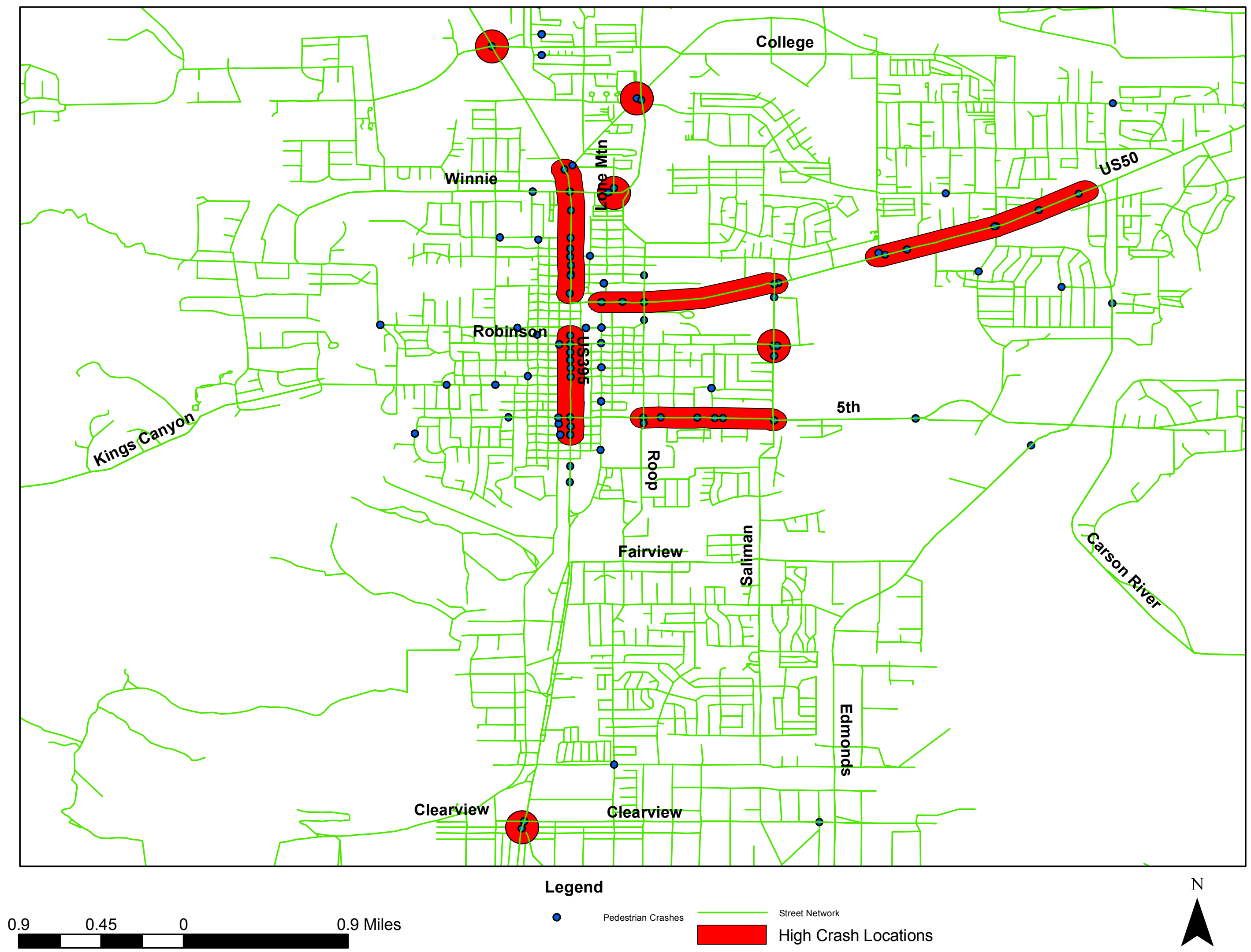

Figure 21 Pedestrian High Crash Locations in Carson City

Figure 22 Pedestrian High Crash Locations in the City of Elko

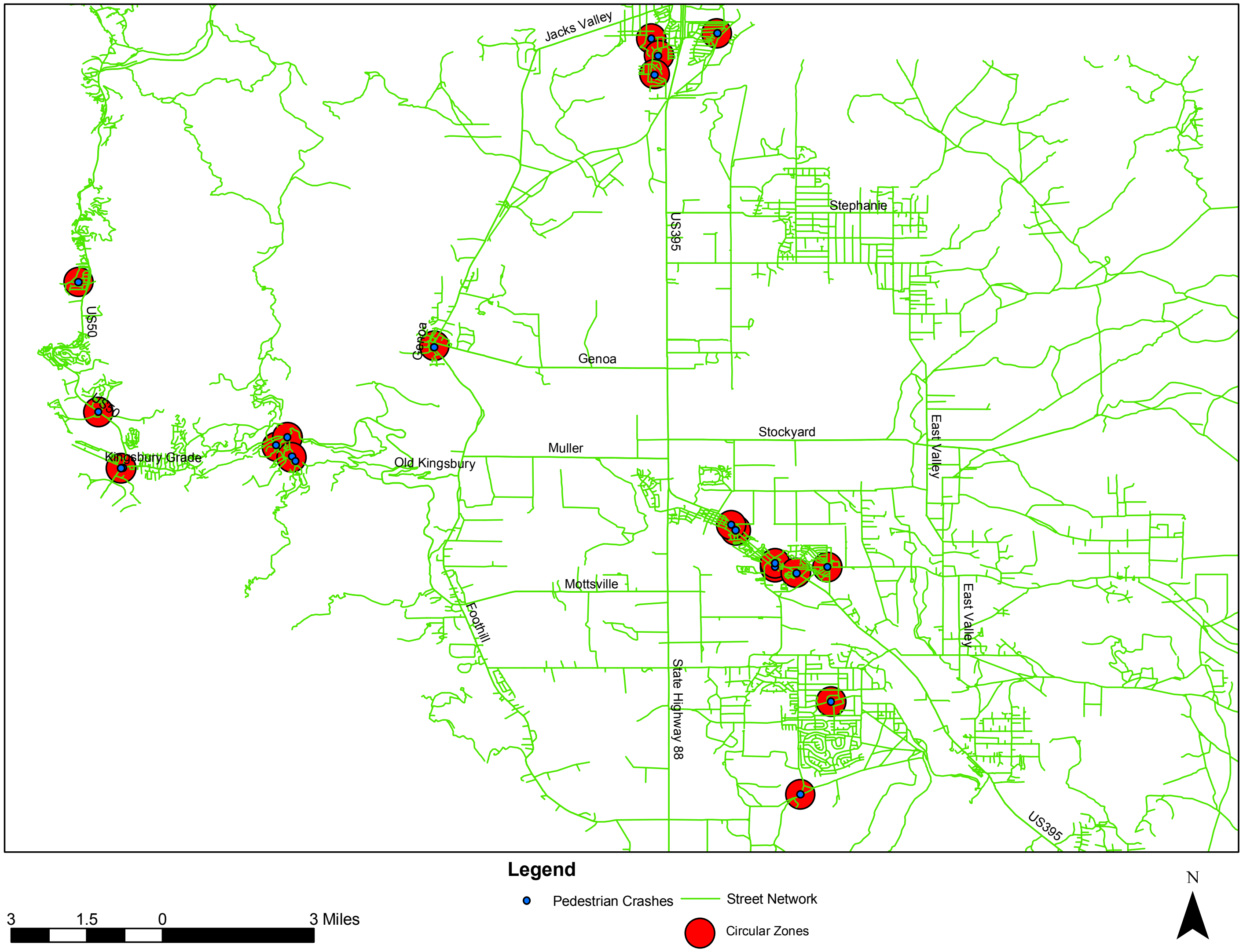

Figure 23 Pedestrian High Crash Locations in Douglas County

CHAPTER 7
RANK HIGH CRASH LOCATIONS

The evaluation of ranking methods is based on high risk zones identified using crash data maintained by NDOT. The identification of high risk zones for the selected counties was discussed and depicted in Chapter 6. Tables 11 to 15 shows the characteristics of the high risk zones in Clark County, Washoe County, Carson City, Elko County, and Douglas County of Nevada, respectively.

Attempts were made to obtain data pertaining to economic loss estimates from Nevada Department of Transportation. However, such data was not available exclusively for pedestrian crashes. In general, the estimated economic loss due to a fatal crash is \$2,432,000. Likewise, the estimated economic loss due to an injury crash is \$24,700. Based on these estimates, fatal crash and severe injury crashes (type "A") were given a weight of 97.67 whereas injury type "B" and type "C" crashes were given a weight of 1 in order to compute CF_S.

As high crash zones include both linear and circular zones, crash density was estimated based on area. A width of 200 feet times the length of the linear zone was used to estimate the area of a linear zone. Half-mile buffers were generated around each high crash zone to estimate population by age group. The population used was based on Census 2000 data. The age groups considered in this study are < 18, 18 – 64, and >= 64.

The data pertaining to vehicular volumes (average daily traffic – ADT) was obtained from NDOT's Traffic Reports. Vehicular volumes were not available for each link of each street in each high crash zone. Hence, crash rates were computed based on number of vehicles rather than vehicle miles of travel. The average of vehicular volumes for available links of the street was used to estimate vehicular volume in case of linear zones. However, circular zones may comprise of several such streets. So, in case of circular zones, the average vehicular volumes for each street were summed to estimate vehicular volume of the circular zone. These vehicular volumes were estimated for each study year and then summed to estimate the total vehicular volume of a zone during the study period (1998 to 2002). Table's 16 to 20 shows zone type, area, population by age group, and vehicular volume of each high crash zone in

Clark County, Washoe County, Carson City, Elko County, and Douglas County of Nevada, respectively.

Table 21 to 25 shows the computed indices using each of the selected methods for Clark County, Washoe County, Carson City, Elko County, and Douglas County of Nevada, respectively. Table 26 to 30 shows the rank of each high risk zones obtained using each selected methods for Clark County, Washoe County, Carson City, Elko County, and Douglas County of Nevada, respectively.

As can be seen from the tables, the zones in each county vary in size, population, area, average annual vehicular traffic, and the number of crashes, and hence the computed indices and ranks obtained using CD_A, $CR_{PP,}$ CR_{PA} and CR_{VV} methods. As area, number of pedestrian crashes based on severity, population in the vicinity of a zone, and vehicular volume play a key role in defining risk of a zone, the SR and CS methods which are a combination of these methods are recommended for use in ranking of high risk zones. Figure 24 to 28 shows variations in rank obtained by using SR and CS methods for the selected counties in the State of Nevada. Rankings obtained for each zone were relatively consistent for the high crash zones when SR and CS methods were used as compared to when individual methods were used. This reflects a degree of robustness.

Table 11 Crash Characteristics of high crash zones in Clark County, Nevada

Zone #	Zone	Fatal			Injury type"A"			Injury type"B"			Injury type"C"			Unknown			Total
		0-18	18-64	>64	0-18	18-64	>64	0-18	18-64	>64	0-18	18-64	>64	Age	Severity	Both	
1	Las Vegas Blvd: Fashion Show Dr to Reno Av	0	2	1	0	14	3	0	39	2	3	47	4	8	0	0	123
2	Las Vegas Blvd: 4th St to Stardust Rd	0	1	1	1	13	2	3	24	4	3	34	5	7	0	0	98
3	Downtown Las Vegas	0	9	3	2	21	5	13	74	8	22	137	19	22	2	0	337
4	Las Vegas Blvd: Cheyenne Av to Foremaster La	0	5	2	4	15	2	4	8	5	2	20	2	5	0	0	74
5	Charleston Blvd: Decatur Blvd to Buffalo Dr	0	1	0	1	6	0	8	7	0	5	16	2	2	0	0	48
6	Charleston Blvd: Main St to Rancho Dr	0	1	0	0	4	0	0	7	1	0	13	2	3	0	0	31
7	Charleston Blvd: Nellis Blvd to Eastern Av	0	2	0	1	3	0	6	14	3	4	16	1	1	0	0	51
8	Sahara Ave: Mcleod Dr to Paradise Rd	0	1	2	2	7	0	5	9	2	3	21	5	2	0	0	59
9	Sahara Ave: Arville Av to Rainbow Blvd	0	0	0	0	2	0	1	9	1	3	12	2	2	1	0	33
10	Sahara Ave: Fairfield Av to Valley View Blvd	0	3	1	0	8	1	0	7	0	1	16	1	5	0	0	43
11	Maryland Pkwy: Karen Av to Hacienda Av	0	3	1	3	13	1	8	35	2	12	54	11	9	4	1	155
12	Tropicana Av: Pecos Rd to Tamarus St	0	0	1	2	1	0	4	18	2	2	15	0	4	1	0	50
13	Tropicana Av: Boulder Av to Sandhill Rd	1	0	0	1	7	1	5	6	0	6	4	2	5	0	0	38
14	Boulder Highway-Pecos Rd	0	3	1	2	8	1	6	14	2	2	12	2	1	0	0	54
15	Boulder Highway-Desert Inn Rd	0	4	0	2	3	0	0	7	1	2	13	1	5	0	0	38
16	Flamingo Rd: Sandhill Rd to Escondido St	0	1	0	1	2	0	4	11	2	5	12	1	3	0	0	42
17	Tropicana Av: Wilbur St to Tropicana CC Bdry	0	7	2	1	3	0	1	12	2	2	14	2	3	0	0	49
18	Flamingo Rd: Claymont St to Las Vegas Blvd	0	3	1	0	7	0	1	21	1	2	22	2	3	1	0	64
19	Harmon Avenue	0	1	1	0	5	0	0	7	2	1	11	0	2	0	0	30
20	Paradise-Twain	1	5	1	2	7	0	4	20	4	2	22	0	6	0	0	74
21	Flamingo Rd: I-15 to Ravenwood Dr	0	1	0	0	10	3	3	14	1	6	21	3	0	0	0	62
22	Tropicana Ave: I-15 to Raibow Blvd	0	1	0	1	7	0	4	12	1	5	18	2	6	0	0	57
23	Desert Inn Rd - Arville St	0	1	0	5	9	2	13	14	2	12	27	1	8	0	0	94
24	Decatur Blvd: Lake Mead Blvd to Dover Pl	0	1	1	1	1	0	6	6	1	3	10	4	6	0	0	40
25	Rancho Dr: Carey Ave to Palomino Ln	0	1	1	1	5	0	1	8	2	5	13	0	3	1	0	41
26	Jones Blvd: Somke Ranch Rd to Chelse Cr	0	1	0	1	1	0	5	2	0	9	6	0	0	0	0	25
27	Martin L King Blvd: Cartier Av to Bonanza Rd	0	1	0	0	0	0	7	12	0	5	9	0	3	0	0	37
28	Lake Mead Blvd-Mojave Rd	1	0	3	10	20	2	16	12	1	19	25	0	6	0	0	115
29	Nellis Blvd: Harris Av to Sahara Av	0	1	1	3	8	0	5	7	1	7	23	3	2	0	0	61

Table 12 Crash Characteristics of high crash zones in Washoe County, Nevada

Zone #	Zone	Fatal			Injury type"A"			Injury type"B"			Injury type"C"			Unknown			TOTAL
		0-18	18-64	>64	0-18	18-64	>64	0-18	18-64	>64	0-18	18-64	>64	Age	Severity	Both	
1	4th Street: Lake Street to Keystone Avenue	0	1	1	0	6	2	4	6	3	1	22	3	5	0	0	54
2	Virginia Street: 6th Street to 1st Street	0	1	0	0	3	2	3	10	5	0	10	3	5	0	0	42
3	2nd Street: Lake Street to Keystone Place	1	0	1	0	5	2	0	7	3	1	9	3	6	0	0	38
4	Virginia Street: Linden Street to Peckham Lane	0	0	1	1	9	1	1	8	2	0	5	1	1	0	0	30
5	Sun Valley Blvd: 7th Avenue to Scottsdale Road	0	2	0	3	4	0	3	6	1	3	5	0	1	0	0	28
6	Sutro Street: Oliver Avenue to 4th Street	0	0	3	1	4	3	1	5	2	1	3	0	3	0	0	26
7	Arlington Avenue: 6th Street to Island Avenue	0	0	0	1	4	1	0	5	1	2	6	1	3	0	0	24
8	Moana Lane: Kietzke Lane to Lakeside Drive	0	0	0	1	2	1	0	1	3	0	6	2	0	0	0	16
9	Virginia Street: College Drive to 9th Street	0	0	0	0	4	0	0	3	0	0	4	0	2	0	0	13
10	Neil Road: Moana Lane to Peckham Lane	1	0	0	1	1	0	2	0	1	3	4	0	0	0	0	13
11	Kietzke Lane: Plumb Lane to Gentry Way	0	0	0	0	0	0	2	5	0	0	3	0	1	1	0	12
12	Virginia Street: Pueblo Street to Plumb Lane	0	0	0	1	1	0	0	1	0	0	4	1	2	0	0	10
13	Grove Street: Wrondel Way to Kietzke Lane	0	0	0	0	2	0	2	1	0	0	3	1	0	1	0	10
14	Montello Street: Oliver Avenue to 9th Street	0	0	0	1	1	0	0	1	0	3	1	0	2	0	0	9
15	Oddie Blvd: Sullivan Lane to Silverada Blvd	0	1	0	1	0	0	1	1	0	1	3	1	0	0	0	9
16	Mill Street: Kietzke Lane to Pringle Way	0	1	0	0	3	0	0	1	0	2	2	0	0	0	0	9
17	Kirman Avenue: Mill Street to Ryland Street	0	1	0	0	3	0	0	1	0	2	2	0	0	0	0	9
18	California Street: Virginia Street to Hill Street	0	0	0	0	0	0	0	3	0	0	5	0	0	0	0	8
19	Sierra Street: College Drive to 10th Street	0	0	0	0	2	0	1	2	0	0	1	0	2	0	0	8
20	Wells Avenue: Kuenzli Street to Mill Street	0	0	1	0	1	0	0	1	0	0	4	0	1	0	0	8
21	Baring Blvd: Springland Drive to Sparks Blvd	0	0	0	4	0	0	4	0	0	0	0	0	0	0	0	8
22	Keystone Avenue: Sunnyside Drive to 5th Street	0	0	0	1	0	0	0	3	0	0	3	0	0	0	0	7
23	Wells Avenue: Thoma Street to Taylor Street	0	0	1	0	2	1	1	1	0	0	1	0	0	0	0	7
24	El Rancho Drive: G Street to Prater Way	0	0	0	0	0	0	1	2	0	0	3	0	0	0	0	6
25	Brinkby Avenue: Robinhood Drive to Lakeside Dr	0	0	0	2	1	1	1	1	0	0	0	0	0	0	0	6
26	Virginia Street: Bailey Drive to Talus Way	0	1	1	0	2	0	0	0	0	0	1	0	1	0	0	6
27	Rock Blvd: Glendale Avenue to Freeport Blvd	0	0	0	0	2	0	0	2	0	0	1	0	0	0	0	5
28	Lakeside Drive: Plumb Lane to Hillcrest Drive	0	0	0	0	2	0	0	1	1	0	1	0	0	0	0	5
29	Vassar Street & Harvard Way	0	0	0	0	0	0	0	1	0	1	2	0	0	0	0	4
30	Stead Blvd & Silver Lake Road	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0	4
31	Peckham Lane & Kietzke Lane	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	3
32	Wells Avenue & Pueblo Street	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	3
33	Mill Street & Center Street	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	3
34	Silverada Blvd & Orchid Way	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	3
35	Sulivan Lane & Greenbrae Drive	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	3
36	Wells Avenue & 6th Street	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	3
37	Vassar Street & Kietzke Lane	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
38	Plumb Lane & Harvard Way	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
39	Terminal Way & Mill Street	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	2
40	Vassar Street & Locust Street	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
41	Stewart Street & Wells Avenue	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	2
42	Second Street & Wells Street	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	2
43	7th & Center Street	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	2
44	5th Street & Sierra Street	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	2
45	Center Street & 5th Street	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	2
46	Newland Circle & California Avenue	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2
47	7th Street & Elgin Avenue	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	2
48	9th Street & Shone Drive	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2
49	Prater Way & Sullivan Lane	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	2
50	Plumb Lane & Arlington Avenue	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2

Table 13 Crash Characteristics of high crash zones in Carson City, Nevada

Zone #	Zone	Fatal			Injury type"A"			Injury type"B"			Injury type"C"			Unknown			Total
		0-18	18-64	>64	0-18	18-64	>64	0-18	18-64	>64	0-18	18-64	>64	Age	Severity	Both	
1	US395 Highway: Hotsprings Road to John Street	0	1	0	0	3	1	2	1	0	2	2	0	0	0	0	12
2	US395 Highway: Caroline Street to 7th Street	0	0	0	1	2	1	1	2	1	3	5	2	2	1	0	21
3	US 50 Highway: Stewart Street to Saliman Road	0	0	0	0	2	0	2	1	0	3	0	0	1	0	0	9
4	US 50 Highway: Lompa Lane to Brown Street	0	1	0	1	3	0	1	0	0	1	0	0	0	0	0	7
5	5th Street: Root Street to Saliman Road	0	0	0	0	0	0	2	1	0	2	2	0	1	0	0	8
6	Robinson Street & Saliman Road	0	0	0	1	0	0	1	0	0	2	0	0	0	0	0	4
7	Winnie Lane & Lone Mtn Drive	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	2
8	Hotsprings Road & Pine Lane	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2
9	College Parkway & US395 Highway	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	2
10	US395 & Snyder Avenue	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2

Table 14 Crash Characteristics of high crash zones in Elko County, Nevada

Zone #	Zone	Fatal			Injury type"A"			Injury type"B"			Injury type"C"			Unknown			Total
		0-18	18-64	>64	0-18	18-64	>64	0-18	18-64	>64	0-18	18-64	>64	Age	Severity	Both	
1	Cedar Street & 12th Street	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0	3
2	5th Street & Railroad Street	0	0	0	0	1	1	2	1	0	2	1	1	0	0	0	9
3	Water Street & 6th Street	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
4	9th Street & Douglas Street	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
5	5th Street & Carlin Court	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
6	Wilson Avenue & 6th Street	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2
7	Cedar Street & Buns Road	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
8	Idaho Street & 11th Street	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	4
9	Idaho Street & College Avenue	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	2
10	Silver Street & Elecart Blvd	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
11	Idaho Street & Cedar Street	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
12	Second Street & Willow Street	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
13	Mittry Avenue & College Court	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
14	Argent Avenue & Copper Street	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
15	Antimony Road & Carlson Avenue	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
16	Chris Avenue & Colonial Drive	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2
17	Spruce Road & Noodle Lane	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
18	Kittridge Canyon Road & Lupine Street	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
19	Spring Valley Pardway & Cedarlawn Drive	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
20	Berry Creek Place & Berry Creek Drive	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
21	Tres Cartes Avenue & Berry Creek Drive	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1

Table 15 Crash Characteristics of high crash zones in Douglas County, Nevada

Zone #	Zone	Fatal			Injury type"A"			Injury type"B"			Injury type"C"			Unknown			Total
		0-18	18-64	>64	0-18	18-64	>64	0-18	18-64	>64	0-18	18-64	>64	Age	Severity	Both	
1	US 50 Highway & Elks Point Road	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2	US 50 Highway & Kingsbury Grade Road	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	2
3	Tahoe Drive & Lynn Way	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
4	Benjamin Drive & Tina Court	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
5	Kingsbury Grade Road & Tramway Drive	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
6	Tramay Drive & Jacks Circle	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	2
7	Main Street & County Road	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
8	Main Street & First Street	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
9	Meadow Lane & Douglas Avenue	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
10	Main Street & Eddy Street	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
11	US395 Highway & Kingslane Court	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
12	Waterloo Lane & Toler Lane	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
13	Muir Drive & Lyell Way	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
14	Main Street & Mill Street	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
15	Heritage Lane & Tillman Lane	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
16	Mica Drive & Calcite Drive	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
17	Tourmaline Drive & Granite Court	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
18	Somerset Way & Plymouth Drive	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
19	Sunridge Drive & Starshine Court	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1

Table 16 Zone type, area, population, and vehicular volume of high crash zones in Clark County, Nevada

Zone #	Zone	Type	Area	Population				Vehicular
			Square Miles	0-18	18-64	>64	Total	ADT
1	Las Vegas Blvd: Fashion Show Dr to Reno Av	Linear	0.102	309	1,921	374	2,604	267,842
2	Las Vegas Blvd: 4th St to Stardust Rd	Linear	0.066	1,950	6,815	1,407	10,172	153,500
3	Downtown Las Vegas	Circular	3.799	1,493	6,056	1,268	8,816	1,202,067
4	Las Vegas Blvd: Cheyenne Av to Foremaster La	Linear	0.123	12,740	22,342	2,128	37,209	102,730
5	Charleston Blvd: Decatur Blvd to Buffalo Dr	Linear	0.119	6,270	16,224	2,842	25,335	147,646
6	Charleston Blvd: Main St to Rancho Dr	Linear	0.041	800	3,375	991	5,166	213,100
7	Charleston Blvd: Nellis Blvd to Eastern Av	Linear	0.091	7,442	17,241	2,717	27,401	199,475
8	Sahara Ave: Mcleod Dr to Paradise Rd	Linear	0.095	5,443	14,899	3,164	23,506	257,900
9	Sahara Ave: Arville Av to Rainbow Blvd	Linear	0.092	3,788	10,113	1,748	15,649	244,150
10	Sahara Ave: Fairfield Av to Valley View Blvd	Linear	0.069	3,431	9,829	2,641	15,900	311,100
11	Maryland Pkwy: Karen Av to Hacienda Av	Linear	0.123	8,921	28,719	4,546	42,186	177,100
12	Tropicana Av: Pecos Rd to Tamarus St	Linear	0.067	4,038	14,045	2,643	20,727	275,070
13	Tropicana Av: Boulder Av to Sandhill Rd	Linear	0.087	5,925	14,203	1,994	22,122	188,600
14	Boulder Highway-Pecos Rd	Circular	1.766	1,549	3,793	930	6,273	513,617
15	Boulder Highway-Desert Inn Rd	Circular	0.785	1,176	2,914	711	4,801	551,000
16	Flamingo Rd: Sandhill Rd to Escondido St	Linear	0.092	3,309	14,140	3,420	20,869	218,133
17	Tropicana Av: Wilbur St to Tropicana CC Bdry	Linear	0.062	2,046	7,048	879	9,973	410,600
18	Flamingo Rd: Claymont St to Las Vegas Blvd	Linear	0.060	3,767	15,808	2,005	21,581	307,900
19	Harmon Avenue	Circular	0.580	1,412	5,455	570	7,438	792,450
20	Paradise-Twain	Circular	1.130	2,337	8,607	1,297	12,241	661,350
21	Flamingo Rd: I-15 to Ravenwood Dr	Linear	0.148	7,475	23,202	3,763	34,440	249,500
22	Tropicana Ave: I-15 to Raibow Blvd	Linear	0.128	4,642	16,286	3,056	23,984	179,043
23	Desert Inn Rd - Arville St	Circular	2.543	1,682	4,686	652	7,020	878,550
24	Decatur Blvd: Lake Mead Blvd to Dover Pl	Linear	0.088	5,083	11,915	2,926	19,924	172,675
25	Rancho Dr: Carey Ave to Palomino Ln	Linear	0.123	4,534	10,480	1,911	16,926	182,700
26	Jones Blvd: Somke Ranch Rd to Chelse Cr	Linear	0.071	8,074	17,208	2,260	27,543	133,367
27	Martin L King Blvd: Cartier Av to Bonanza Rd	Linear	0.077	5,043	7,702	992	13,738	113,950
28	Lake Mead Blvd-Mojave Rd	Circular	1.766	3,648	5,935	611	10,194	510,150
29	Nellis Blvd: Harris Av to Sahara Av	Linear	0.088	7,319	15,268	1,952	24,539	245,100

Table 17 Zone type, area, population, and vehicular volume of high crash zones in Washoe County, Nevada

Zone #	Zone	Type	Area	Population				Vehicular Volume
			Square Miles	0-18	18-64	>64	Total	ADT
1	4th Street: Lake Street to Keystone Av	Lin	0.032	1014	6687	1270	8,971	14,185
2	Virginia Street: 6th Street to 1st St	Lin	0.019	676	5518	881	7,075	13,330
3	2nd Street: Lake Street to Keystone Pl	Lin	0.032	880	6016	1241	8,137	7,860
4	Virginia Street: Linden Street to Peckham Ln	Lin	0.032	3084	7458	1131	11,672	30,620
5	Sun Valley Blvd: 7th Avenue to Scottsdale Rd	Lin	0.097	3557	7489	964	12,009	24,605
6	Sutro Street: Oliver Avenue to 4th S	Lin	0.033	3305	6491	840	10,635	13,810
7	Arlington Avenue: 6th Street to Island Av	Lin	0.022	689	5719	905	7,313	DNA
8	Moana Lane: Kietzke Lane to Lakeside Dr	Lin	0.039	3310	8396	1784	13,490	20,800
9	Virginia Street: College Drive to 9th St	Lin	0.011	676	5446	603	6,724	17,560
10	Neil Road: Moana Lane to Peckham Ln	Lin	0.024	3022	6342	725	10,090	15,240
11	Kietzke Lane: Plumb Lane to Gentry Way	Lin	0.029	2674	6313	978	9,965	26,790
12	Virginia Street: Pueblo Street to Plumb Ln	Lin	0.015	1813	5516	818	8,147	25,440
13	Grove Street: Wrondel Way to Kietzke Ln	Lin	0.015	2322	5720	836	8,878	6,250
14	Montello Street: Oliver Avenue to 9th S	Lin	0.019	3095	5554	816	9,465	5,580
15	Oddie Blvd: Sullivan Lane to Silverada Blvd	Lin	0.023	3921	8670	1923	14,514	21,720
16	Mill Street: Kietzke Lane to Pringle Way	Lin	0.015	1500	3888	662	6,050	26,480
17	Kirman Avenue: Mill Street to Ryland St	Lin	0.005	1359	4232	704	6,294	4,600
18	California Street: Virginia Street to Hill St	Lin	0.006	920	4969	800	6,689	12,280
19	Sierra Street: College Drive to 10th St	Lin	0.012	626	5338	635	6,599	9,180
20	Wells Avenue: Kuenzli Street to Mill St	Lin	0.007	1027	4218	570	5,816	20,200
21	Baring Blvd: Springland Drive to Sparks Blvd	Lin	0.018	2427	5579	746	8,751	7,230
22	Keystone Avenue: Sunnyside Drive to 5th St	Lin	0.014	1111	5131	992	7,233	25,550
23	Wells Avenue: Thoma Street to Taylor St	Lin	0.005	1542	5585	774	7,900	17,820
24	El Rancho Drive: G Street to Prater Way	Lin	0.008	1894	4661	991	7,546	17,620
25	Brinkby Avenue: Robinhood Drive to Lakeside I	Lin	0.006	1876	5408	1215	8,499	4,600
26	Virginia Street: Bailey Drive to Talus Way	Lin	0.023	365	1242	219	1,826	11,395
27	Rock Blvd: Glendale Avenue to Freeport Blvd	Lin	0.005	73	394	54	522	19,880
28	Lakeside Drive: Plumb Lane to Hillcrest Dr	Lin	0.003	830	2749	583	4,161	9,880
29	Vassar Street & Harvard Way	Cir	0.005	596	1602	351	2,550	15,240
30	Stead Blvd & Silver Lake Road	Cir	0.005	717	1539	129	2,386	11,276
31	Peckham Lane & Kietzke Lane	Cir	0.005	1528	3530	392	5,450	41,040
32	Wells Avenue & Pueblo Street	Cir	0.005	1364	4031	602	5,996	DNA
33	Mill Street & Center Street	Cir	0.005	451	3310	640	4,401	13,970
34	Silverada Blvd & Orchid Way	Cir	0.005	1913	3539	1076	6,528	13,325
35	Sulivan Lane & Greenbrae Drive	Cir	0.005	2117	4911	797	7,825	7,710
36	Wells Avenue & 6th Street	Cir	0.005	753	2324	316	3,394	37,830
37	Vassar Street & Kietzke Lane	Cir	0.005	872	2297	546	3,715	36,150
38	Plumb Lane & Harvard Way	Cir	0.005	953	2350	402	3,705	33,960
39	Terminal Way & Mill Street	Cir	0.005	19	199	31	250	41,120
40	Vassar Street & Locust Street	Cir	0.005	1453	4212	654	6,319	8,460
41	Stewart Street & Wells Avenue	Cir	0.005	1246	5028	752	7,026	17,820
42	Second Street & Wells Street	Cir	0.005	618	3288	412	4,318	DNA
43	7th & Center Street	Cir	0.005	408	3474	408	4,290	22,430
44	5th Street & Sierra Street	Cir	0.005	354	3176	550	4,079	19,920
45	Center Street & 5th Street	Cir	0.005	386	2867	504	3,756	18,130
46	Newland Circle & California Avenue	Cir	0.005	642	2958	631	4,230	13,140
47	7th Street & Elgin Avenue	Cir	0.005	842	3114	605	4,561	12,840
48	9th Street & Shone Drive	Cir	0.005	1711	3697	923	6,331	DNA
49	Prater Way & Sullivan Lane	Cir	0.005	1703	4275	562	6,541	20,960
50	Plumb Lane & Arlington Avenue	Cir	0.005	487	1859	564	2,910	27,000

Table 18 Zone type, area, population, and vehicular volume of high crash zones in Carson City, Nevada

Zone #	Zone	Type	Area	Population				Vehicular
			Square Miles	0-18	18-64	>64	Total	ADT
1	US395 Highway: Hotsprings Road to John Street	Linear	0.026	1,509	3,820	1,016	6,345	200,300
2	US395 Highway: Caroline Street to 7th Street	Linear	0.020	876	2,791	696	4,364	171,050
3	US 50 Highway: Stewart Street to Saliman Road	Linear	0.028	1,217	3,375	845	5,437	145,900
4	US 50 Highway: Lompa Lane to Brown Street	Linear	0.036	2,075	4,678	1,043	7,796	125,150
5	5th Street: Roop Street to Saliman Road	Linear	0.021	1,056	2,999	589	4,643	38,950
6	Robinson Street & Saliman Road	Circular	0.005	674	1,596	326	2,595	52,300
7	Winnie Lane & Lone Mtn Drive	Circular	0.005	1,188	2,592	567	4,347	23,150
8	Hotsprings Road & Pine Lane	Circular	0.005	1,104	2,347	313	3,764	33,700
9	College Parkway & US395 Highway	Circular	0.005	801	1,916	306	3,024	198,450
10	US395 & Snyder Avenue	Circular	0.005	176	427	201	804	220,920

Table 19 Zone type, area, population, and vehicular volume of high crash zones in Elko County, Nevada

Zone #	Zone	Type	Area	Population				Vehicular
			Square Miles	0-18	18-64	>64	Total	ADT
1	Cedar Street & 12th Street	Linear	0.102	336	694	88	1,117	DNA
2	5th Street & Railroad Street	Linear	0.066	311	781	134	1,227	DNA
3	Water Street & 6th Street	Circular	3.799	714	1326	145	2,185	DNA
4	9th Street & Douglas Street	Linear	0.123	632	1104	111	1,846	DNA
5	5th Street & Carlin Court	Linear	0.119	905	1532	138	2,575	DNA
6	Wilson Avenue & 6th Street	Linear	0.041	877	1560	156	2,592	DNA
7	Cedar Street & Buns Road	Linear	0.091	157	499	129	785	DNA
8	Idaho Street & 11th Street	Linear	0.095	208	516	67	791	DNA
9	Idaho Street & College Avenue	Linear	0.092	105	309	67	481	DNA
10	Silver Street & Elecart Blvd	Linear	0.069	427	1045	189	1,662	DNA
11	Idaho Street & Cedar Street	Linear	0.123	348	952	247	1,546	DNA
12	Second Street & Willow Street	Linear	0.067	476	1125	365	1,966	DNA
13	Mittry Avenue & College Court	Linear	0.087	499	962	132	1,592	DNA
14	Argent Avenue & Copper Street	Circular	1.766	884	1464	41	2,388	DNA
15	Antimony Road & Carlson Avenue	Circular	0.785	820	1368	27	2,215	DNA
16	Chris Avenue & Colonial Drive	Linear	0.092	836	1421	41	2,299	DNA
17	Spruce Road & Noodle Lane	Linear	0.062	546	1036	62	1,645	DNA
18	Kittridge Canyon Road & Lupine Street	Linear	0.060	3	4	0	7	DNA
19	Spring Valley Pardway & Cedarlawn Drive	Circular	0.580	159	328	16	503	DNA
20	Berry Creek Place & Berry Creek Drive	Circular	1.130	209	357	21	587	DNA
21	Tres Cartes Avenue & Berry Creek Drive	Linear	0.148	130	232	15	378	DNA

Table 20 Zone type, area, population, and vehicular volume of high crash zones in Douglas County, Nevada

Zone #	Zone	Type	Area	Population				Vehicular
			Square Miles	0-18	18-64	>64	Total	ADT
1	US 50 Highway & Elks Point Road	Circular	0.005	52	214	40	306	DNA
2	US 50 Highway & Kingsbury Grade Rd	Circular	0.005	208	617	86	911	DNA
3	Tahoe Drive & Lynn Way	Circular	0.005	84	219	142	445	DNA
4	Benjamin Drive & Tina Court	Circular	0.005	49	388	26	462	DNA
5	Kingsbury Grade Road & Tramway Dr	Circular	0.005	51	369	22	442	DNA
6	Tramay Drive & Jacks Circle	Circular	0.005	49	451	23	523	DNA
7	Main Street & County Road	Circular	0.005	236	582	143	960	DNA
8	Main Street & First Street	Circular	0.005	208	537	127	872	DNA
9	Meadow Lane & Douglas Avenue	Circular	0.005	316	905	368	1,589	DNA
10	Main Street & Eddy Street	Circular	0.005	316	891	351	1,559	DNA
11	US395 Highway & Kingslane Court	Circular	0.005	465	1111	337	1,912	DNA
12	Waterloo Lane & Toler Lane	Circular	0.005	357	773	172	1,302	DNA
13	Muir Drive & Lyell Way	Circular	0.005	592	1219	208	2,019	DNA
14	Main Street & Mill Street	Circular	0.005	30	59	17	106	DNA
15	Heritage Lane & Tillman Lane	Circular	0.005	45	115	19	179	DNA
16	Mica Drive & Calcite Drive	Circular	0.005	386	772	170	1,328	DNA
17	Tourmaline Drive & Granite Court	Circular	0.005	416	842	170	1,428	DNA
18	Somerset Way & Plymouth Drive	Circular	0.005	343	655	107	1,105	DNA
19	Sunridge Drive & Starshine Court	Circular	0.005	274	653	155	1,082	DNA

Table 21 Crash indices based on selected methods of high crash zones in Clark County, Nevada

Zone #	Zone	CF_N	CF_S	CD_A	CR_{PP}	$CR_{PP<18}$	$CR_{PP18-64}$	$CR_{PP>64}$	CR_{PA}	CRvv	SR	CS
		# crashes	# crashes	# crashes/un	#crashes/ pop	#crashes/ pop	#crashes/ pop	#crashes/ pop	#crashes/ pop	#crashes/MV	Avg of Ranks	Score
1	Las Vegas Blvd: Fashion Show Dr to Reno Av	123	2154	21,079	0.83	0.01	0.86	1.06	1.93	8,041	2.67	203
2	Las Vegas Blvd: 4th St to Stardust Rd	98	1839	27,851	0.18	0.05	0.21	0.21	0.48	11,978	3.33	166
3	Downtown Las Vegas	337	4687	1,233	0.53	0.15	0.52	0.64	1.31	3,899	14.33	86
4	Las Vegas Blvd: Cheyenne Av to Foremaster La	74	2975	24,158	0.08	0.03	0.09	0.19	0.31	28,959	4.33	203
5	Charleston Blvd: Decatur Blvd to Buffalo Dr	48	822	6,879	0.03	0.02	0.04	0.00	0.06	5,565	16.00	47
6	Charleston Blvd: Main St to Rancho Dr	31	515	12,582	0.10	0.00	0.15	0.00	0.15	2,414	15.00	61
7	Charleston Blvd: Nellis Blvd to Eastern Av	51	631	6,961	0.02	0.01	0.03	0.00	0.05	3,164	19.33	38
8	Sahara Ave: Mcleod Dr to Paradise Rd	59	1219	12,795	0.05	0.04	0.05	0.06	0.16	4,728	11.33	70
9	Sahara Ave: Arville Av to Rainbow Blvd	33	322	3,510	0.02	0.00	0.02	0.00	0.02	1,319	25.33	18
10	Sahara Ave: Fairfield Av to Valley View Blvd	43	1300	18,943	0.08	0.00	0.11	0.07	0.19	4,179	10.33	92
11	Maryland Pkwy: Karen Av to Hacienda Av	155	2278	18,518	0.05	0.04	0.06	0.05	0.14	12,865	8.33	118
12	Tropicana Av: Pecos Rd to Tamarus St	50	436	6,535	0.02	0.05	0.01	0.04	0.10	1,584	21.33	34
13	Tropicana Av: Boulder Av to Sandhill Rd	38	1005	11,578	0.05	0.03	0.05	0.05	0.13	5,329	12.67	67
14	Boulder Highway-Pecos Rd	54	1601	907	0.26	0.13	0.29	0.21	0.64	3,118	17.00	47
15	Boulder Highway-Desert Inn Rd	38	908	1,157	0.19	0.17	0.24	0.00	0.41	1,648	20.00	31
16	Flamingo Rd: Sandhill Rd to Escondido St	42	527	5,722	0.03	0.03	0.02	0.00	0.06	2,414	22.00	32
17	Tropicana Av: Wilbur St to Tropicana CC Bdry	49	1306	21,072	0.13	0.05	0.14	0.23	0.42	3,181	9.00	108
18	Flamingo Rd: Claymont St to Las Vegas Blvd	64	1223	20,337	0.06	0.00	0.06	0.05	0.12	3,973	13.00	93
19	Harmon Avenue	30	707	1,218	0.10	0.00	0.11	0.18	0.29	892	22.00	22
20	Paradise-Twain	74	1911	1,691	0.16	0.13	0.14	0.08	0.35	2,890	17.67	34
21	Flamingo Rd: I-15 to Ravenwood Dr	62	1416	9,570	0.04	0.00	0.05	0.08	0.13	5,675	12.67	61
22	Tropicana Ave: I-15 to Raibow Blvd	57	1024	8,030	0.04	0.02	0.05	0.00	0.07	5,719	14.00	52
23	Desert Inn Rd - Arville St	94	1931	759	0.28	0.31	0.22	0.30	0.83	2,198	19.00	53
24	Decatur Blvd: Lake Mead Blvd to Dover Pl	40	524	5,975	0.03	0.02	0.02	0.04	0.07	3,032	19.67	36
25	Rancho Dr: Carey Ave to Palomino Ln	41	910	7,406	0.05	0.02	0.06	0.05	0.13	4,982	14.33	51
26	Jones Blvd: Somke Ranch Rd to Chelse Cr	25	315	4,426	0.01	0.01	0.01	0.00	0.03	2,363	23.33	25
27	Martin L King Blvd: Cartier Av to Bonanza Rd	37	134	1,731	0.01	0.00	0.02	0.00	0.02	1,173	26.67	11
28	Lake Mead Blvd-Mojave Rd	115	3790	2,146	0.37	0.30	0.34	0.80	1.44	7,428	9.67	108
29	Nellis Blvd: Harris Av to Sahara Av	61	1318	14,905	0.05	0.04	0.06	0.05	0.15	5,378	10.67	80

Table 22 Crash indices based on selected methods of high crash zones in Washoe County, Nevada

Zone #	Zone	CF_N	CF_S	CD_A	CR_{PP}	$CR_{PP<18}$	$CR_{PP18-64}$	$CR_{PP>64}$	CR_{PA}	CRvv	SR	CS
		# crashes	# crashes	# crashes/un	#crashes/ pop	#crashes/ pop	#crashes/ pop	#crashes/ pop	#crashes/ pop	#crashes/MV	Avg of Ranks	Score
1	4th Street: Lake Street to Keystone Av	54	1016	54,726	0.11	0.00	0.03	1.77	1.81	14,325	4	219
2	Virginia Street: 6th Street to 1st St	42	617	19,301	0.09	0.00	0.07	0.23	0.31	9,260	13	77
3	2nd Street: Lake Street to Keystone Pl	38	902	41,451	0.11	0.11	0.08	0.24	0.44	22,959	6	167
4	Virginia Street: Linden Street to Peckham Ln	30	1189	49,930	0.10	0.03	0.12	0.18	0.33	7,769	8	104
5	Sun Valley Blvd: 7th Avenue to Scottsdale Rd	28	897	48,806	0.07	0.08	0.08	0.00	0.16	7,294	11	91
6	Sutro Street: Oliver Avenue to 4th S	26	1087	47,186	0.10	0.03	0.06	0.70	0.79	15,738	5	161
7	Arlington Avenue: 6th Street to Island Av	24	601	93,013	0.08	0.14	0.07	0.11	0.33	DNA	6	0
8	Moana Lane: Kietzke Lane to Lakeside Dr	16	403	14,009	0.03	0.03	0.02	0.06	0.11	3,873	22	38
9	Virginia Street: College Drive to 9th St	13	398	21,056	0.06	0.00	0.07	0.00	0.07	4,531	19	46
10	Neil Road: Moana Lane to Peckham Ln	13	303	7,831	0.03	0.07	0.02	0.00	0.08	3,978	24	30
11	Kietzke Lane: Plumb Lane to Gentry Way	12	10	686	0.00	0.00	0.00	0.00	0.00	75	39	1
12	Virginia Street: Pueblo Street to Plumb Ln	10	201	69,440	0.02	0.05	0.02	0.00	0.07	1,583	18	83
13	Grove Street: Wrondel Way to Kietzke Ln	10	202	31,199	0.02	0.00	0.03	0.00	0.04	6,477	19	63
14	Montello Street: Oliver Avenue to 9th S	9	200	6,041	0.02	0.03	0.02	0.00	0.05	7,183	24	40
15	Oddie Blvd: Sullivan Lane to Silverada Blvd	9	202	26,425	0.01	0.03	0.01	0.00	0.04	1,864	23	38
16	Mill Street: Kietzke Lane to Pringle Way	9	396	84,050	0.07	0.00	0.10	0.00	0.10	2,989	14	106
17	Kirman Avenue: Mill Street to Ryland St	9	396	75,570	0.06	0.00	0.09	0.00	0.09	17,209	9	158
18	California Street: Virginia Street to Hill St	8	8	570	0.00	0.00	0.00	0.00	0.00	130	39	1
19	Sierra Street: College Drive to 10th St	8	199	17,440	0.03	0.00	0.04	0.00	0.04	4,344	24	39
20	Wells Avenue: Kuenzli Street to Mill St	8	200	42,498	0.03	0.00	0.02	0.17	0.20	1,984	15	63
21	Baring Blvd: Springland Drive to Sparks Blvd	8	395	17,237	0.05	0.16	0.00	0.00	0.16	10,921	17	74
22	Keystone Avenue: Sunnyside Drive to 5th St	7	104	8,696	0.01	0.09	0.00	0.00	0.09	812	28	17
23	Wells Avenue: Thoma Street to Taylor St	7	394	26,350	0.05	0.00	0.04	0.25	0.288	4,420	14	62
24	El Rancho Drive: G Street to Prater Way	6	6	919	0.00	0.00	0.00	0.00	0.00	68	40	1
25	Brinkby Avenue: Robinhood Drive to Lakeside Dr	6	393	4,030	0.05	0.10	0.02	0.08	0.20	17,078	17	90
26	Virginia Street: Bailey Drive to Talus Way	6	490	96,578	0.27	0.00	0.24	0.45	0.68	8,591	4	175
27	Rock Blvd: Glendale Avenue to Freeport Blvd	5	198	13,682	0.38	0.00	0.50	0.00	0.50	1,996	19	51
28	Lakeside Drive: Plumb Lane to Hillcrest Dr	5	198	6,108	0.05	0.00	0.07	0.00	0.07	4,016	25	28
29	Vassar Street & Harvard Way	4	4	789	0.00	0.00	0.00	0.00	0.00	52	38	1
30	Stead Blvd & Silver Lake Road	4	101	18,678	0.04	0.14	0.00	0.00	0.140	1,786	21	35
31	Peckham Lane & Kietzke Lane	3	100	19,671	0.02	0.00	0.03	0.00	0.029	486	28	24
32	Wells Avenue & Pueblo Street	3	196	38,750	0.03	0.00	0.05	0.00	0.049	DNA	20	0
33	Mill Street & Center Street	3	100	18,493	0.02	0.00	0.06	0.92	0.98	1,427	17	80
34	Silverada Blvd & Orchid Way	3	99	18,307	0.02	0.00	0.03	0.00	0.028	1,481	28	27
35	Sulivan Lane & Greenbrae Drive	3	3	556	0.00	0.00	0.00	0.00	0.00	78	39	1
36	Wells Avenue & 6th Street	3	196	36,429	0.06	0.00	0.04	0.31	0.35	1,038	17	62
37	Vassar Street & Kietzke Lane	2	2	395	0.00	0.00	0.00	0.00	0.0009	11	44	1
38	Plumb Lane & Harvard Way	2	2	395	0.00	0.00	0.00	0.00	0.00	12	42	1
39	Terminal Way & Mill Street	2	1	197	0.00	0.00	0.01	0.00	0.01	5	44	1
40	Vassar Street & Locust Street	2	2	395	0.00	0.00	0.00	0.00	0.001	47	42	1
41	Stewart Street & Wells Avenue	2	99	19,473	0.01	0.00	0.02	0.00	0.02	1,108	28	26
42	Second Street & Wells Street	2	1	197	0.00	0.00	0.00	0.00	0.000	DNA	49	0
43	7th & Center Street	2	99	18,307	0.02	0.00	0.03	0.00	0.03	880	30	24
44	5th Street & Sierra Street	2	2	371	0.00	0.00	0.00	0.00	0.00	20	45	1
45	Center Street & 5th Street	2	99	18,307	0.03	0.00	0.03	0.00	0.03	1,089	28	26
46	Newland Circle & California Avenue	2	2	371	0.00	0.00	0.00	0.00	0.00	30	42	1
47	7th Street & Elgin Avenue	2	195	36,244	0.04	0.12	0.03	0.00	0.15	3,044	16	59
48	9th Street & Shone Drive	2	99	18,307	0.02	0.06	0.00	0.00	0.06	DNA	25	0
49	Prater Way & Sullivan Lane	2	1	185	0.00	0.00	0.00	0.00	0.00	10	48	0
50	Plumb Lane & Arlington Avenue	2	2	371	0.00	0.00	0.00	0.00	0.00	15	42	1

Table 23 Crash indices based on selected methods of high crash zones in Carson City, Nevada

Zone #	Zone	CF_N	CF_S	CD_A	CR_{PP}	$CR_{PP<18}$	$CR_{PP18-64}$	$CR_{PP>64}$	CR_{PA}	CRvv	SR
		# crashes	# crashes	# crashes/unit area	#crashes/pop	#crashes/pop	#crashes/pop	#crashes/pop	#crashes/pop	#crashes/MV	Avg of Ranks
1	US395 Highway: Hotsprings Road to John Street	12	496	19,237	0.08	0.00	0.10	0.10	0.20	2,474	3.67
2	US395 Highway: Caroline Street to 7th Street	21	405	19,790	0.09	0.12	0.07	0.14	0.33	2,367	2.67
3	US 50 Highway: Stewart Street to Saliman Road	9	201	7,089	0.04	0.00	0.06	0.00	0.06	1,380	7.00
4	US 50 Highway: Lompa Lane to Brown Street	7	491	13,631	0.06	0.05	0.08	0.00	0.13	3,919	4.33
5	5th Street: Roop Street to Saliman Road	8	7	336	0.00	0.00	0.00	0.00	0.00	180	9.00
6	Robinson Street & Saliman Road	4	101	19,868	0.04	0.15	0.00	0.00	0.15	1,925	3.67
7	Winnie Lane & Lone Mtn Drive	2	99	19,473	0.02	0.00	0.00	0.17	0.17	4,263	2.33
8	Hotsprings Road & Pine Lane	2	99	19,473	0.03	0.09	0.00	0.00	0.09	2,929	4.00
9	College Parkway & US395 Highway	2	2	395	0.00	0.00	0.00	0.00	0.00	10	9.00
10	US395 & Snyder Avenue	2	2	395	0.00	0.01	0.00	0.00	0.01	9	8.67

Table 24 Crash indices based on selected methods of high crash zones in Elko County, Nevada

Zone #	Zone	CF_N	CF_S	CD_A	CR_{PP}	$CR_{PP<18}$	$CR_{PP18-64}$	$CR_{PP>64}$	CR_{PA}	SR	CS
		# crashes	# crashes	# crashes/un	#crashes/pop	#crashes/pop	#crashes/pop	#crashes/pop	#crashes/pop	Avg of Ranks	Score
1	Cedar Street & 12th Street	3	100	7,081	0.09	0.01	0.14	0.00	0.15	6.00	17
2	5th Street & Railroad Street	9	202	3,594	0.17	0.01	0.13	0.74	0.88	5.00	11
3	Water Street & 6th Street	1	1	444	0.00	0.00	0.00	0.00	0.00	14.00	1
4	9th Street & Douglas Street	1	98	43,371	0.05	0.00	0.09	0.00	0.09	4.00	100
5	5th Street & Carlin Court	1	0	0	0.00	0.00	0.00	0.00	0.00	21.00	0
6	Wilson Avenue & 6th Street	2	2	222	0.00	0.00	0.00	0.00	0.00	16.00	1
7	Cedar Street & Buns Road	2	2	888	0.00	0.01	0.00	0.00	0.01	8.50	2
8	Idaho Street & 11th Street	4	4	284	0.01	0.01	0.00	0.01	0.03	13.00	1
9	Idaho Street & College Avenue	2	195	21,686	0.41	0.00	0.32	1.46	1.78	3.50	56
10	Silver Street & Elecart Blvd	1	1	444	0.00	0.00	0.00	0.00	0.00	13.50	1
11	Idaho Street & Cedar Street	1	1	444	0.00	0.00	0.00	0.00	0.00	10.00	1
12	Second Street & Willow Street	1	1	444	0.00	0.00	0.00	0.00	0.00	11.50	1
13	Mittry Avenue & College Court	1	1	444	0.00	0.00	0.00	0.00	0.00	12.00	1
14	Argent Avenue & Copper Street	1	1	444	0.00	0.00	0.00	0.00	0.00	14.50	1
15	Antimony Road & Carlson Avenue	1	1	444	0.00	0.00	0.00	0.00	0.00	13.00	1
16	Chris Avenue & Colonial Drive	2	2	222	0.00	0.00	0.00	0.00	0.00	15.50	1
17	Spruce Road & Noodle Lane	1	1	444	0.00	0.00	0.00	0.00	0.00	12.50	1
18	Kittridge Canyon Road & Lupine Street	1	98	43,371	13.88	0.00	27.35	0.00	27.35	1.00	200
19	Spring Valley Pardway & Cedarlawn Drive	1	1	444	0.00	0.01	0.00	0.00	0.01	9.50	1
20	Berry Creek Place & Berry Creek Drive	1	98	43,371	0.17	0.47	0.00	0.00	0.47	2.50	102
21	Tres Cartes Avenue & Berry Creek Drive	1	98	43,371	0.26	0.00	0.42	0.00	0.42	3.00	102

Table 25 Crash indices based on selected methods of high crash zones in Douglas County, Nevada

Zone #	Zone	CF_N	CF_S	CD_A	CR_{PP}	$CR_{PP<18}$	$CR_{PP18-64}$	$CR_{PP>64}$	CR_{PA}	SR	CS
		# crashes	# crashes	# crashes/uni	#crashes/ pop	#crashes/ pop	#crashes/ pop	#crashes/ pop	#crashes/ pop	Avg of Ranks	Score
1	US 50 Highway & Elks Point Road	1	98	19,276	0.32	1.87	0.00	0.00	1.87	1.00	200
2	US 50 Highway & Kingsbury Grade Road	2	2	395	0.00	0.00	0.00	0.00	0.00	5.50	2
3	Tahoe Drive & Lynn Way	1	98	19,276	0.22	1.16	0.00	0.00	1.16	1.50	162
4	Benjamin Drive & Tina Court	1	0	0	0.00	0.00	0.00	0.00	0.00	17.00	0
5	Kingsbury Grade Road & Tramway Drive	1	1	197	0.00	0.00	0.00	0.00	0.00	8.00	1
6	Tramay Drive & Jacks Circle	2	2	395	0.00	0.00	0.00	0.00	0.00	5.00	2
7	Main Street & County Road	1	1	197	0.00	0.00	0.00	0.00	0.00	9.50	1
8	Main Street & First Street	1	1	197	0.00	0.00	0.00	0.00	0.00	9.00	1
9	Meadow Lane & Douglas Avenue	1	1	197	0.00	0.00	0.00	0.00	0.00	7.00	1
10	Main Street & Eddy Street	1	0	0	0.00	0.00	0.00	0.00	0.00	17.00	0
11	US395 Highway & Kingslane Court	1	1	197	0.00	0.00	0.00	0.00	0.00	8.50	1
12	Waterloo Lane & Toler Lane	1	1	197	0.00	0.00	0.00	0.00	0.00	7.50	1
13	Muir Drive & Lyell Way	1	1	197	0.00	0.00	0.00	0.00	0.00	10.00	1
14	Main Street & Mill Street	1	1	197	0.01	0.03	0.00	0.00	0.03	5.00	3
15	Heritage Lane & Tillman Lane	1	1	197	0.01	0.00	0.01	0.00	0.01	5.50	1
16	Mica Drive & Calcite Drive	1	98	19,276	0.07	0.00	0.13	0.00	0.13	2.00	107
17	Tourmaline Drive & Granite Court	1	1	197	0.00	0.00	0.00	0.00	0.00	11.00	1
18	Somerset Way & Plymouth Drive	1	0	0	0.00	0.00	0.00	0.00	0.00	17.00	0
19	Sunridge Drive & Starshine Court	1	1	197	0.00	0.00	0.00	0.00	0.00	10.50	1

Table 26 Ranking of high crash zones in Clark County, Nevada

Zone #	Zone	Rank CF_N	Rank CF_S	Rank CD_A	Rank CR_{PP}	Rank CR_{PA}	Rank CR_{VV}	Rank SR	Rank CS
1	Las Vegas Blvd: Fashion Show Dr to Reno Av	3	5	3	1	1	4	1	1
2	Las Vegas Blvd: 4th St to Stardust Rd	5	8	1	7	6	3	2	3
3	Downtown Las Vegas	1	1	25	2	3	15	14	9
4	Las Vegas Blvd: Cheyenne Av to Foremaster La	7	3	2	13	10	1	3	2
5	Charleston Blvd: Decatur Blvd to Buffalo Dr	18	20	16	22	24	8	17	18
6	Charleston Blvd: Main St to Rancho Dr	27	25	10	10	14	21	16	13
7	Charleston Blvd: Nellis Blvd to Eastern Av	15	22	15	25	26	17	21	20
8	Sahara Ave: Mcleod Dr to Paradise Rd	12	15	9	18	13	12	9	11
9	Sahara Ave: Arville Av to Rainbow Blvd	26	27	21	27	28	27	28	28
10	Sahara Ave: Fairfield Av to Valley View Blvd	19	13	6	12	12	13	7	8
11	Maryland Pkwy: Karen Av to Hacienda Av	2	4	7	15	16	2	4	4
12	Tropicana Av: Pecos Rd to Tamarus St	16	26	17	26	21	26	24	23
13	Tropicana Av: Boulder Av to Sandhill Rd	23	17	11	19	17	10	10	12
14	Boulder Highway-Pecos Rd	14	9	28	5	5	18	18	19
15	Boulder Highway-Desert Inn Rd	23	19	27	6	8	25	23	25
16	Flamingo Rd: Sandhill Rd to Escondido St	20	23	19	24	25	22	25	24
17	Tropicana Av: Wilbur St to Tropicana CC Bdry	17	12	4	9	7	16	5	5
18	Flamingo Rd: Claymont St to Las Vegas Blvd	9	14	5	14	20	14	12	7
19	Harmon Avenue	28	21	26	11	11	29	25	27
20	Paradise-Twain	7	7	24	8	9	20	19	22
21	Flamingo Rd: I-15 to Ravenwood Dr	10	10	12	21	19	7	10	14
22	Tropicana Ave: I-15 to Raibow Blvd	13	16	13	20	23	6	13	16
23	Desert Inn Rd - Arville St	6	6	29	4	4	24	20	15
24	Decatur Blvd: Lake Mead Blvd to Dover Pl	22	24	18	23	22	19	22	21
25	Rancho Dr: Carey Ave to Palomino Ln	21	18	14	16	18	11	14	17
26	Jones Blvd: Somke Ranch Rd to Chelse Cr	29	28	20	28	27	23	27	26
27	Martin L King Blvd: Cartier Av to Bonanza Rd	25	29	23	29	29	28	29	29
28	Lake Mead Blvd-Mojave Rd	4	2	22	3	2	5	6	6
29	Nellis Blvd: Harris Av to Sahara Av	11	11	8	17	15	9	8	10

Table 27 Ranking of high crash zones in Washoe County, Nevada

Zone #	Zone	Rank CF_N	Rank CF_S	Rank CD_A	Rank CR_{PP}	Rank CR_{PA}	Rank CR_{VV}	Rank SR	Rank CS
1	4th Street: Lake Street to Keystone Av	1	3	6	3	1	5	1	1
2	Virginia Street: 6th Street to 1st St	2	6	21	7	10	7	9	12
3	2nd Street: Lake Street to Keystone Pl	3	4	11	4	6	1	5	3
4	Virginia Street: Linden Street to Peckham Ln	4	1	7	6	8	9	6	7
5	Sun Valley Blvd: 7th Avenue to Scottsdale Rd	5	5	8	9	14	10	8	8
6	Sutro Street: Oliver Avenue to 4th S	6	2	9	5	3	4	3	4
7	Arlington Avenue: 6th Street to Island Av	7	7	2	8	9	DNA	4	47
8	Moana Lane: Kietzke Lane to Lakeside Dr	8	9	30	24	18	18	24	24
9	Virginia Street: College Drive to 9th St	9	10	18	12	25	13	19	20
10	Neil Road: Moana Lane to Peckham Ln	9	16	33	23	22	17	26	26
11	Kietzke Lane: Plumb Lane to Gentry Way	11	37	39	40	43	36	39	37
12	Virginia Street: Pueblo Street to Plumb Ln	12	19	5	26	23	25	18	10
13	Grove Street: Wrondel Way to Kietzke Ln	12	17	15	28	31	12	21	15
14	Montello Street: Oliver Avenue to 9th S	14	20	35	30	27	11	28	21
15	Oddie Blvd: Sullivan Lane to Silverada Blvd	14	17	16	36	30	23	25	23
16	Mill Street: Kietzke Lane to Pringle Way	14	11	3	10	19	20	10	6
17	Kirman Avenue: Mill Street to Ryland St	14	11	4	11	20	2	7	5
18	California Street: Virginia Street to Hill St	18	38	40	39	44	34	39	35
19	Sierra Street: College Drive to 10th St	18	22	28	22	29	15	26	22
20	Wells Avenue: Kuenzli Street to Mill St	18	20	10	20	13	22	12	14
21	Baring Blvd: Springland Drive to Sparks Blvd	18	13	29	17	15	6	14	13
22	Keystone Avenue: Sunnyside Drive to 5th St	22	28	32	34	21	32	32	33
23	Wells Avenue: Thoma Street to Taylor St	22	14	17	14	11	14	10	16
24	El Rancho Drive: G Street to Prater Way	24	39	37	41	45	37	41	34
25	Brinkby Avenue: Robinhood Drive to Lakeside Dr	24	15	36	16	12	3	16	9
26	Virginia Street: Bailey Drive to Talus Way	24	8	1	2	4	8	2	2
27	Rock Blvd: Glendale Avenue to Freeport Blvd	27	23	31	1	5	21	20	19
28	Lakeside Drive: Plumb Lane to Hillcrest Dr	27	23	34	15	24	16	29	27
29	Vassar Street & Harvard Way	29	40	38	38	38	38	37	36
30	Stead Blvd & Silver Lake Road	29	29	22	19	17	24	23	25
31	Peckham Lane & Kietzke Lane	31	30	19	31	33	33	32	32
32	Wells Avenue & Pueblo Street	31	25	12	21	28	DNA	22	47
33	Mill Street & Center Street	31	30	23	29	2	27	17	11
34	Silverada Blvd & Orchid Way	31	32	24	33	35	26	32	28
35	Sulivan Lane & Greenbrae Drive	31	41	41	47	41	35	38	38
36	Wells Avenue & 6th Street	31	25	13	13	7	30	14	17
37	Vassar Street & Kietzke Lane	37	42	42	44	47	44	47	44
38	Plumb Lane & Harvard Way	37	42	42	43	42	43	44	42
39	Terminal Way & Mill Street	37	48	48	37	37	46	46	45
40	Vassar Street & Locust Street	37	42	42	48	46	39	44	39
41	Stewart Street & Wells Avenue	37	32	20	35	36	28	31	29
42	Second Street & Wells Street	37	48	48	49	49	DNA	50	47
43	7th & Center Street	37	32	24	27	34	31	36	31
44	5th Street & Sierra Street	37	42	45	45	48	41	48	43
45	Center Street & 5th Street	37	32	24	25	32	29	32	30
46	Newland Circle & California Avenue	37	42	45	46	40	40	42	40
47	7th Street & Elgin Avenue	37	27	14	18	16	19	13	18
48	9th Street & Shone Drive	37	32	24	32	26	DNA	30	47
49	Prater Way & Sullivan Lane	37	48	50	50	50	45	49	46
50	Plumb Lane & Arlington Avenue	37	42	45	42	39	42	43	41

Table 28 Ranking of high crash zones in Carson City, Nevada

Zone #	Zone	Rank CF_N	Rank CF_S	Rank CD_A	Rank CR_{PP}	Rank CR_{PA}	Rank CR_{VV}	Rank SR	Rank CS
1	US395 Highway: Hotsprings Road to John Stree	2	1	5	2	2	4	3	3
2	US395 Highway: Caroline Street to 7th Street	1	3	2	1	1	5	2	1
3	US 50 Highway: Stewart Street to Saliman Road	3	4	7	5	7	7	7	7
4	US 50 Highway: Lompa Lane to Brown Street	5	2	6	3	5	2	6	4
5	5th Street: Roop Street to Saliman Road	4	8	10	9	9	8	9	8
6	Robinson Street & Saliman Road	6	5	1	4	4	6	3	6
7	Winnie Lane & Lone Mtn Drive	7	6	3	7	3	1	1	2
8	Hotsprings Road & Pine Lane	7	6	3	6	6	3	5	5
9	College Parkway & US395 Highway	7	9	8	10	10	9	9	10
10	US395 & Snyder Avenue	7	9	8	8	8	10	8	9

Table 29 Ranking of high crash zones in Elko County, Nevada

Zone #	Zone	Rank CF_N	Rank CF_S	Rank CD_A	Rank CR_{PP}	Rank CR_{PA}	Rank SR	Rank CS
1	Cedar Street & 12th Street	3	3	6	6	6	7	6
2	5th Street & Railroad Street	1	1	7	5	3	6	7
3	Water Street & 6th Street	8	12	9	18	19	17	16
4	9th Street & Douglas Street	8	4	1	7	7	5	4
5	5th Street & Carlin Court	8	21	21	21	21	21	21
6	Wilson Avenue & 6th Street	4	9	19	12	13	20	20
7	Cedar Street & Buns Road	4	9	8	9	9	8	8
8	Idaho Street & 11th Street	2	8	18	8	8	14	18
9	Idaho Street & College Avenue	4	2	5	2	2	4	5
10	Silver Street & Elecart Blvd	8	12	9	16	18	16	15
11	Idaho Street & Cedar Street	8	12	9	13	11	10	10
12	Second Street & Willow Street	8	12	9	17	14	11	11
13	Mittry Avenue & College Court	8	12	9	14	15	12	12
14	Argent Avenue & Copper Street	8	12	9	20	20	18	17
15	Antimony Road & Carlson Avenue	8	12	9	19	17	14	14
16	Chris Avenue & Colonial Drive	4	9	19	11	12	19	19
17	Spruce Road & Noodle Lane	8	12	9	15	16	13	13
18	Kittridge Canyon Road & Lupine Street	8	4	1	1	1	1	1
19	Spring Valley Pardway & Cedarlawn Drive	8	12	9	10	10	9	9
20	Berry Creek Place & Berry Creek Drive	8	4	1	4	4	2	2
21	Tres Cartes Avenue & Berry Creek Drive	8	4	1	3	5	3	3

Table 30 Ranking of high crash zones in Douglas County, Nevada

Zone #	Zone	Rank CF_N	Rank CF_S	Rank CD_A	Rank CR_{PP}	Rank CR_{PA}	Rank SR	Rank CS
1	US 50 Highway & Elks Point Road	3	1	1	1	1	1	1
2	US 50 Highway & Kingsbury Grade Road	1	4	4	8	7	6	6
3	Tahoe Drive & Lynn Way	3	1	1	2	2	2	2
4	Benjamin Drive & Tina Court	3	17	17	17	17	17	17
5	Kingsbury Grade Road & Tramway Drive	3	6	6	7	10	10	10
6	Tramay Drive & Jacks Circle	1	4	4	6	6	4	5
7	Main Street & County Road	3	6	6	10	13	13	13
8	Main Street & First Street	3	6	6	9	12	12	12
9	Meadow Lane & Douglas Avenue	3	6	6	14	8	8	8
10	Main Street & Eddy Street	3	17	17	17	17	17	17
11	US395 Highway & Kingslane Court	3	6	6	15	11	11	11
12	Waterloo Lane & Toler Lane	3	6	6	12	9	9	9
13	Muir Drive & Lyell Way	3	6	6	16	14	14	14
14	Main Street & Mill Street	3	6	6	4	4	4	4
15	Heritage Lane & Tillman Lane	3	6	6	5	5	6	7
16	Mica Drive & Calcite Drive	3	1	1	3	3	3	3
17	Tourmaline Drive & Granite Court	3	6	6	13	16	16	16
18	Somerset Way & Plymouth Drive	3	17	17	17	17	17	17
19	Sunridge Drive & Starshine Court	3	6	6	11	15	15	15

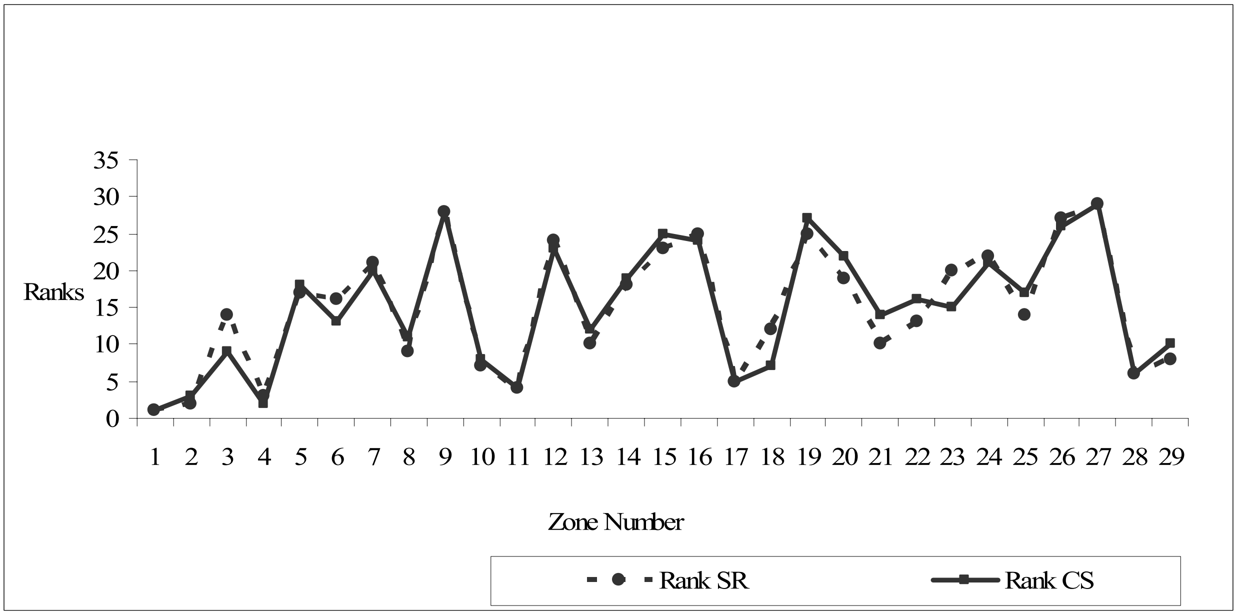

Figure 24 Comparison of ranks obtained using SR method and CR method for high crash zones in Clark County, Nevada

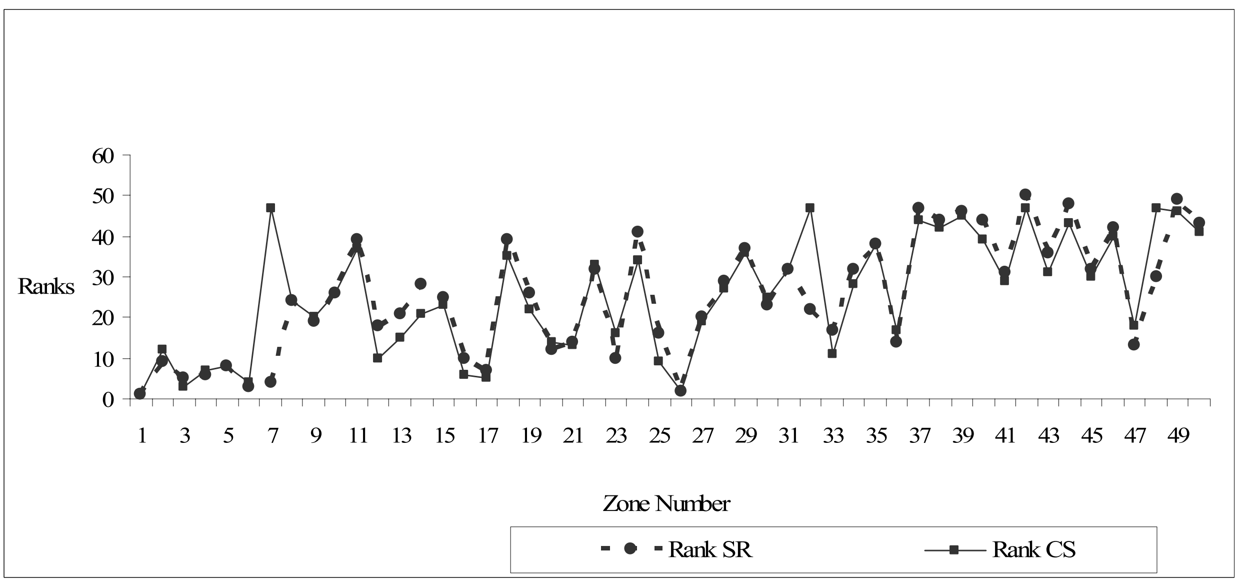

Figure 25 Comparison of ranks obtained using SR method and CR method for high crash zones in Washoe County, Nevada

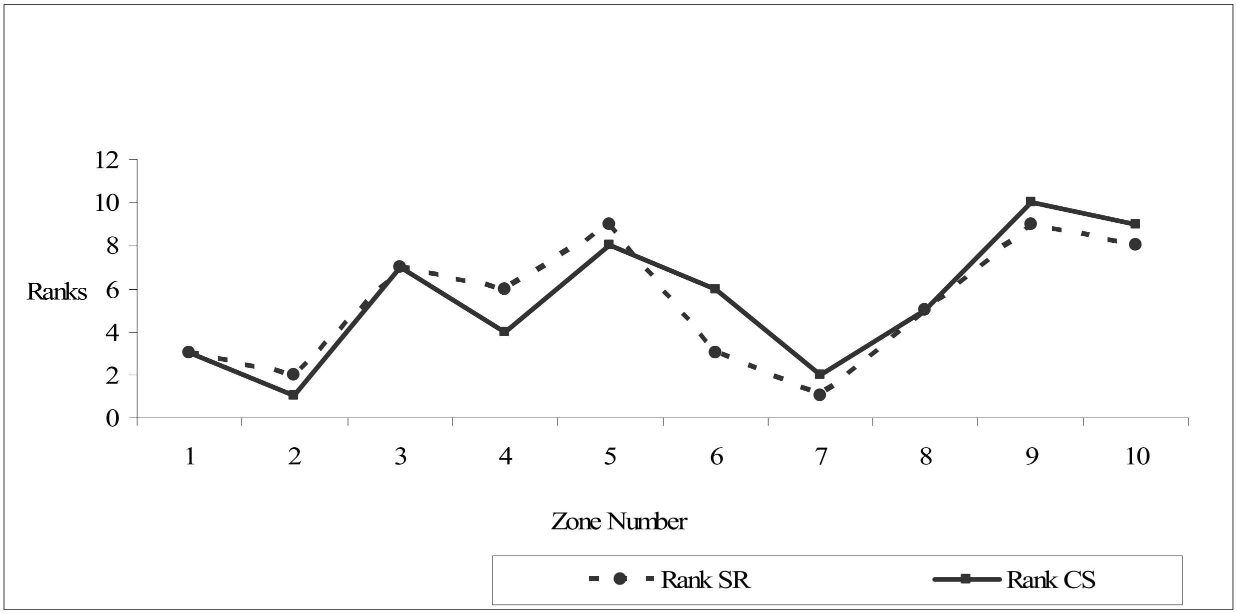

Figure 26 Comparison of ranks obtained using SR method and CR method for high crash zones in Carson City, Nevada

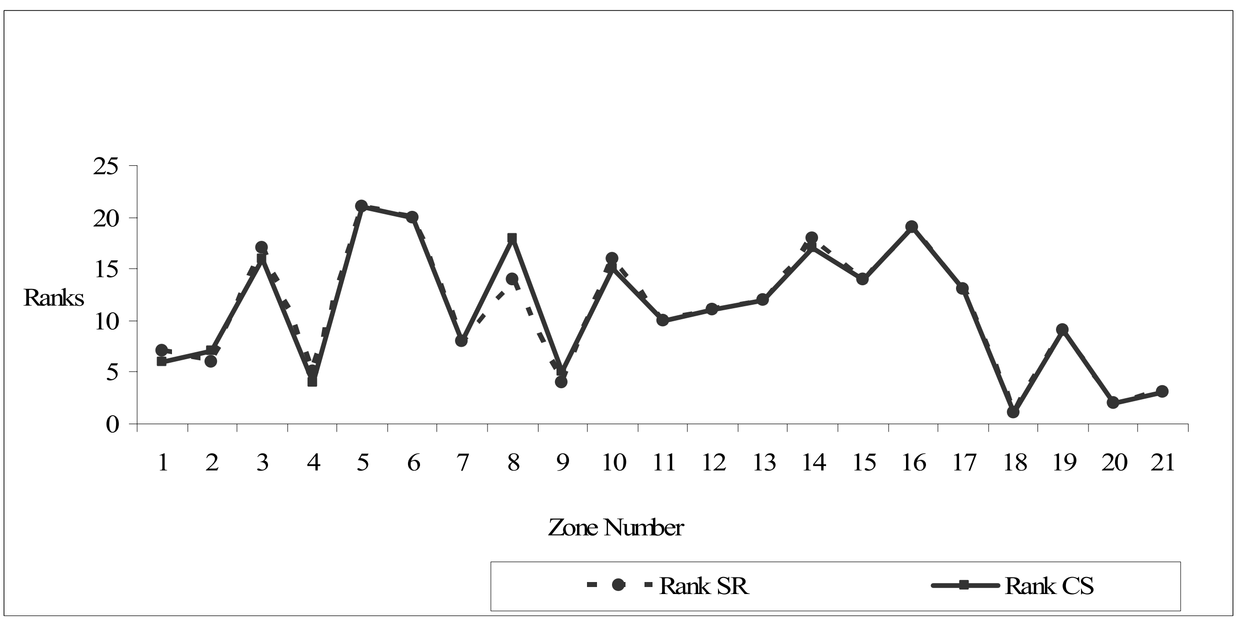

Figure 27 Comparison of ranks obtained using SR method and CR method for high crash zones in Elko County, Nevada

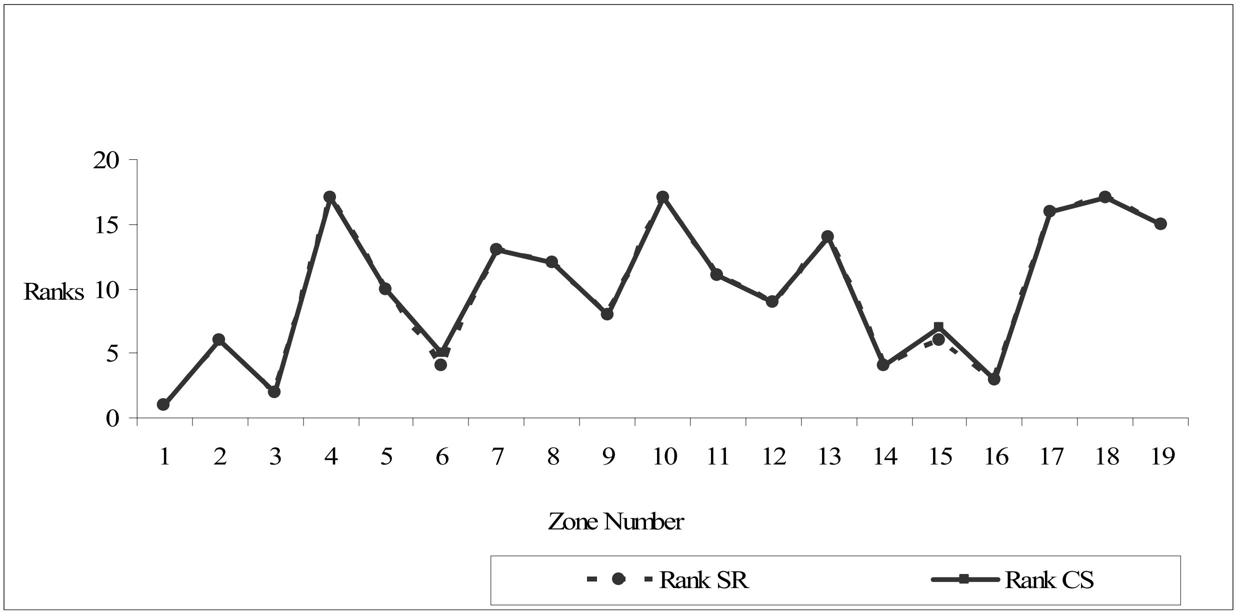

Figure 28 Comparison of ranks obtained using SR method and CR method for high crash zones in Douglas County, Nevada

CHAPTER 8
SUMMARY

This report documents efforts on and findings of a cooperative agreement between the Nevada Department of Transportation (NDOT) and University of Nevada, Las Vegas (UNLV) Transportation Research Center (TRC), titled *Development of Criteria to Identify Pedestrian High Crash Locations*. The main objective of the program is to develop criteria to identify pedestrian high crash locations in order to allocate recourses including federal safety funds, for safety improvements. The criteria will help in the development of a "Pedestrian Safety Program", as a part of the NDOT's Highway Safety Improvement Program (HSIP). The developed criteria will assist the system managers not only in Las Vegas and Nevada, but also nationally, in better understanding the cause of the crashes and identifying appropriate operating strategies to enhance pedestrian safety.

A Geographic Information Systems (GIS) based methodology is used to identify pedestrian high crash locations in the study areas (Clark County, Washoe County, Carson City, Elko County, and Douglas County). The tasks involved are (1) conduct a review of the existing literature; (2) geocode (addressmatch) / digitize the pedestrian crashes over corresponding street center lines in order to do analyses using GIS; (3) identify crash concentrations by building crash density maps; (4) identify potential high crash locations; (5) develop and evaluate criteria to rank the pedestrian high crash locations.

Pedestrian crashes in the selected study areas were geocoded. Density maps were then created to identify pedestrian high crash locations. Using data identified, the pedestrian high crash locations in each study area were ranked. The ranks obtained were significantly different for each high crash zone in each study area when methods such as crash frequency, crash density, and crash rates were used. As area, number of pedestrian crashes based on severity, population in the vicinity of a zone, and vehicular volume play a key role in defining crash risk of a zone, the sum of the ranks and crash score methods which are a combination of these methods are more suitable for use in ranking of high crash zones. Results obtained indicate that rankings are relatively consistent when sum of ranks method and crash score method were used when compared to individual methods.

CHAPTER 9
FURTHER RESEARCH

The scope for further research is presented in this chapter. Pedestrian exposure would be an excellent measure to rank the zones or locations by computing crash rates. Instead of pedestrian counts, demographics data near the crash locations are used to compute crash rates in this project. The underlying assumption is that, the potential pedestrians in the crash locations are its population nearby. But this might not be true in all the cases. For example in Las Vegas Boulevard, even though there are no resident population, high number of pedestrian crashes exists. This can be attributed to the higher number of visitors/tourists in the city. In such a case the crash rate with demographics will not be an accurate measure. Field data collection should be conducted for estimating the pedestrian counts in the high crash locations in order to compute the crash rates and rank the high crash locations. An alternative to field data collection is to develop pedestrian trip generation models to estimate the number of pedestrian trips based on the demographics and land-use characteristics of the area.

Statistical analysis of the pedestrian crash data will help to identify: (1) when and were did these crashes when and where did these crashes occur (date, time of the day, day of the week, location (urban or rural), weather and lighting conditions, roadway number of lanes, road system identifier, and road surface conditions); (2) causal factors (for example, alcohol related, failed to yield the right-of-way and stepped into the path of an oncoming vehicle, disregarded a traffic signal, or made some improper action that contributed to the crash like crossing not at intersection, crossing at mid block crosswalk, crossing at intersection, walking along road with traffic, walking along road against traffic, working on vehicle in road, standing playing in road, standing in pedestrian island, etc); (3) and characteristics of pedestrian involved in crashes (gender, age and ethnicity). Even though some attempts were made to identify the above said factors, no statistical tests were performed. Moreover these factors were also not incorporated in developing criteria to identify high crash locations. Thus, (1) performing a statistical test to identify the factors contributing the pedestrian crashes, and (2) incorporating these factors while developing the criteria, are the studies proposed for further research.

Developing an automated GIS tool to identify pedestrian high crash locations will help the system managers nationally, in better understanding the cause of the crashes and identifying appropriate operating strategies to enhance pedestrian safety. As a potential topic for further research, an automated tool that implements the methodology used for the program to identify and rank the pedestrian high crash locations is proposed. The inputs for the proposed GIS tool will be street network data and pedestrian crash data (in GIS format), and other data required to compute crash rates (census data, pedestrian counts, etc.) of the study area. By implementing the methodology adopted for the program, the tool will identify and rank pedestrian high crash locations using the developed criteria. Automation can be achieved using ESRI ArcGIS, programming ESRI ArcObjects with Visual Basic, programming Microsoft Excel with Visual Basic Macro.

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