Bicycle Crash Analysis for Wisconsin Using a Crash Typing Tool (PBCAT) and Geographic Information System (GIS)

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16. Abstract

Successful efforts have been made over the past three decades in Wisconsin to reduce the number of crashes and fatalities related to bicycle–vehicle crashes. However, a more complete understanding of these crashes was necessary in order to continue to decrease the number of serious and fatal crashes. This comprehensive crash analysis takes the first and most important step of "typing" bike-motor vehicle crashes for 2003. This report goes on to analyze these crashes in more depth and identifies commonalities between these crashes and crash characteristics, specifically related to traffic conditions, roadway attributes, and the users involved in the crashes.

The approach used in conducting the report included the use of the Pedestrian and Bicycle Crash Analysis Tool (PBCAT, version 2.0b) and GIS. PBCAT was considered effective and constructive. However, each crash record's diagram had to be evaluated by viewing it on microfiche which elongated the evaluation process. The GIS process was also found to be a worthwhile and an essential step. By pinpointing and geocoding the location of crashes, other data files having these reference points, could be cross-referenced. A methodology that explains this process was developed as part of this study and is available in the form of a mini-manual.

The report and analyses found that the largest concentration of bike-motorist crashes occurred at intersections on urban arterial streets – 94% of them were reported in urban areas while 66% occurred at intersections. Rural crashes represented only 6% of all crashes in the state, but almost 80% were on roads with 55 mph posted speeds. The fatal crash rate based on bicycle miles traveled was almost twice as high in rural areas as in urban areas. Four out of the top five crash types indicated that the motorist made the critical error. Nearly 65% of the top 10 crash types indicated motorist error as the primary error. The detailed analysis of roadway characteristics pointed to low crash rates (based on volume of traffic) for both the local road and state highway systems in rural areas. The wider the travel lanes the lower the crash rate for local rural roads and state highways. Crash rates were the lowest on state highways with five foot paved shoulders compared to all other two-lane highways. Finally, crashes related to sidewalks, paths and crosswalks adjacent to streets accounted for a surprising 28% of all of the state's crashes. Motorist driving out from both sign and signal-controlled intersections were by far the most common crash types in this group.

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EXECUTIVE SUMMARY

Crashes between bicyclists and motorists (bicycle – vehicle crashes) in the State of Wisconsin continue to decrease on an annual basis. Although strides have been made over the past three decades to reduce the number of crashes and fatalities related to bicycle–vehicle crashes, a more complete understanding of these crashes is necessary in order for the state to continue to decrease the number of serious and fatal crashes. This report analyzes bicycle – vehicle crashes in the State of Wisconsin that occurred in the year 2003, and attempts to identify any commonalities between these crashes by looking at crash characteristics, traffic characteristics, and roadway design characteristics. The report is separated into the following eight sections;

- *Background*
- *Literature Review and Study Limitations*
- *Crash Overview*
- *Urban and Rural Crashes*
- *Crash Rates*
- *Crash Types*
- *In-Depth Analysis*
- *Major Findings*

The *Background and Literature Review* and Study Limitations sections provide the reader with information regarding previous studies dealing with bicycle crashes. It also provides a brief narrative on how this study is different from previous studies and how this study relates to the Wisconsin Department of Transportation's Bicycle Plan that was developed in 1999.

The *Crash Overview* section analyzes bicycle – vehicle crash trends by looking at crashes throughout a six-year period from 1999 – 2004. Several graphs and charts visually display general characteristics of the crashes obtained from the MV4000 Report. In the future, when more data are available, this section can be used to conduct a more complete time series analysis of bicycle – vehicle crash characteristics.

The *Urban and Rural Crashes* section specifically looks at bicycle – vehicle crashes that occurred in 2003. However, because of the limited number of crashes occurring in a rural setting, rural crashes include data from the years 2002 and 2004 as well. This section compares crashes occurring in the two different environments by looking at roadway characteristics such as posted speed and average daily traffic.

The *Crash Rates* section uses several measures to identify crash rates in different settings. Bicycle Miles Traveled data from the National Household Travel Survey were obtained to create an exposure rate for bicyclists to vehicles as well as Vehicle Miles Traveled data. Crash rates by Population, miles of roadway, and types of roadway are also identified.

The *Crash Types* section breaks down each crash by the circumstances that caused the crash. The Pedestrian Bicycle Crash Analysis Tool was used to assign each crash a certain crash type number as well as description. A chart with crash types for all crashes is included, as well as separate charts showing the most common crashes in both urban and rural settings. The five most common urban crash types are then compared to the universe of urban crashes.

The *In-Depth Analysis* section analyzes both urban and rural crashes in further detail. After crash typing urban crashes, it was obvious that sidepath crashes were common so further analysis of sidepath crashes is provided. Roadway width, the presence of paved shoulders and the bicycle suitability rating are all looked at in further detail for rural crashes.

The *Major Findings* section summarizes results that are significant and worth noting. Some of those findings discussed in that section include the following; there were far more urban crashes than rural crashes (94% compared 6%), the majority of crashes occurred at intersections (66% compared to 34%), there was a high frequency of sidewalk/crosswalk-type crashes (28% of all crashes), and there were lower crash rates on wider roadways for both local roads and state highways. While urban streets had a much higher crash rate, rural highways had a much higher rate of fatalities (fatal crashes as a percent of all bike – vehicle crashes). Four of the top five crash types (and 7 of the top 10) indicated that the motorist made the critical error that contributed to the crash. Overall, the number of bike-vehicle crashes continued to decline from 1999 to 2004, while the number of fatalities related to vehicle – bicycle crashes during that same time frame fluctuated from 9 to 18.

A Note about Crashes and Accidents

Why does this report refer to collisions between motorists and bicyclists as crashes and not accidents? This is best explained by the National Highway Traffic Safety Administration.

"Changing the way we think about events, and the words we use to describe them, affects the way we behave. Motor vehicle crashes and injuries are predictable, preventable events. Continued use of the word "accident" promotes the concept that these events are outside of human influence or control. In fact, they are predictable results of specific actions.

Since we can identify the causes of crashes, we can take action to alter the effect, and avoid collisions. These events are not "acts of God" but predictable results of the laws of physics.

The concept of "accident" works against bringing all the appropriate resources to bear on the enormous problem of motor vehicle collisions. Continuous use of "accident" fosters the idea that the resulting injuries are an unavoidable part of life."

INTRODUCTION

Wisconsin is often perceived to be a good state for bicycling by both its own residents and out-of-state visitors. When bicyclists are asked why they think the state is held in such high esteem, responses will likely include the excellent network of country roads and the state trail system. However, there is a negative side to bicycling in the state and that is the existence of crashes, the most serious of which involves crashes between motorists and bicyclists. Although strides have been made over the past three decades to reduce the number of crashes and fatalities related to bicyclist–vehicle crashes, a more complete understanding of these crashes is necessary in order for the state to continue to decrease serious and fatal crashes. Realistically, bicycle crashes will continue to occur as long as there are people bicycling, but if bicycling is to retain momentum as a growing travel mode and recreation activity, both the crash rate and crash perception will need to be reduced. This report is intended to steer the state in that direction.

A more detailed crash analysis than what currently exists was conducted for this report, namely "Crash typing" was done. These crashes were then cross-referenced by user characteristics, and roadway, traffic, and intersection characteristics to determine any outstanding associations. A need exists to develop a better picture between the types of crashes and the physical conditions of roadway and traffic conditions that may have contributed to bicycle – vehicle crashes. It is with a better understanding of this relationship that the State will be properly equipped to analyze and recommend appropriate engineering, education, and enforcement countermeasures for the increased safety of bicyclists.

Most of the report uses a single year of crash data – 2003. Where necessary, such as for the *Crash Overview* section, a six-year trend of crash data is used. Furthermore, several sections contain analysis that expands upon the 2003 data for purposes of building a larger set of crash data for rural bicycle – vehicle crashes. The readers should be able to identify the major findings of this report section by section. However, as a way to summarize these findings, the last section – *Major Findings* - will bring these together for the reader.

BACKGROUND, LITERATURE REVIEW and STUDY LIMITATIONS

Background

The Wisconsin Department of Transportation (WisDOT) approved the Wisconsin Bicycle Transportation Plan in 1999. The plan has two main goals: to increase bicycle use and at the same time reduce crashes by 10%. WisDOT has made changes to roadway design elements to improve the accommodation of bicyclists to meet these two goals. The implementation of these improvements, as well as education efforts, has been ongoing with the strong suspicion that they are improving the accommodation and safety of bicyclists. A very cursory and descriptive analysis of bicycle crashes that was performed as part of the bike plan supports these measures, but a case-by-case evaluation of crashes was not preformed for the state bike plan as was done for the Wisconsin Pedestrian Policy Plan for crashes between pedestrians and motorists.

Literature Review

Crashes involving collisions between bicyclists and motorists are reported under WisDOT's Division of Motor Vehicle's *Motor Vehicle Accident Report Form* (MV4000) and are eventually recorded under the Federal Accident Reporting System (FARS). Crashes are not "crash typed" under this system. Cross and Fisher, in a 1976 study "*A Study of Bicycle/Motor Vehicle Accidents*", devised a crash typing system that is still used today and used in a national study by Hunter, Stutts, and Pein entitled "*Pedestrian and Bicycle Crash Types of the Early 1990's*". However, crash types were not analyzed by specific roadway or traffic conditions. Arthur Ross, in "Bicyclist Crash Analysis in a City of Adult Bicyclists (Madison)", did a crash typing exercise, but again, this study did not include detailed roadway information for the crash locations. Ross's work examined a community with a predominant adult crash problem (almost 90% of bicycle – vehicle crashes involved people aged 16 and older). Ross's study was used extensively in the state bicycle plan to present the adult crash types.

According to the North Carolina Highway Safety Research Center (NCHSRC), detailed cross-referencing of crashes with geo-coded location information remains in its infancy.

NCHSRC has developed software for the FHWA that enables crash typing for many reporting systems, but again there is no link with roadway and traffic data.

Daniel Carter from NCHSRC, in a yet to be published report "*Factors Contributing to Pedestrian and Bicycle Crashes on Rural Highways*", looked specifically at rural bicycle - vehicle crashes in North Carolina. Two interesting roadway characteristics that Carter looked at were roadway speed and paved vs. unpaved shoulders. He compared the characteristics of the major crash types to all crash types on rural 2-lane roadways. Carter found that speed and unpaved shoulders were moderately over-represented in most of these crashes.

Study Limitations

This study had several significant limitations. First, the study only examined *reported bicycle - vehicle* crashes. By far, the most common crash circumstance among bicyclists is a simple fall. The severity of these crashes varies, but typically they do not result in a need to visit an emergency center. These crashes result from a variety of mishaps but usually have losing control of the bicycle in common. Losing control can result from striking an object, loss of traction, failure of equipment, etc. The second major crash type involves colliding with another cyclist. Neither of these two crash types is reported through the MV4000 system because they did not involve crashes with motorists. Additionally, there are numerous crashes involving motorists and bicyclists that are not reported even though many of them could, and should be reported. There are two thresholds requiring the reporting of a crash: Injury/death or property damage of $1,000 or more. Crashes between bicyclists and motorists usually meet the injury threshold but seldom meet the second threshold without an injury. As remarkable as it may seem, crashes between bicyclists and motorists do not always result in an injury to the bicyclist, or more realistically, the cyclist initially does not realize that he or she is injured. There are many explanations for why cyclists react this way immediately after a crash: the rush of adrenalin, the strong desire to believe they are injury free, or to say they are not injured just to get the encounter over with. In any event, an officer is not summoned or the officer is convinced that there is no injury. Unless more than $1,000 of property damage is incurred, this crash will not be reported.

The extent of unreported crashes is significant. Some studies that have compared crash reports with actual emergency room admittances estimate that crashes involving ER visits as a ratio to reported crashes is five to one or greater.

The second major limitation of this study is the lack of *bicycle usage* data. This is important when deriving crash rates. Fortunately, some bicycle usage data were used from the National Household Travel Survey (NHTS), but only for large geographic areas. This study could not relate crash data to usage data for most of the detailed analysis conducted. It is possible that one reason why bicycle crashes may be more significant among a specific roadway characteristic or feature is because bicycle use may be higher, thus the rate itself may actually be *lower* when considering the relatively high bicycle usage. For example, urban bicycle use is usually higher than rural bicycle use. A true crash rate would account for this. In this study, to consider the difference in usage for rural and urban areas, crashes were examined separately for both of these geographic classifications. Other then trying to account for bicycle use in this manner, there was not much else that could be done in a study of this magnitude. Occasionally, the reader will be reminded of this limitation when findings are discussed. However, it would be of good practice for the reader to constantly ask himself or herself when reading the report: "is there likely to be a variance in bicycle usage and is that likely to affect the analysis that was just presented?"

CRASH OVERVIEW AND TRENDS

General Characteristics

Annual Bicycle Crashes and Severity of Crashes

Figure 1 shows the annual number of bicyclist-motorist (bicycle – vehicle) crashes that occurred in Wisconsin from 1999 – 2004.

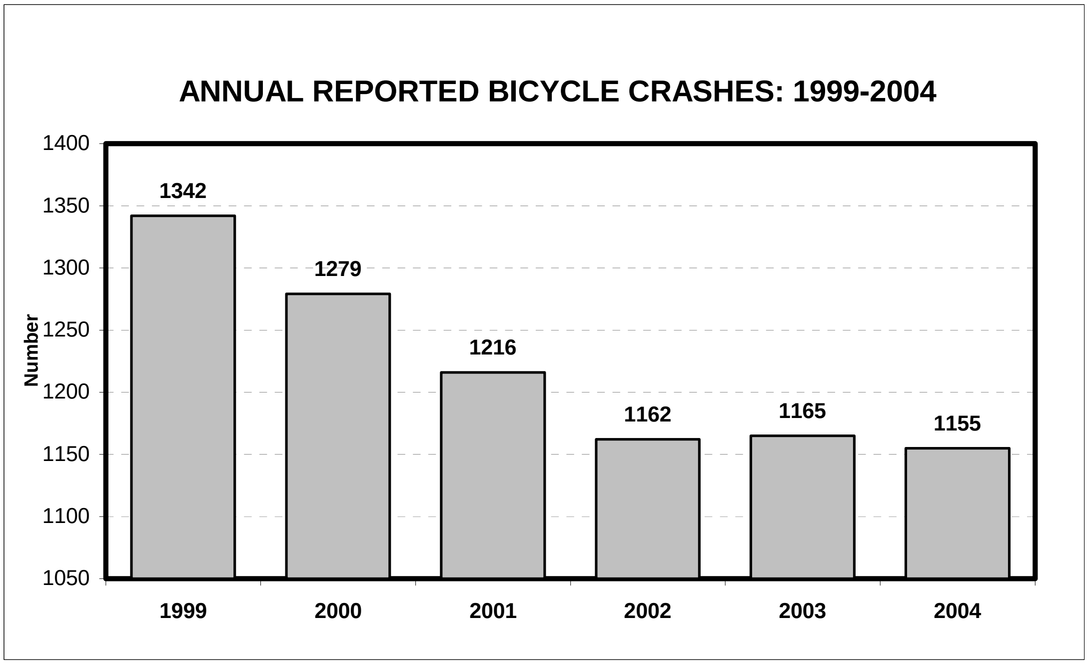


Figure 1

Bicycle – vehicle crashes have decreased by 13.9% over the six-year period. The crashes have declined every year except for a slight increase of 2003 crashes over 2002 crashes. The numbers of crashes resulting in an injury to the bicyclist have followed the same trend as total crashes, however, fatal crashes have increased since 2002 (Table 1).

Table 1

	Total Crashes	Injury Crashes	%	Fatal Crashes	%
1999	1342	1271	94.7%	18	1.3%
2000	1279	1233	96.4%	10	0.8%
2001	1216	1159	95.3%	9	0.7%
2002	1162	1102	94.8%	9	0.8%
2003	1165	1109	95.2%	12	1.0%
2004	1155	1095	94.8%	14	1.2%

The severity of crashes was also examined for 2003. The most serious crashes, those that incapacitated a bicyclist, accounted for 11% of crashes. Injuries that were less severe and did not disable a person from leaving the scene under their own power, accounted for 47% of crashes. Another 36% of the crashes were categorized as bicyclists sustaining possible injuries. These injuries were not observable at the scene, but the bicyclist was indicating an injury or the officer suspected one. One percent of all bicycle – vehicle crashes in 2003 resulted in a fatality. Five percent of the crashes did not result in an injury to the bicyclist. A state-based map locates all of the bicycle – vehicle crashes for 2003. Another map, using Madison as an example, shows a more detailed account of crash locations for a community.

It is noted that an attempt at conducting a time series analysis of numerous crash characteristics over the six-year period did not result in any major or meaningful fluctuations in the data by year. Therefore, because a more detailed analysis of the year 2003 crashes is included in this report, only the general characteristics of the 2003 crashes follow. All of the general characteristics are from the MV4000 Reports (police reports) recorded at the crash. Most of the descriptive statistics include all 1,165 crashes that occurred in 2003, but the detailed analysis only includes 1,112 crashes because of errors within the MV4000 reports. These errors resulted in the inability to geocode the crashes to the location in which they occurred; therefore, street characteristics were not joined to the crashes.

Crashes by Month

Bicycle use in the State of Wisconsin is highly dependent on climatic change. Winter months are cold and snowy and bicycle use is lower, whereas, spring, summer and fall months are much warmer, resulting in an increase in bicycle usage. It is expected that bicycle crashes will increase as bicycle use increases; resulting in a higher number of crashes as the temperatures rises. Figure 2 depicts bicycle – vehicle crashes per month along with the historical mean temperature for the State of Wisconsin[1].

[1] Historical Climate Data, 1971-2000; Wisconsin State Climatology Office.

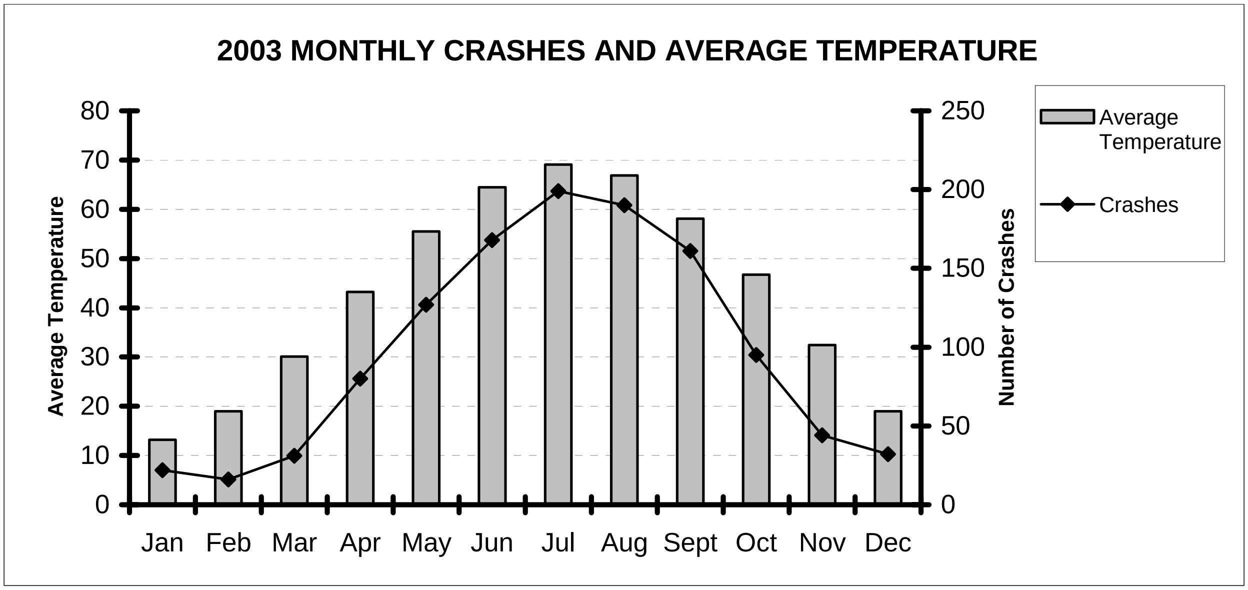


Figure 2

The diagram does indeed show that the highest number of bicycle – vehicle crashes occurred in the warm weather months of June, July, August and September. The numbers of crashes appear to be comparatively higher however, in the late fall/early winter months of November and December than in the late winter/early spring months of February and March even though the mean temperatures are similar. This may be a factor of bicycle use and indicate that bicyclists are more likely to continue biking as long as possible into the winter, but are reluctant to begin biking again in spring until the temperature greatly increases. Yet another explanation could be that bicycle use is indeed comparable between these two time periods, but crashes may be more numerous because of darker light conditions in the late fall – there are more hours of darkness in November and December than there are for February and March.

Crashes by Day of Week

Most bicycle trips in Wisconsin are for recreational purposes (62.1%), with the next most common trip purpose being commuter trips (10.0%) [2]. Although data on when the recreational trips occur are not available, one would suspect that most recreational trips occur on the weekend. However, as Figure 3 shows, the majority of bicycle – vehicle

[2] 2001 National Household Travel Survey.

crashes occurred on weekdays even though only 10.0% of bike trips are commuter related.

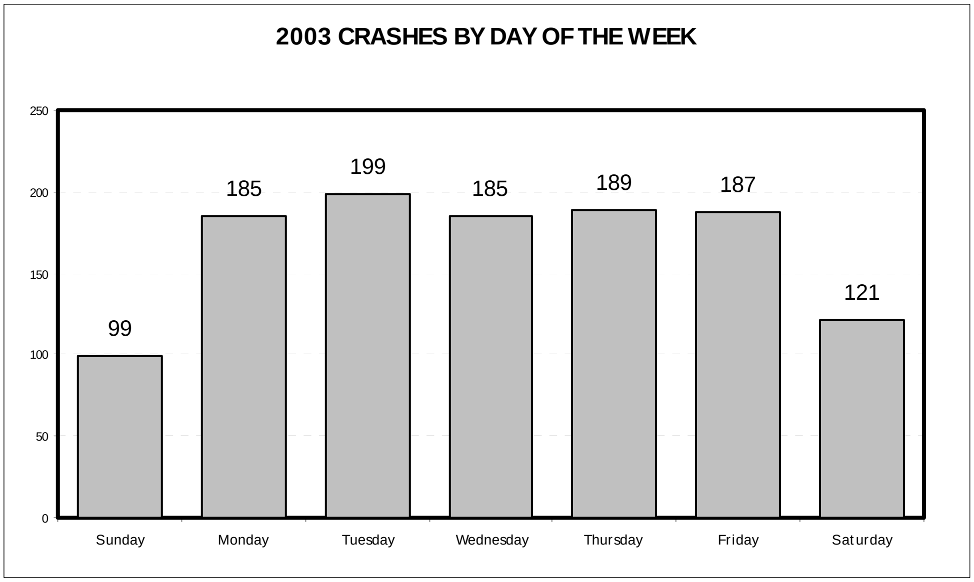


Figure 3

Possible explanations for this finding may be that most commuter trips occur during peak hour traffic, and as a result, create more vehicular exposure to the bicyclists. Recreational trips occurring on weekends are often at a time and place that permits riders to use much more discretion over the routes they choose, thus avoiding higher volume roadways and perhaps sticking to well-designed roadways and bikeways.

Crashes by Time of Day

Bicycle – vehicle crashes occurred most frequently between the afternoon/early evening hours of 2:00pm and 5:59pm (Table 2). This period encompasses both the weekday P.M. commute and the late afternoon hours in which bicycle use may be higher on weekends. The A.M commute period from 5:00a.m. to 10:00a.m. had a much lower percentage of crashes. This may be because of less bicycle use during these hours on weekends. It is interesting to note that a sizable percentage of crashes occurred from 6:00pm to 9:00pm. Further analysis may indicate if a large percentage of these crashes occurred at times throughout the year when it was dark during these hours.

Table 2

Time	Count	%
5:00am - 9:59am	143	12.86%
10:00am - 1:59pm	222	19.96%
2:00pm - 5:59pm	468	42.09%
6:00pm - 8:59pm	206	18.53%
9:00pm - 12:59am	66	5.94%
1:00am - 4:59am	7	0.63%

Crashes by Bicyclist Sex

In the State of Wisconsin, 68% of all bicycle travel in 2002 was completed by male riders and 32% by females.[3] The universe of bicycle crashes occurring in the State of Wisconsin in 2003 shows a much higher percentage of male bicyclists involved in crashes than female bicyclists (74% vs. 25%, see Table 3), but is comparable to the miles ridden by each sex.

Table 3

ALL		
Sex	**Count**	**%**
Male	857	73.56%
Female	293	25.15%
Unknown	15	1.29%
Total	1165	

Tables 4 and 5 look at the difference in percentage of crashes by sex between adults and children. Crashes involving children gravitated towards a more even split between male and female riders, whereas crashes involving adults experienced a slightly greater difference between the sexes. However, in all situations, male bicycle riders were involved in many more bicycle – vehicle related crashes than were female riders.

Table 4

UNDER 14		
Sex	**Count**	**%**
Male	287	70.86%
Female	118	29.14%
Total	405	

Table 5

14 AND OLDER		
Sex	**Count**	**%**
Male	506	75.86%
Female	161	24.14%
Total	667	

[3] 2002 National Household Travel Survey

Crashes by Age of Bicyclist

Almost half of the bicycle – vehicle crashes in the year 2003 involved riders between the ages of 10 and 19 (Table 6). Riders under the age of 30 accounted for 74% of the crashes and about 3% of crashes involved the elderly (60+).

Table 6

Age	Count	%
0-9 Years	128	12.02%
10-19 Years	529	49.67%
20-29 Years	132	12.39%
30-39 Years	86	8.08%
40-49 Years	106	9.95%
50-59 Years	53	4.98%
60-69 Years	20	1.88%
70+ Years	11	1.03%
Unknown	100	

Crash Frequency by County

The majority of bicycle – vehicle crashes in 2003 occurred in highly populated counties. Table 7 identifies the 25 counties with the highest number of crashes in 2003. Milwaukee County and Dane County clearly had many more crashes than any other county within the state. Milwaukee and Dane Counties are one and two in population, respectively, and bicycle and vehicle exposure rates may be a main reason for the high numbers of crashes that occurred in these two counties. Further analysis on exposure rates is included later in the report.

Table 7

County	Crashes	%
Milwaukee	259	22.23%
Dane	130	11.16%
Kenosha	73	6.27%
Winnebago	55	4.72%
Rock	49	4.21%
Racine	47	4.03%
Brown	45	3.86%
Outagamie	45	3.86%
La Crosse	41	3.52%
Waukesha	39	3.35%
Fond du Lac	34	2.92%
Sheboygan	29	2.49%
Washington	24	2.06%
Manitowoc	23	1.97%
Marathon	22	1.89%
Portage	21	1.80%
Wood	20	1.72%
Eau Claire	19	1.63%
Jefferson	18	1.55%
Walworth	12	1.03%
Sauk	11	0.94%
Ozaukee	11	0.94%
Barron	11	0.94%
Dodge	10	0.86%
Marinette	9	0.77%

More detailed analysis of Table 7 indicates that the total number of crashes per county tend to be proportionate to county population. The 12 counties with the highest number of crashes all contain at least one large urban area and are the 12 most populated counties in the state. The remaining 13 counties all decrease in population, but are either adjacent to large metropolitan areas or have a smaller urban area within the county. The one exception to this observation is Barron County, a predominantly rural county lacking a major urban area in or around it.

Crashes by City

Crashes that occurred in the ten most populated cities in Wisconsin account for 548 of the 1165 total crashes (47%). The crashes did not necessarily decrease proportionately as population decreased. Figure 4 displays the ten most populated cities from left to right, and shows several fluctuations in the relationship between city population and the number of crashes.

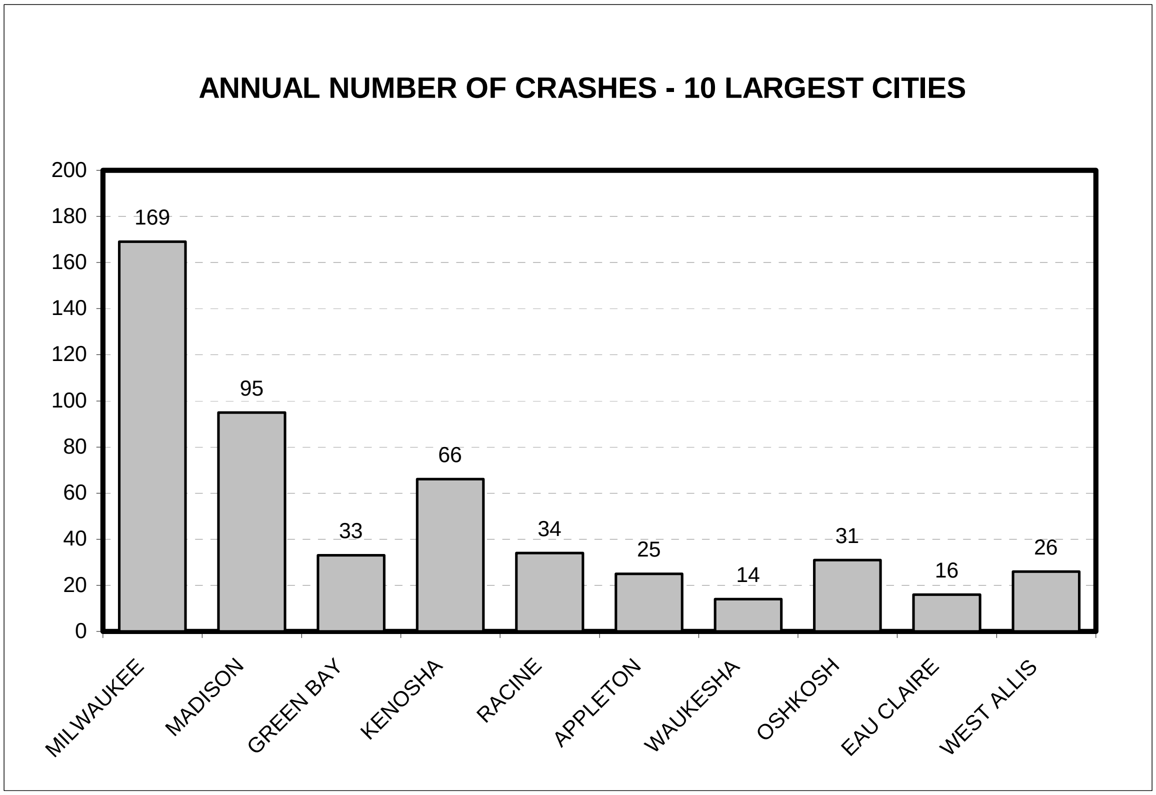


Figure 4

Further analysis of the crashes in these ten cities is included in Table 8. Table 8 identifies the average crash rate for each major city over the six-year study period. These crash rates indicate the average number of crashes occurring in each city, per 1,000 people. The crash rates were calculated by multiplying the six-year crash average by 1,000, and then dividing that number by the Census year 2000 population of the city.

Table 8

City	6 Year Crash Average	2000 Population	Crashes per 1,000 People
Kenosha	49.2	90,352	0.54
West Allis	31	61,254	0.51
Racine	41.2	81,855	0.50
Madison	100.5	208,054	0.48
Oshkosh	26.7	62,916	0.42
Appleton	25	70,087	0.36
Milwaukee	195.8	596,974	0.33
Green Bay	31.3	102,313	0.31
Eau Claire	16.3	61,704	0.26
Waukesha	14.3	64,825	0.22

The crash rates further indicate that bicycle – vehicle crashes are not dependent on population. Although Milwaukee has nearly double the average number of annual crashes compared to other cities, its crash rate is in the lower half of the 10 cities. Green Bay is the third largest city in the state, but its crash rate is relatively low. However, Madison, Kenosha and Racine - all larger cities - do have relatively high crash rates. The cities with the lowest crash rates are Waukesha and Eau Claire, seventh and ninth in total population respectively. West Allis is unique as a smaller city in this grouping, but with a high crash rate.

Location Characteristics

Crashes by Municipality Type

The MV4000 Report reports crashes as occurring in a city, a village, or a town. The distinction between the three is often difficult to decipher, but in most cases is as follows:

- "City" includes any urban area designated as a city no matter the population
- "Village" includes all urban areas designated as villages
- "Town" includes crashes occurring in predominately rural areas

However, some reports inaccurately record a city as a village, a village as a town, and so on. Table 9 includes the breakdown of crashes occurring in 2003, by municipality type as reported on the MV4000 reports.

Table 9

Municipality Type	Count	%
City	923	83.00%
Village	105	9.44%
Town	84	7.55%

As expected, a large majority of bicycle – vehicle crashes occurred in areas classified as cities. This once again points towards bicycle usage as being a major contributing factor in the number of crashes. Later analysis will look at bicycle usage and exposure to vehicles to determine if these numbers are proportionate to what should be expected.

Urban vs. Rural

The majority of bicycle – vehicle crashes in 2003 occurred in an urban setting. Table 10 shows the large disparity between urban and rural crashes for the year 2003 only.

Table 10

Location	Count	%
Urban	1041	93.62%
Rural	71	6.38%

The MV4000 Report contains two fields that contain urban and rural classifications and therefore, combining the two fields created a unique definition of both urban and rural. The first field, "URBRURAL", contains four different classifications, 1 through 4:

- 1: Rural – Town
- 2: Rural – Less than 5,000
- 3: Urban – Less than 5,000
- 4: Urban – Greater than 5,000

After examining crashes that fit into each category, it was possible to better define these classifications. Crashes classified as "Rural – Town" occurred in predominately rural areas, but a small number also occurred in very small towns with some urban characteristics (i.e. sidewalks, 25mph speed limit, etc…). Crashes classified as "Rural – Less than 5,000" occurred in cities and villages isolated from major urban areas. These crashes occurred in cities or villages such as Edgerton, Wisconsin or Wisconsin Dells, Wisconsin. Crashes classified as "Urban – Less than 5,000" occurred in small cities and villages within a larger urban area. These crashes occurred in cities or villages such as West Milwaukee, Wisconsin or Bayside, Wisconsin. Finally, crashes classified as "Urban – Greater than 5,000" occurred in any urban or metro area with more than 5,000 people.

The second urban/rural identifier included in the MV4000 Report is a field labeled "URBCLASS". This attribute contains two variables, URBAN and RURAL. This classification was not very accurate and often placed crashes labeled as urban in areas that appeared to be rural and vice versa. However, after combining the “URBRURAL” and “URBCLASS” fields, a reliable indicator of true rural crashes resulted by creating a query that identified crashes by a new unique field. The query identified seventy-one crashes as rural crashes and the remaining 1,041 crashes as urban crashes. A check of the all the crashes verified that the query was accurate, and bicycle – vehicle crashes occurring in areas with urban characteristics fell into the urban category.

Intersection vs. Non-Intersection

Table 11 shows where the crashes occurred on the roadway. More than twice the number

Table 11

Location	Count	%
Intersection	730	65.65%
Non-Intersection	356	32.01%
Unknown	26	2.34%

of crashes occurred at an intersection than at a non-intersection location. Intersections present many more conflict points between bicyclists and motorists and have more traffic controls. Further analysis of intersection related crashes is included later in the study.

Roadway Characteristics

Highway Type

Tables 12 and 13 represent the two different classifications of highway type where crashes occurred. Table 12 identifies a general description of roadways that the MV4000 Report uses. Officers at the scene of the crash use their judgment as to which classification the roadway is. Because the majority of crashes in 2003 occurred in an urban setting, “City Street Urban” and “State Highway Urban” comprise 85% of the crashes.

Table 12

Highway Type	Count	%
City Street Urban	797	71.67%
State Highway Urban	154	13.85%
City Street Rural	56	5.04%
State Highway Rural	51	4.59%
Town Road Rural	40	3.60%
County Trunk Rural	14	1.26%

These classifications are somewhat misleading. According to the data, zero crashes occurred on “County Trunk Urban” roadways even though several crashes did in fact occur on county trunk highways in an urban setting. This error occurred because officers can only choose one classification for the highway type, and in all cases, officers reported the crashes as occurring on a “city street.” Although the table indicates most crashes occurred on urban highways, the number of crashes assigned to rural highways is greater than it should be. This is because most crashes in the “City Street Rural” and “Town Road Rural” category actually occurred in an urban setting, according to the definition of urban used in this report. These crashes occurred in small urban areas isolated from any major metro region.

A better classification of the highway type where crashes occurred is included in Table 13. After geocoding the crashes, it was possible to join the crashes to the local roads data and assign the functional class of the roadway to each crash.

Table 13

Urban Functional Classification	Crashes	%
Urban		
Local Streets	294	30.10%
Collectors	133	13.60%
Minor Arterials	281	28.80%
Principal Arterials	267	27.30%
Expressways	2	0.30%
Total Urban	977	
Rural		
Local Roads	41	40.20%
Minor Collectors	10	9.80%
Major Collectors	22	21.60%
Minor Arterials	17	16.70%
Principal Arterials	11	10.80%
Expressway	1	0.90%
Total	102	

The functional class table shows that most crashes occurred on urban local roads, minor arterials or collectors. These classifications are similar to the “City Street Urban” and

"County Trunk Urban" classifications identified in the MV4000 Report. Once again, urban crashes represent the vast majority of crashes occurring in 2003.

Horizontal & Vertical Road Alignment

Tables 14 and 15 provide a general description of what the roadway alignment was where the crash occurred.

Table 14

Horizontal Characteristics	Count	%
Straight	1122	96.31%
Curve	41	3.52%
NA	2	0.17%

Table 15

Vertical Characteristics	Count	%
Level/Flat	959	82.32%
Hill	142	12.19%
NA	64	5.49%

The tables show that most crashes occurred on straight, flat roadways. There is however, a significant proportion of crashes that occurred while the bicyclist was riding up or down a hill. The horizontal and vertical road alignment was strikingly similar throughout the six-year study period. Given the small percentages for these two alignments, this could indicate the type of roadway may not play a large roll in bicycle – vehicle crashes.

Crash Conditions

Light Conditions

The majority of bicycle – vehicle crashes in 2003 occurred during daylight hours (Table 16). This corresponds with the finding that most bicycle usage occurs in warm weather months when daylight hours are much longer.

Table 16

Light Condition	Count	%
Daylight	930	83.63%
Dark/Lighted	120	10.79%
Dusk	38	3.42%
Dark/Unlit	17	1.53%
Dawn	4	0.36%
N/A	3	0.27%

Of the 1,112 crashes with light condition information, only 17 crashes occurred in a situation where no light was present. Further analysis of the light condition at the time of the crash may indicate if the angle of the sun was impairing the vision of either the bicyclist or the motorist.

Road Conditions

Road conditions can play an important factor in bicycle – vehicle crashes. Table 17 shows the road conditions of all 1,112 crashes occurring in 2003.

Table 17

Road Condition	Count	%
Dry	995	89.48%
Wet	73	6.56%
Snow/Slush	7	0.63%
Sand/Mud/Dirt/Oil	1	0.09%
Other	1	0.09%
N/A	35	3.15%

Almost 90% of crashes occurred on a dry roadway surface. A significant number of crashes, 6.5%, also occurred on wet roadways. Although the percent of crashes on wet roadways is much lower than crashes occurring on dry roadways, far less bicycle usage occurs when the roadway is wet most likely. Therefore, if that assumption is correct, the number of crashes occurring on wet roadways could actually be quite significant.

Vehicular Volume

After sorting bicycle – vehicle crashes by Average Daily Traffic (ADT) of the roadway where the crash occurred, it was evident that many crashes occurred on higher volume roadways (Table 18). More than 43% of all crashes occurred on roadways with an ADT greater than 2,000. Roadways with ADT values greater than 2,000 tend to be urban in nature. A large number of crashes also occurred on roadways with ADT values ranging from 101 to 1,000. These roadways are often located in small towns or subdivisions.

Table 18

ADT	Count	%
1-100	92	8.27%
101-1000	240	21.58%
1001-2000	64	5.76%
2001-10000	266	23.92%
Greater than 10000	217	19.51%
N/A	233	20.95%

Weather Conditions

Two out of every three bicycle – vehicle crashes occurred with clear skies and another 25% of crashes occurred with cloudy skies (Table 19). Very few crashes occurred (5%) when any sort of precipitation was falling. This corresponds with Table 17 above.

Table 19

Weather Condition	Count	%
Clear	750	67.45%
Cloudy	296	26.62%
Rain	49	4.41%
Snow	4	0.36%
Sleet/Hail	2	0.18%
Fog/Smog/Smoke	1	0.09%
N/A	10	0.90%

URBAN AND RURAL CRASHES

There are many differences between urban and rural crashes and this section highlights those differences. As mentioned earlier, bicycle use is also much more commonplace in urban areas than in rural areas. By examining urban and rural areas separately throughout the remainder of the study, many of these differences can be accounted for or at least analyzed as a more cohesive subgroup of all crash observations.

As previously mentioned, most bicycle – vehicle crashes occurred in an urban setting. In 2003, 1,041 crashes occurred in an urban setting and only 71 crashes occurred in a rural setting. The following analysis looks at different characteristics of urban and rural crashes. The urban crash data are characteristics of the 1,041 crashes occurring in 2003. Since the sample size of rural crashes in 2003 is minimal, the rural crash analysis includes rural crashes occurring in 2002, 2003 and 2004. The rural crash total of 208 includes the 71 crashes classified as rural in 2003, along with 69 crashes that occurred in 2002 and 68 crashes that occurred in 2004.

Of the 1,041 urban crashes, seven resulted in a fatality of the bicyclist. This computes to .67% of all urban crashes. On the other hand, 11 of the 208 rural crashes resulted in a fatality, 5.3% of all rural crashes. Therefore, bicycle – vehicle crashes occurring in a rural setting were almost eight times as likely to result in a fatality of the bicyclist than crashes occurring in an urban setting.

The disparities between the number and severity of crashes in urban and rural environments are significant. Following is an analysis of several factors that may contribute to these disparities.

Average Daily Traffic

An important factor relating to the number of crashes appears to be the average daily traffic (ADT) on the roadways where the crashes occurred. Figure 5 shows the large disparity in ADT between urban and rural crashes.

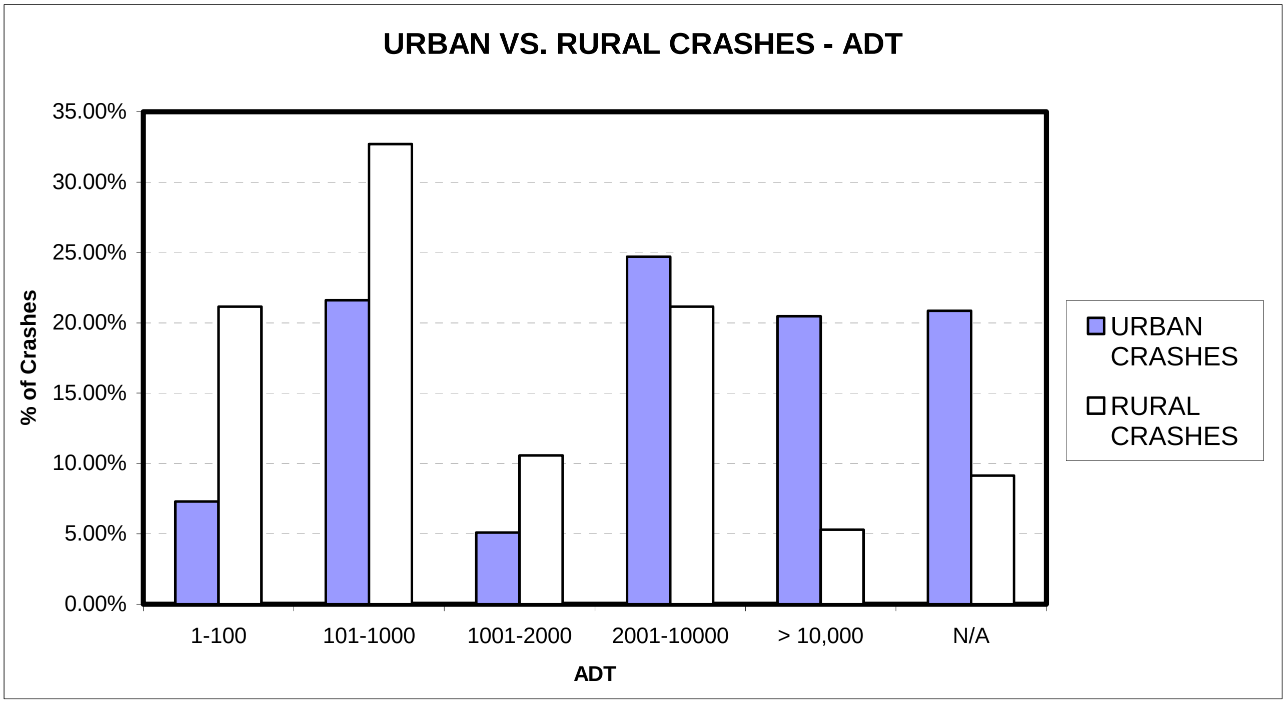


Figure 5

When compared to urban crashes, a high percentage of rural crashes occurred on roadways within low ADT ranges. Almost 55% of rural crashes occurred on roadways in the two lowest ADT ranges. In comparison, only 30% of urban crashes occurred on roadways within those two same ADT ranges. Once ADT increases above 2,000, the majority of crashes become urban crashes. Over 45% of urban crashes occurred on roadways with an ADT greater than 2,000 compared to only 26% of rural crashes occurring on roadways with the same ADT. The fatal crashes also occurred on roadways with a much higher ADT. The average ADT of fatal crashes in an urban setting was 6,201 and the average ADT of fatal crashes in a rural setting was 3,770.

Speed Limit

Another factor with a significant disparity between urban and rural crashes is the posted speed limit on the road where the crash occurred. Because of data limitations, the speed limit of the roadways could only be analyzed for crashes occurring on the State Trunk Network (STN). The Wisconsin Local Roads File (WISLR) does not have accurate speed limit information.

Figure 6 shows the large disparity in posted speeds for urban and rural crashes.

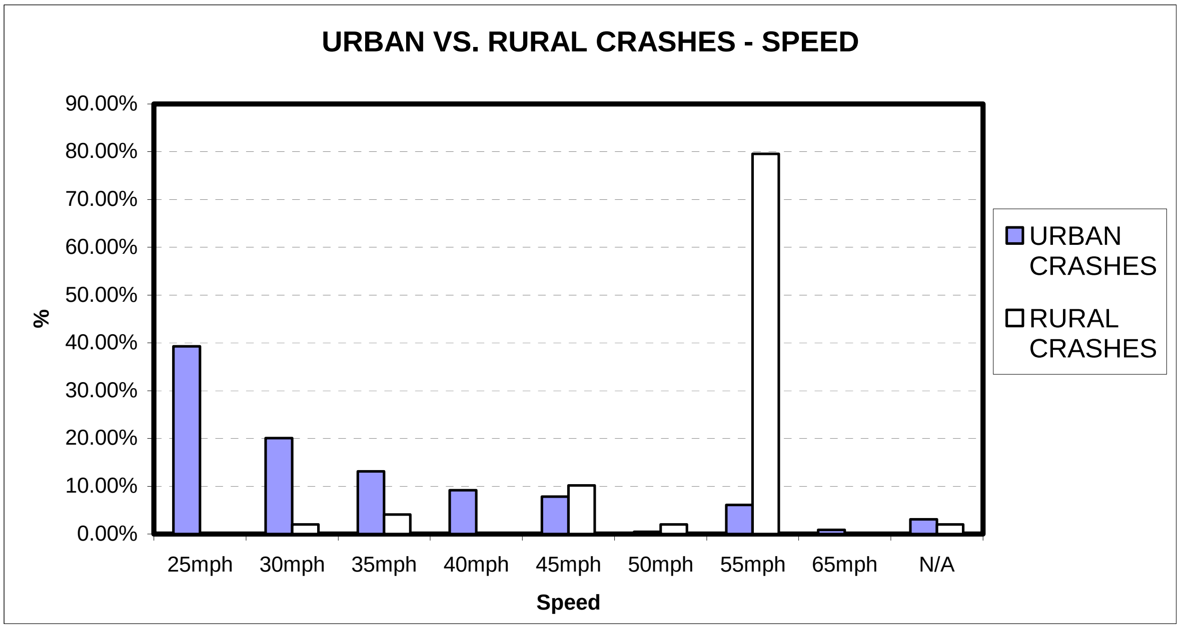


Figure 6

The difference in posted speed between urban and rural crashes is quite noticeable. Almost 75% of urban crashes occurred on roadways with a posted speed limit of 35 miles per hour or less. The large percentage of urban crashes occurring on lower speed roadways may explain the low percentage of urban fatal crashes. Crashes on low speed roadways are less likely to cause severe injury or death to the cyclist because of the lesser impact with the vehicle.

Rural crashes occurred on roadways with much higher speed limits. Almost 80% of rural crashes occurred with a 55-mile per hour speed limit in place and only 6% of the crashes occurred where the posted speed was lower than 45 miles per hour. These data may also explain why rural crashes are more likely to result in a fatality to the bicyclist. A large percentage of rural accidents occurred on high-speed roadways where impact with a vehicle will most likely result in a much more serious injury or even death.

Crash Characteristics

The following table identifies problem areas for each characteristic listed for all crashes. Urban and rural crashes are represented. Since there were so few rural crashes in 2003, additional crash observations were gathered for 2002 and 2004 increasing the universe to 285. The universe of 1,077 urban crashes in 2003 are used.

Table 20

Characteristic	Value	Urban		Rural	
Crash Time	5:00am - 9:59am	136	12.63%	42	14.74%
	10:00am - 1:59pm	215	19.96%	69	24.21%
	2:00pm - 5:59pm	457	42.43%	92	32.28%
	6:00pm - 8:59pm	197	18.29%	71	24.91%
	9:00pm - 12:59am	56	5.20%	9	3.16%
	1:00am - 4:59am	6	0.56%	1	0.35%
	N/A	10	0.93%	1	0.35%
Municipality Type	City	965	89.60%	0	0.00%
	Village	111	10.31%	0	0.00%
	Town	1	0.09%	285	100.00%
Light Condition	Daylight	898	83.38%	243	85.26%
	Dark/Unlit	12	1.11%	20	7.02%
	Dark/Lighted	121	11.23%	5	1.75%
	Dawn	4	0.37%	2	0.70%
	Dusk	39	3.62%	13	4.56%
	N/A	3	0.28%	2	0.70%
Weather Condition	Clear	719	66.76%	207	72.63%
	Cloudy	291	27.02%	65	22.81%
	Rain	50	4.64%	9	3.16%
	Snow	4	0.37%	1	0.35%
	Fog/Smog/Smoke	1	0.09%	1	0.35%
	Sleet/Hail	2	0.19%	0	0.00%
	N/A	10	0.93%	2	0.70%
Road Condition	Dry	961	89.23%	261	91.58%
	Wet	71	6.59%	18	6.32%
	Snow/Slush	9	0.84%	1	0.35%
	Ice	0	0.00%	0	0.00%
	Sand/Mud/Dirt/Oil	1	0.09%	1	0.35%
	Other	1	0.09%	0	0.00%

	N/A	34	3.16%	4	1.40%
Horizontal Road Characteristics	Straight	1044	96.94%	264	92.63%
	Curve	31	2.88%	21	7.37%
	N/A	2	0.19%	0	0.00%
Vertical Road Characteristics	Level/Flat	889	82.54%	210	73.68%
	Hill	125	11.61%	67	23.51%
	N/A	63	5.85%	8	2.81%
Alcohol Flag	Yes	45	4.18%	13	4.56%
	No	1032	95.82%	272	95.44%
Drug Flag	Yes	1	0.09%	1	0.35%
	No	1076	99.91%	284	99.65%
Type of Vehicle	Truck	137	12.72%	64	22.46%
	Auto	912	84.68%	209	73.33%
	Motorcycle	8	0.74%	7	2.46%
	Moped	2	0.19%	0	0.00%
	Bus	3	0.28%	1	0.35%
	N/A	15	1.39%	4	1.40%

CRASH RATES

Types of Crash Rates

Identifying the number of crashes occurring during a specific timeframe for a given geographic area is just a single step in analyzing the seriousness of a crash problem. To help compare the problem from one geographic area to another, having a crash rate is often very beneficial. The most rudimentary of all crash rates is to relate all bike crashes to total population. The most significant limitation with this rate is that if taken at face value, it is only accurate if the same percentages of people are participating in bicycling at the same rate. The most involved, and arguably the best rate, is one that relates crashes to the total exposure of bicyclists. For a fairly complete observation of exposure, total bicycle usage would have to be compared to total motorist use at the time those bicyclists were using the roadway. As good as this rate is, it also has its limitations since the degree of real exposure is widely suspected to vary based on how close motorists are in relation to cyclists and the speed differential of specific roadways. In addition, to measure true exposure of cyclists, both parallel movements *and* crossing movements of bicyclists and motorists need to be considered. This gets at the importance of also measuring exposure at intersections and driveways.

Provided below are analyses of an assortment of crash rates for the state and selected geographic sub-areas. The rates provided do not give the truest measure of exposure, but aim to provide basic rates for comparison. As much as it would be advantageous to have the best crash rate based on the most complete look at exposure - based on street-by-street and intersection-by-intersection data - it is not possible. However, gross exposure rates are provided that look at crashes in relation to total bicycle miles traveled (BMT) and total motor vehicle miles traveled (VMT). First, the most basic crash rates will be summarized.

Crash Rate based on Population

The bicycle crash rate per 1,000 Wisconsin residents was .212 in 2003, or it can be expressed as one bicycle crash for approximately every 5,000 residents. Since the number of bicycle crashes has been declining over the past 30 years while the number of residents is increasing, the bicycle crash rate, based on population, has continued to decline.

Crash rates vary from one community to another. Ten of the state's largest cities were analyzed using 2003 crash data. Not surprisingly, all ten cities experienced a crash rate higher than the overall state crash rate. In part, this is because more cycling occurs in the urban areas of the state compared to the state taken as an average. Only the City of Waukesha was remotely close to the statewide rate, while Kenosha had the highest crash rate. Madison, Racine, Oshkosh, and West Allis all experienced a comparable crash rate. Table 8 is provided in the first section of this report.

Crash Rates by Miles of Roadway

There are 113,698 total miles of city, village, county, town and state roadways in Wisconsin. Using 2003 bicycle crash data, the resulting state crash rate (crashes/total miles of roadway) was 9.78 crashes per thousand miles of roadway. There are far more miles of roadway located in rural areas than in urban areas. Theoretically, the more roadway miles there are in a given area, the greater the potential there is for crashes simply based on an expanded environment where these crashes can occur. However, when evaluating the crash data, the inverse held true – for urban areas, there were 47 crashes per 1,000 miles of roadway, while just less than one crash occurred per 1,000 miles of rural roadway. Crashes are more likely to occur where people reside and ride their bikes, and there is significantly more bicycling occurring in urban areas. This is supported by various data. The huge variation in the number and rate of urban vs. rural crashes is especially revealing when compared to roadway mileage. This was one reason why this study analyzed urban and rural crashes separately in more depth.

Crash Rates by Vehicle Miles of Travel

Urban areas are busier with more motorist travel within their boundaries. Rather then relate bicycle crashes to just miles of roadway with its limitations noted above, a comparison was made that looked at the amount of motorist travel in urban and rural areas. The simple premise behind this comparison stems from the association between these two modes – they both must be present in order to have the potential for a crash between them. In general, the more vehicle traffic the higher the potential for a crash.

Collectively for all roadways within the state, just over 60 billion miles of motorist travel occurred and there were .018 bicycle crashes per one million miles of motorist travel. For urban areas, the crash rate is .0323 bicycle crashes per million miles of travel, while the rate drops to .002 bicycle crashes per million miles for rural areas (Table 21). Clearly, when looking at urban and rural areas, there is a stronger positive relationship between crashes based on motorist miles traveled then there are between crashes and miles of roadway. The association is still much, much stronger in urban areas then it is for rural areas.

Table 21

Location	VMT	# Of Crashes	Crash Rate (In Millions)
Urban	32,250,000,000	1041	0.032
Rural	28,148,000,000	71	0.002
Statewide	60,398,000,000	1112	0.018

Crash Rates by Bicycle Miles Traveled and Average Rates

An additional way to examine crash rates is by relating crashes to bicycle miles traveled (BMT) instead of vehicle miles traveled. For the same number of bicycle – vehicle crashes, the more bicycling occurring in an area the lower the crash rate will be. For example, consider a high bicycle use city like Madison. When comparing the two crash rates of Madison with other cities – one based on vehicle miles traveled and one based on bicycle miles traveled - the crash rate per mile of bicycle travel will be lower since bicycle use is relatively high.

Data for bicycle miles traveled were obtained from the National Household Travel Survey (NHTS). Wisconsin purchased tens of thousands of additional surveys to provide statistically reliable sample sizes for most of the state's metropolitan areas and several counties. Not all metropolitan areas or counties are included in each table however; because the sample size of surveys returned must be at least 30 in order to obtain statistically significant results. Table 22 presents urban and rural crashes by BMT for the year 2003. Overall, the state crash rate based on BMT is 6.26 crashes per one million miles of biking.

Table 22

Location	BMT	# Of Crashes	Crash Rate
Urban	128,520,000	1041	8.1
Rural	49,094,000	71	1.45
Statewide	177,614,005	1112	6.26

In 2003, there were 71 rural bike crashes in Wisconsin, or 1.45 crashes per 1 million miles of bicycle travel in rural areas. For urban bike crashes, the rate was 8.1 crashes per million miles of BMT.

To achieve a more complete picture of exposure, crash rates by BMT were considered at the same time as the rate based on VMT was. A means of accounting for both BMT and VMT and providing a single average rate can be a valuable exercise for comparing places within the state, but the rates are vastly different. Table 23 provides these average rates after each set of rates were given equal weights and adjusted. This was necessary because of the high disparity in the rates. The two rates were then averaged to provide one rate (the VMT rate was adjusted up to the BMT rate). As the table shows, the gap between urban and rural crash rates continues to be significant as the average rate for urban crashes is eight times the rate for rural crashes.

Table 23

Location	BMT Crash Rate (In Millions)	VMT Crash Rate (In Millions)	Average Crash Rate*
Urban	8.1	0.032	9.6
Rural	1.45	0.002	1.1
Statewide	6.26	0.018	5.3

*Average of the two rates after adjustment

Crash Rates for Major Counties and Cities

Crash rates based on VMT were also determined for counties and cities. Table 24 expresses the crash rates by select counties within Wisconsin. The rates range from .019 crashes per million miles of VMT in Marathon County and .023 for Eau Claire County, to a high of .052 crashes per million VMT for La Crosse County and .047 for Milwaukee County. With the exception of these 4 counties, all other counties that were studied ranged between .025 crashes per million VMT to .044 crashes per million VMT.

Table 24

County	BMT	# Of Crashes	BMT Crash Rate	VMT*	VMT Crash Rate	Average Rate**
BROWN	8,240,000	44	5.34	1,728,700,000	0.025	5.47
DANE	33,657,000	128	3.8	3,286,625,000	0.039	6.28
EAU CLAIRE	1,847,000	18	9.75	765,189,000	0.023	7.46
LA CROSSE	4,320,000	40	9.26	771,929,000	0.052	10.90
MARATHON	3,904,000	22	5.64	1,160,576,000	0.019	4.95
MILWAUKEE	23,390,000	251	10.73	5,349,378,000	0.047	15.61
OUTAGAMIE	6,709,000	41	6.11	1,318,223,000	0.031	6.54
PORTAGE	1,490,000	21	14.09	590,647,000	0.035	10.98
ROCK	5,001,000	45	9	1,187,174,000	0.037	8.66
SHEBOYGAN	3,447,000	28	8.12	771,192,000	0.036	8.11
WINNEBAGO	6,264,000	52	8.3	1,181,841,000	0.044	9.10
WOOD	4,772,000	20	4.19	695,400,000	0.028	5.24

*Total VMT Minus Interstate VMT in millions

**For Comparison with Other Identified Counties Only

County crash rates based on BMT ranged from a low of 3.8 for Dane County to a high of 14.1 for Portage County. When compared to the other counties that were studied, both of these counties experienced a significant change in crash rates compared to rates based on VMT. Both counties were in the mid-range of counties when crashes were related to VMT, but went in opposite directions when BMT was considered. Brown, Marathon, and Wood Counties remained consistently low among both indices.

Crash rates for cities ranged from a low of .020 per million miles of VMT in the City of Eau Claire to .060 per million miles of VMT in the City of Sheboygan (Table 25). All of the city rates except Green Bay are higher than the statewide average. The highest rates are substantially higher than the statewide averages and for those of the corresponding counties.

Table 25

City	# Of Crashes	VMT	VMT Crash Rate (In Millions)	BMT	BMT Crash Rate (In Millions)	Average Rate
Appleton	25	1,152,797,000	0.022	6,085,000	4.11	3.83
Eau Claire	16	817,923,000	0.020	1,878,000	8.52	5.87
Green Bay	33	1,834,788,000	0.018	5,681,000	5.81	4.36
Janesville	24	738,110,000	0.033	4,325,000	5.55	5.44
La Crosse	30	550,641,000	0.055	3,020,000	9.93	9.40
Madison	95	2,358,275,000	0.040	27,369,000	3.47	4.96
Sheboygan	27	448,969,000	0.060	2,495,000	10.82	10.25
Stevens Point	16	377,777,000	0.042	1,146,000	13.96	10.37
Wausau	13	476,998,000	0.027	2,157,000	6.03	5.19

*Total VMT Minus Interstate VMT

**For Comparison with Other Identified Cities Only

The City of Madison achieved the lowest crash rate based on BMT at 3.47 crashes per million BMT while Stevens Point was on the other end of the spectrum at 13.96 crashes per million BMT. La Crosse, Sheboygan and Eau Claire all had relatively high rates with 9.93 per million BMT, 10.82 per million BMT and 8.52 per million BMT respectively. Madison went from a moderately high crash rate based on VMT alone to the lowest crash rate based on BMT. This is because of its extraordinarily high amount of BMT for the city. This reversal in rates illustrates the importance of using a variety of crash rates to describe conditions and to realize that all crash rates have inherent limitations that can overstate or understate crash conditions.

As explained in the previous section, in an attempt to meld the two crash rates together to get a more complete sense of exposure, the VMT and BMT crash rates were given an average value. When comparing the average rates of the 12 counties, the range in values is noteworthy. Milwaukee County had an average rate of 31.22 compared to Marathon County with a rate of 9.91. Brown and Wood Counties, with relatively low rates for both VMT and BMT, understandably also had low average rates. Dane County had a high VMT rate, but because of a low BMT rate, the average rate ended up being very low.

As for the cities that were examined, Green Bay and Appleton had the lowest average rates. A group of four cities - Eau Claire, Janesville, Madison and Wausau - were just slightly higher. Three of these cities had moderate rates for both BMT and VMT, but Madison was somewhat unusual in this group since its two rates had a significant variation.

Bicycle miles traveled are very high for Madison and when taken into account, have more than a neutralizing effect on a moderately high VMT rate for the city. By offering and examining a variety of crash rates, there is a greater understanding of the dynamics taking place that may affect crashes in different places in the state. On the surface, a city or county may be singled out because of the relatively high number of bicycle – vehicle crashes, but as more information becomes available on BMT there is a better understanding of what is happening, taking Madison as an example. Other studies have argued that the presence of high BMT within a community in and of itself may have a reduction effect on crashes because of the constant awareness on the part of motorists that bicyclists are present.

Bicyclist Crash Rates Compared to Overall Crash Rates

The public often wants to know how safe bicycling is when compared to other forms of travel. Additionally, this knowledge can be helpful when making decisions regarding the in which geographic location crash rates are highest or lowest. The intent of this section is not to provide a definitive answer to questions on relative safety, but to provide rather simple statewide measures of crash rates that are comparable to motor vehicle crash rates.

There were 1,112 reported bicycle – vehicle crashes in 2003. Based on the 177 million BMT, there were 6.3 crashes per million BMT. This compares to 2.9 vehicle crashes per million VMT. The reader will again be reminded that the comparison is between *reported* crashes for both bicycle and motor vehicle crashes. Both crash types are under-reported, but bicycle – vehicle crashes are believed to be much more under-reported than vehicle – vehicle crashes. Different rates of reporting will affect a true comparison.

Another comparison can be made of the crashes resulting in an injury. In this case, the number of unreported bicycle – vehicle crashes is believed to be less. Of the 1,112 reported bicycle – vehicle crashes, 95% resulted in injury. Only 30.0% of the 131,191 vehicle – vehicle crashes resulted in an injury. The crash rates reflect this with 6.4 bike crashes per million BMT resulting in injury compared to just .9 injury crashes for vehicle – vehicle crashes per million VMT.

Comparing fatal crash rates is yet another way to consider differences in rates. In 2003, there were 12 fatal bicycle crashes or .07 per million BMT (incidentally, there was an average of 11 fatalities per year over a five year period including 2003, so using the 2003 data reasonably reflects fatal crashes). This compares to .02 per million for total VMT. The crash rate for rural areas was .102 per million miles of bicycle travel compared to .054 for urban areas. This illustrates how much more likely it is for a rural crash to be fatal, despite having a much lower overall incidence of crashes. High speeds are certainly a factor that is involved in the seriousness of rural crashes.

Crash Rates by Highway Class

Crash rates per 1,000 miles of roadway are much higher along city streets and urban state highways then they are for town roads and county trunk highways. This is because, as Table 26 shows, urban roadways contain far less total mileage than rural roadways, yet have much higher volumes of traffic – both bicycle and motor vehicle. Crashes on rural state highways occur much more commonly then they do on town and county roads, but the rate is just 1/8th of what it is for city streets. The data below also show that although “town road rural” roadways comprise the greatest number of roadway miles, the second lowest number of crashes occur on these roadways.

Table 26

Highway Class	# Of Crashes	Miles of Roadway	Crash Rate
City Street Urban	853	20,041	42.56
Town Road Rural	40	61,941	0.65
Co. Trunk Rural	14	18,102	0.77
STH Urban	154	1,849	83.29
STH Rural	51	9,220	5.53

CRASH TYPING

Crash Typing Procedure

Identifying crash types for every bicycle – vehicle crash was essential for this study. Once each crash was assigned a crash type, further analysis was completed on the most common crash types. Countermeasures can be used to reduce these crashes.

The Pedestrian and Bicycle Crash Analysis Tool (PBCAT), developed by the North Carolina Highway Safety Research Center (NCHSRC) and the Federal Highway Administration (FHWA), allowed WisDOT officials to assign each bicycle – vehicle crash a unique crash type. Analysts used crash diagrams and crash write-ups from the MV4000 Reports to enter the information into the PBCAT. The PBCAT asks a series of questions regarding the crash circumstances to develop a unique crash type based on crash typing procedure developed by Cross and Fisher in 1977. The crash types appear as 3-digit numbers but have corresponding descriptions for each number. For example, crash type 141 is defined as “Motorist Drive Out – Sign Control”. Crash types are then recorded, along with a unique crash identification number, in spreadsheet format. Once the crash typing was complete, the crashes and their crash types were joined with the crashes and their roadway characteristics based on the unique crash ID number.

Crash typing has proven valuable in identifying common crash characteristics and common crash locations. The following analysis will look at these crash types in a general overview of all crashes and as in-depth analysis of the most common crash types. By identifying problem areas and problem crash types, countermeasures such as education, enforcement, and design can be included in future bicycle plans and projects.

Crash Types – 2003 Bicycle–Vehicle Crashes

Table 27 lists the crash type of each crash that occurred in 2003 and is sorted by crash type number. It is evident in the table that the PBCAT has a few broad categories of crash types (Ride-Out, Drive-Out, Overtaking, etc…) and then separates the broad crash types into more detailed crash types by who is at fault and where the crashes occurred.

Table 27

Crash Type	Description	Count	% Of Crashes
111	Motorist Turning Error - Left Turn	16	1.44%
112	Motorist Turning Error - Right Turn	29	2.61%
113	Motorist Turning Error - Other	3	0.27%
114	Bicyclist Turning Error - Left	9	0.81%
115	Bicyclist Turning Error - Right	4	0.36%
121	Bicyclist Lost Control - Mechanical Problems	20	1.80%
122	Bicyclist Lost Control - Oversteering/Improper Braking	3	0.27%
123	Bicyclist Lost Control - Alcohol/Drug Impairment	3	0.27%
124	Bicyclist Lost Control - Surface Conditions	4	0.36%
129	Bicyclist Lost Control - Other/Unknown Circumstances	7	0.63%
134	Motorist Lost Control - Surface Conditions	1	0.09%
139	Motorist Lost Control - Other/Unknown	2	0.18%
141	Motorist Drive-Out - Sign Control	159	14.30%
142	Bicyclist Drive-Out - Sign Control	46	4.14%
143	Motorist Drive-Through - Sign Control	11	0.99%
144	Bicyclist Ride-Through - Sign Control	79	7.10%
147	Multiple Threat - Sign-Controlled Intersection	4	0.36%
148	Sign Control Intersection - Other	5	0.45%
151	Motorist Drive-Out - Right Turn on Red	60	5.40%
152	Motorist Drive-Out - Signal Control Intersection	11	0.99%
153	Bicyclist Ride-Out - Signal Control	14	1.26%
154	Motorist Drive-Through - Signal Control	8	0.72%
155	Bicyclist Ride-Through - Signal Control	41	3.69%
156	Bicyclist Failed to Clear - Trapped	16	1.44%
157	Bicyclist Failed to Clear - Multiple Threat	4	0.36%
160	Uncontrolled Intersection	36	3.24%
180	Crossing Path - Intersection Other	6	0.54%
211	Motorist Left Turn - Same Direction	18	1.62%
212	Motorist Left Turn - Opposite Direction	68	6.12%
213	Motorist Right Turn - Same Direction	28	2.52%
214	Motorist Right Turn - Opposite Direction	16	1.44%
217	Motorist Right Turn on Red - Same Direction	1	0.09%
218	Motorist Turn - Other	1	0.09%
221	Bicyclist Left Turn - Same Direction	24	2.16%
222	Bicyclist Left Turn - Opposite Direction	7	0.63%
223	Bicyclist Right Turn - Same Direction	3	0.27%
224	Bicyclist Right Turn - Opposite Direction	3	0.27%
225	Bicyclist Ride-Out - Sidewalk	24	2.16%
231	Motorist Overtaking - Undetected Bicyclist	9	0.81%
232	Motorist Overtaking - Misjudged Space	39	3.51%
235	Motorist Overtaking - Bicyclist Swerved	8	0.72%
239	Motorist Overtaking - Other/Unknown	2	0.18%
241	Bicyclist Overtaking - Right Side	2	0.18%
242	Bicyclist Overtaking - Left Side	5	0.45%
243	Bicyclist Overtaking - Parked Vehicle	6	0.54%

244	Bicyclist Overtaking - Extended Door	4	0.36%
249	Bicyclist Overtaking - Other/Unknown	1	0.09%
250	Head-On - Bicyclist	16	1.44%
255	Head-On - Motorist	3	0.27%
280	Parallel Path - Other	3	0.27%
311	Bicyclist Ride-Out - Residential Driveway	25	2.25%
312	Bicyclist Ride-Out - Commercial Driveway/Alley	35	3.15%
318	Bicyclist Ride-Out - Non-Intersection Other	16	1.44%
319	Bicyclist Ride-Out - Non-Intersection Unknown	12	1.08%
321	Motorist Ride-Out - Residential Driveway	13	1.17%
322	Motorist Ride-Out - Commercial Driveway/Alley	56	5.04%
328	Motorist Ride-Out - Non-Intersection Other	2	0.18%
329	Motorist Ride-Out - Non-Intersection Unknown	1	0.09%
357	Multiple Threat - Midblock	7	0.63%
380	Crossing Path - Non-Intersection Other	1	0.09%
510	Motorist Intentionally Caused	3	0.27%
600	Backing Vehicle	11	0.99%
700	Play Vehicle Related	4	0.36%
800	Unusual Circumstances	6	0.54%
910	Non-Roadway - Other	2	0.18%
990	Unknown/Insufficient Information	26	2.34%
TOTAL		1112	

Table 28 contains the same data but is sorted by frequency of crash type instead of crash type number.

Table 28

Crash Type	Description	Count	% Of Crashes
141	Motorist Drive-Out - Sign Control	159	14.30%
144	Bicyclist Ride-Through - Sign Control	79	7.10%
212	Motorist Left Turn - Opposite Direction	68	6.12%
151	Motorist Drive-Out - Right Turn on Red	60	5.40%
322	Motorist Ride-Out - Commercial Driveway/Alley	56	5.04%
142	Bicyclist Drive-Out - Sign Control	46	4.14%
155	Bicyclist Ride-Through - Signal Control	41	3.69%
232	Motorist Overtaking - Misjudged Space	39	3.51%
160	Uncontrolled Intersection	36	3.24%
312	Bicyclist Ride-Out - Commercial Driveway/Alley	35	3.15%
112	Motorist Turning Error - Right Turn	29	2.61%
213	Motorist Right Turn - Same Direction	28	2.52%
990	Unknown/Insufficient Information	26	2.34%
311	Bicyclist Ride-Out - Residential Driveway	25	2.25%
221	Bicyclist Left Turn - Same Direction	24	2.16%
225	Bicyclist Ride-Out - Sidewalk	24	2.16%
121	Bicyclist Lost Control - Mechanical Problems	20	1.80%
211	Motorist Left Turn - Same Direction	18	1.62%
111	Motorist Turning Error - Left Turn	16	1.44%
156	Bicyclist Failed to Clear - Trapped	16	1.44%
214	Motorist Right Turn - Opposite Direction	16	1.44%
250	Head-On - Bicyclist	16	1.44%
318	Bicyclist Ride-Out - Non-Intersection Other	16	1.44%
153	Bicyclist Ride-Out - Signal Control	14	1.26%
321	Motorist Ride-Out - Residential Driveway	13	1.17%
319	Bicyclist Ride-Out - Non-Intersection Unknown	12	1.08%
143	Motorist Drive-Through - Sign Control	11	0.99%
152	Motorist Drive-Out - Signal Control Intersection	11	0.99%
600	Backing Vehicle	11	0.99%
114	Bicyclist Turning Error - Left	9	0.81%
231	Motorist Overtaking - Undetected Bicyclist	9	0.81%
154	Motorist Drive-Through - Signal Control	8	0.72%
235	Motorist Overtaking - Bicyclist Swerved	8	0.72%
129	Bicyclist Lost Control - Other/Unknown Circumstances	7	0.63%
222	Bicyclist Left Turn - Opposite Direction	7	0.63%
357	Multiple Threat - Midblock	7	0.63%
180	Crossing Path - Intersection Other	6	0.54%
243	Bicyclist Overtaking - Parked Vehicle	6	0.54%
800	Unusual Circumstances	6	0.54%
148	Sign Control Intersection - Other	5	0.45%
242	Bicyclist Overtaking - Left Side	5	0.45%

115	Bicyclist Turning Error - Right	4	0.36%
124	Bicyclist Lost Control - Surface Conditions	4	0.36%
147	Multiple Threat - Sign-Controlled Intersection	4	0.36%
157	Bicyclist Failed to Clear - Multiple Threat	4	0.36%
244	Bicyclist Overtaking - Extended Door	4	0.36%
700	Play Vehicle Related	4	0.36%
113	Motorist Turning Error - Other	3	0.27%
122	Bicyclist Lost Control - Oversteering/Improper Braking	3	0.27%
123	Bicyclist Lost Control - Alcohol/Drug Impairment	3	0.27%
223	Bicyclist Right Turn - Same Direction	3	0.27%
224	Bicyclist Right Turn - Opposite Direction	3	0.27%
255	Head-On - Motorist	3	0.27%
280	Parallel Path - Other	3	0.27%
510	Motorist Intentionally Caused	3	0.27%
139	Motorist Lost Control - Other/Unknown	2	0.18%
239	Motorist Overtaking - Other/Unknown	2	0.18%
241	Bicyclist Overtaking - Right Side	2	0.18%
328	Motorist Ride-Out - Non-Intersection Other	2	0.18%
910	Non-Roadway - Other	2	0.18%
134	Motorist Lost Control - Surface Conditions	1	0.09%
217	Motorist Right Turn on Red - Same Direction	1	0.09%
218	Motorist Turn - Other	1	0.09%
249	Bicyclist Overtaking - Other/Unknown	1	0.09%
329	Motorist Ride-Out - Non-Intersection Unknown	1	0.09%
380	Crossing Path - Non-Intersection Other	1	0.09%
TOTAL		1112	

This table shows that crash type 141 – Motorist Drive Out – Sign Control, was the most common crash type in 2003. This crash type occurred almost twice as frequently as the next most common crash type, 144 – Bicyclist Ride Through – Sign Control. It is also of interest to note that four out of the top five crashes resulted from a critical error on behalf of the motorists. Of the 1,112 crashes, the operator making what is believed to be the critical error was known in 1,012 crashes. Five hundred and seventy nine (579) of the 1,012 crashes (57.2%) resulted from an error on the motorist's behalf and 433 of the 1,012 crashes (42.8%) resulted from an error on the bicyclist's behalf. It is important to note that the crash typing procedure is not a devise to assign fault for crashes, however it does provide a window as to which operator made the critical error that likely led to the crash. Each crash had different circumstances and it is impossible to know if other factors besides what the MV4000 Report and diagram reports caused the crash.

Crash Types – Urban Crashes

The distribution of crash types of urban bicycle – vehicle crashes is very similar to all crashes in 2003. This is because 1,041 of the 1,112 crashes occurring in 2003 were urban crashes. The five most common crash types are the same as well. Table 29 shows urban crashes by frequency.

Table 29

Crash Type	Description	Count	% Of Crashes
141	Motorist Drive-Out - Sign Control	152	14.60%
144	Bicyclist Ride-Through - Sign Control	77	7.40%
212	Motorist Left Turn - Opposite Direction	65	6.24%
151	Motorist Drive-Out - Right Turn on Red	59	5.67%
322	Motorist Ride-Out - Commercial Driveway/Alley	56	5.38%
142	Bicyclist Drive-Out - Sign Control	45	4.32%
155	Bicyclist Ride-Through - Signal Control	41	3.94%
160	Uncontrolled Intersection	36	3.46%
312	Bicyclist Ride-Out - Commercial Driveway/Alley	34	3.27%
112	Motorist Turning Error - Right Turn	29	2.79%
232	Motorist Overtaking - Misjudged Space	29	2.79%
213	Motorist Right Turn - Same Direction	27	2.59%
990	Unknown/Insufficient Information	26	2.50%
225	Bicyclist Ride-Out - Sidewalk	24	2.31%
311	Bicyclist Ride-Out - Residential Driveway	23	2.21%
121	Bicyclist Lost Control - Mechanical Problems	18	1.73%
221	Bicyclist Left Turn - Same Direction	18	1.73%
211	Motorist Left Turn - Same Direction	17	1.63%
156	Bicyclist Failed to Clear - Trapped	16	1.54%
214	Motorist Right Turn - Opposite Direction	15	1.44%
111	Motorist Turning Error - Left Turn	14	1.34%
153	Bicyclist Ride-Out - Signal Control	14	1.34%
318	Bicyclist Ride-Out - Non-Intersection Other	12	1.15%
319	Bicyclist Ride-Out - Non-Intersection Unknown	12	1.15%
143	Motorist Drive-Through - Sign Control	11	1.06%
152	Motorist Drive-Out - Signal Control Intersection	11	1.06%
250	Head-On - Bicyclist	11	1.06%
321	Motorist Ride-Out - Residential Driveway	11	1.06%
600	Backing Vehicle	11	1.06%
114	Bicyclist Turning Error - Left	8	0.77%
154	Motorist Drive-Through - Signal Control	8	0.77%
222	Bicyclist Left Turn - Opposite Direction	7	0.67%
357	Multiple Threat - Midblock	7	0.67%
129	Bicyclist Lost Control - Other/Unknown Circumstances	6	0.58%
180	Crossing Path - Intersection Other	6	0.58%
148	Sign Control Intersection - Other	5	0.48%
231	Motorist Overtaking - Undetected Bicyclist	5	0.48%

235	Motorist Overtaking - Bicyclist Swerved	5	0.48%
242	Bicyclist Overtaking - Left Side	5	0.48%
243	Bicyclist Overtaking - Parked Vehicle	6	0.58%
800	Unusual Circumstances	5	0.48%
124	Bicyclist Lost Control - Surface Conditions	4	0.38%
244	Bicyclist Overtaking - Extended Door	4	0.38%
113	Motorist Turning Error - Other	3	0.29%
115	Bicyclist Turning Error - Right	3	0.29%
122	Bicyclist Lost Control - Oversteering/Improper Braking	3	0.29%
123	Bicyclist Lost Control - Alcohol/Drug Impairment	3	0.29%
147	Multiple Threat - Sign-Controlled Intersection	3	0.29%
157	Bicyclist Failed to Clear - Multiple Threat	3	0.29%
224	Bicyclist Right Turn - Opposite Direction	3	0.29%
510	Motorist Intentionally Caused	3	0.29%
700	Play Vehicle Related	3	0.29%
139	Motorist Lost Control - Other/Unknown	2	0.19%
223	Bicyclist Right Turn - Same Direction	2	0.19%
241	Bicyclist Overtaking - Right Side	2	0.19%
255	Head-On - Motorist	2	0.19%
280	Parallel Path - Other	2	0.19%
328	Motorist Ride-Out - Non-Intersection Other	2	0.19%
910	Non-Roadway - Other	2	0.19%
217	Motorist Right Turn on Red - Same Direction	1	0.10%
218	Motorist Turn - Other	1	0.10%
249	Bicyclist Overtaking - Other/Unknown	1	0.10%
329	Motorist Ride-Out - Non-Intersection Unknown	1	0.10%
380	Crossing Path - Non-Intersection Other	1	0.10%
TOTAL		1041	

Comparison of Top Urban Crashes to the Universe of Urban Crashes

Crash Type 141 – Motorist Drive-Out – Sign Control

As is the case with the universe of crashes, crash type 141 is the most common crash for urban crashes. This crash type occurs when a motorist comes to a stop at a sign controlled intersection, and then proceeds into the intersection, striking a bicyclist whom already was in that intersection. This crash occurred 152 times and represented 14.6% of all urban crashes. The following tables compare characteristics of crash type 141 to the universe of urban crashes and attempt to identify any noticeable differences between the two.

Figure 7 shows the functional class of the roadway where the crashes occurred.

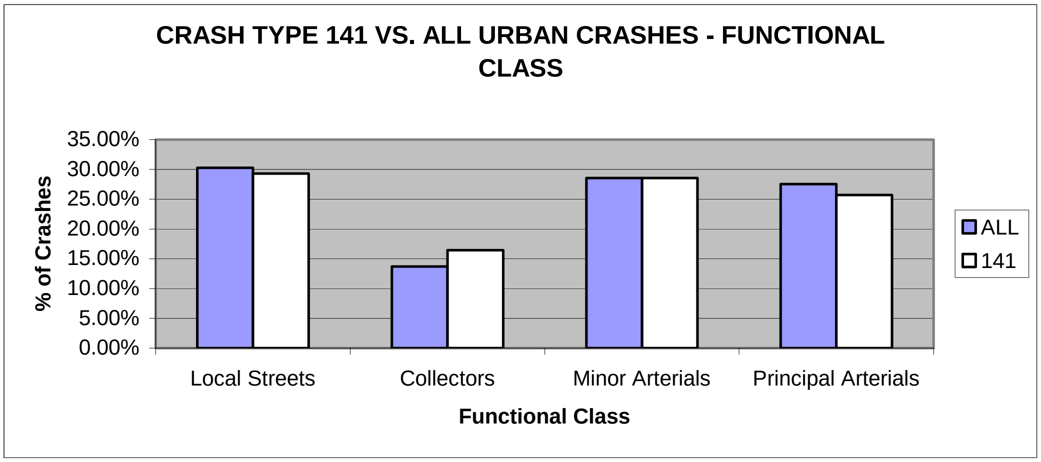


Figure 7

The figure shows that proportionately, crashes typed as 141 occur on the same types of roadways as the universe of urban crashes. Crashes occur evenly on local streets, minor arterials and principal arterials, with less crashes occurring on collectors.

Figure 8 shows the time of day when these crashes occurred.

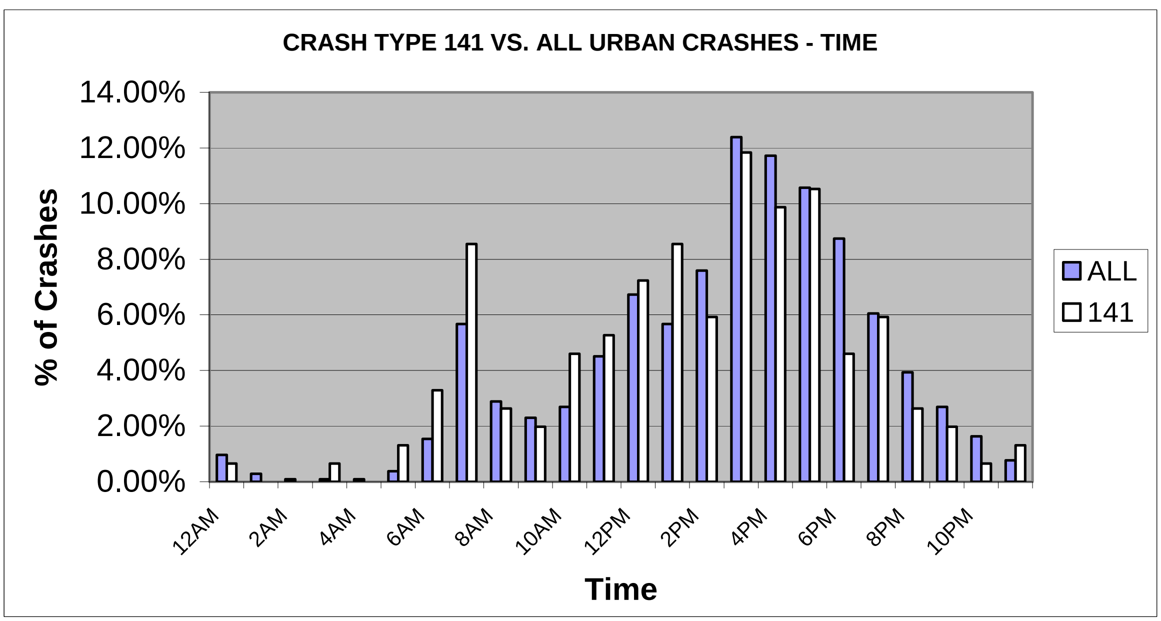


Figure 8

Crashes typed as 141 appear to occur more frequently during the a.m. peak hours of 6 and 7 o'clock. Crashes typed as 141 also appear to occur less frequently during the p.m. peak hours than the urban universe of crashes.

The following figures (Figures 9 & 10) look at the age of both the motorist and the bicyclist involved in the crash.

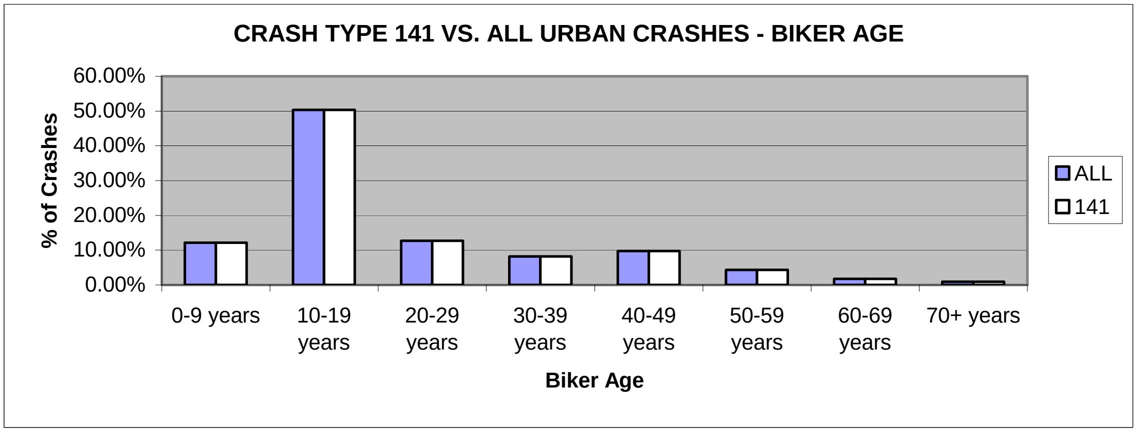


Figure 9

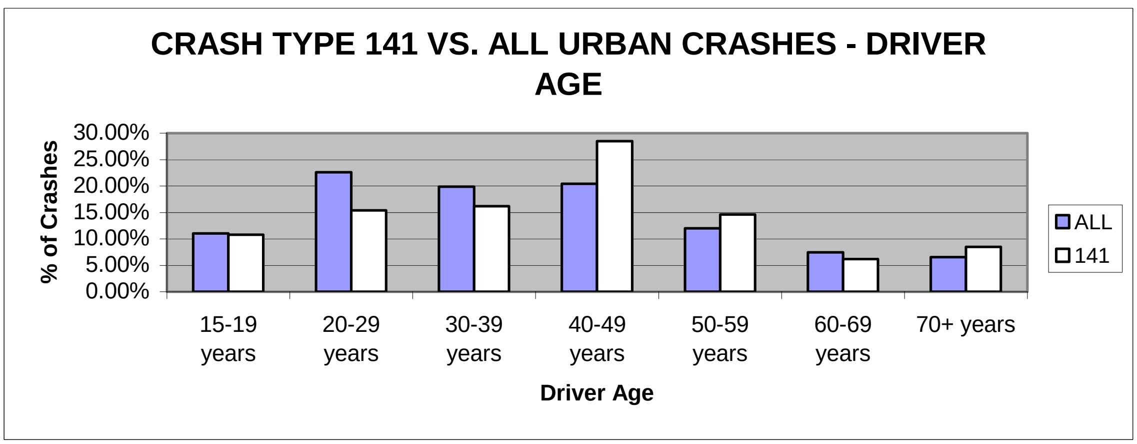


Figure 10

Figure 9 shows that there is no difference in biker age between crashes typed as 141 and the universe of urban crashes. However, there is a discrepancy in crashes with drivers between the ages 40 and 49. More than 28% of urban crashes typed as 141 occurred with a driver between these ages compared to only 20% of all urban crashes.

In summary, when compared to the universe of urban crashes, Crash Type 141 – Motorist Drive-Out – Sign Control, occurs on similar types of roadways, more frequently in the a.m. and less frequently in the p.m., with almost identically aged bicyclists, and more commonly with middle-aged motorists (40-60 years old).

Crash Type 144 – Bicyclist Ride-Through – Sign Control

As is the case with the universe of crashes, crash type 144 is the second most common crash for urban crashes. This crash type occurs when a bicyclist rides through a sign-controlled intersection without stopping, and strikes a vehicle. This crash occurred 77 times and represented 7.4% of all urban crashes. The following tables compare characteristics of crash type 144 to the universe of urban crashes and attempts to identify any noticeable differences between the two.

Figure 11 shows the functional class of the roadway where the crashes occurred.

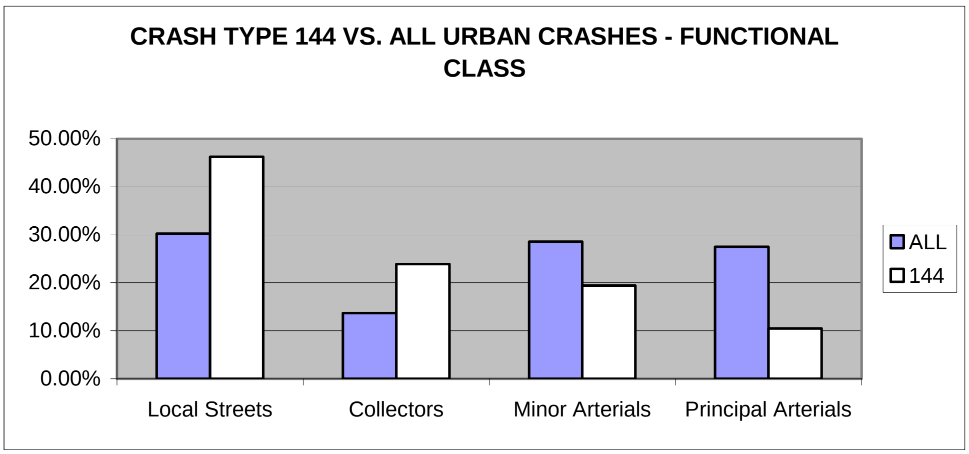


Figure 11

The figure shows that proportionately, crashes typed as 144 occur more commonly on local streets and collectors, and less commonly on minor and principal arterials, than the universe of urban crashes. More than two thirds of crashes typed as 144 occurred on the two most common types of roadway compared to only 44% of the universe of urban crashes.

Figure 12 shows the time of day when these crashes occurred.

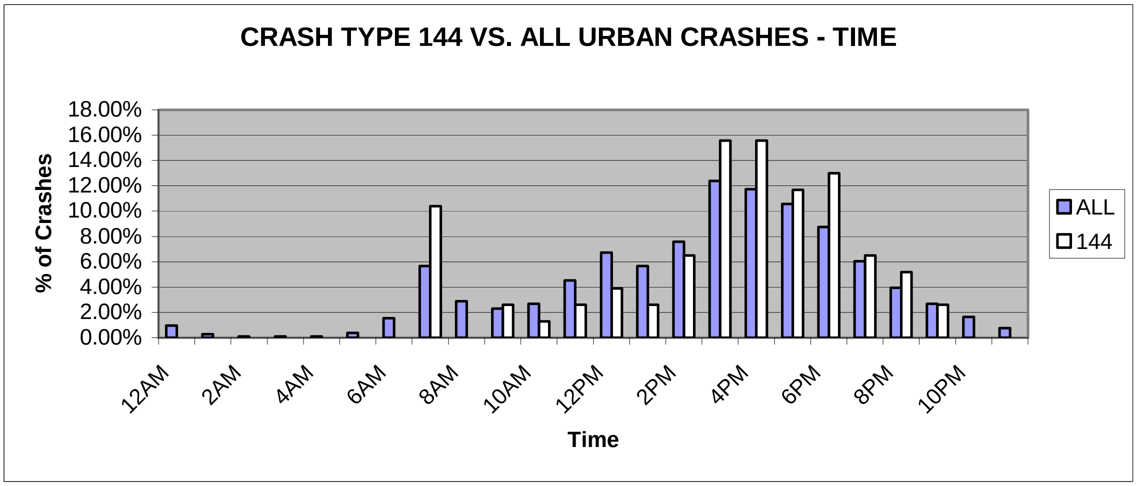


Figure 12

Crashes typed as 144 occurred more frequently than the urban universe of crashes during the p.m. peak hours of 3, 4, 5, 6 and 7 o'clock. Crashes typed as 144 also appear to occur less frequently during the a.m. peak hours than the urban universe of crashes, except for the 7 o'clock hour where crashes typed as 144 occurred almost two times as frequently.

The following figures (Figures 13 & 14) look at the age of both the motorist and the bicyclist involved in the crash.

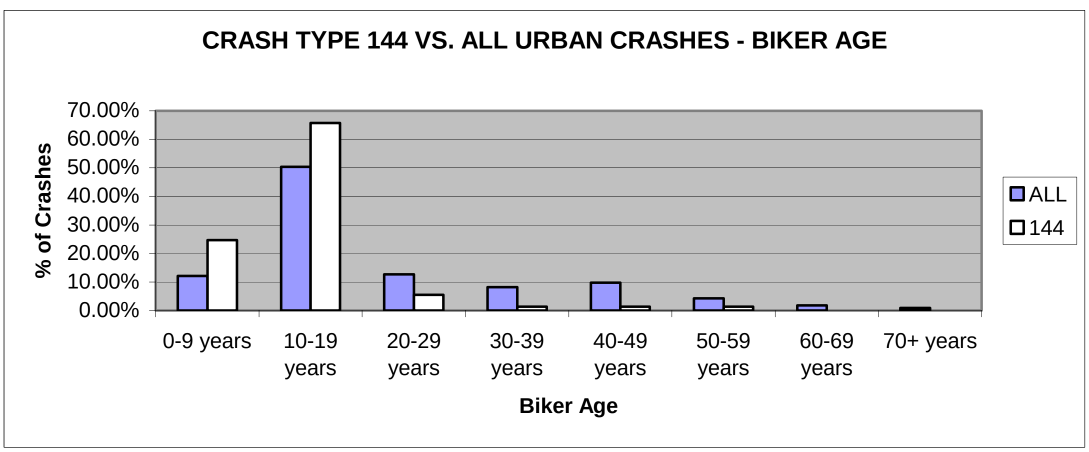


Figure 13

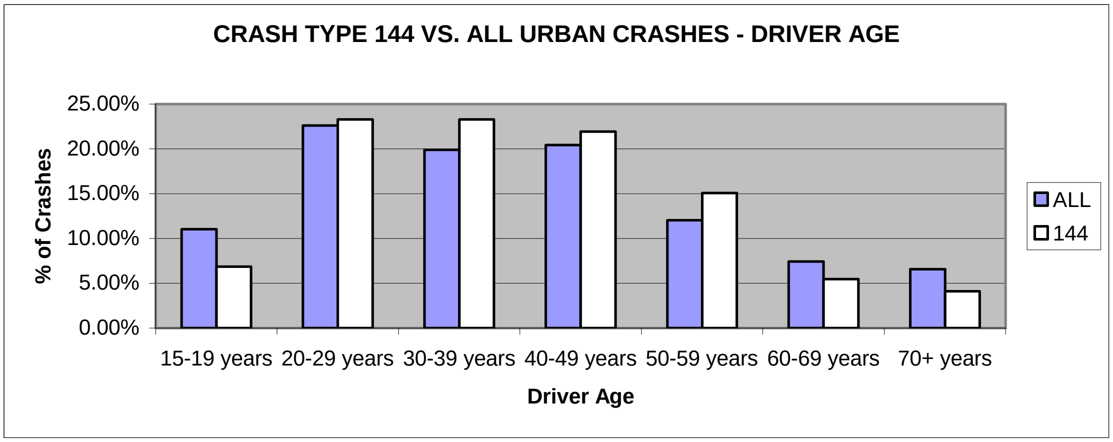


Figure 14

Figure 13 shows that crashes typed as 144 are very common amongst children and teenagers. 90% of crashes typed as 144 occurred with bicyclists under the age of 20 compared to only 62% of the universe of urban crashes. However, there is not a large discrepancy in crashes with drivers. Motorists between the ages of 15 and 19 were involved in fewer crashes typed as 144 than they were for the universe of urban crashes, and motorists between the ages of 20 and 59 were involved in slightly more crashes typed as 144 than in the universe of urban crashes. However, the differences are minimal and not a cause of concern.

In summary, when compared to the universe of urban crashes, Crash Type 144 – Bicyclist Ride-Through – Sign Control, occurs on more collectors and local streets, more frequently in the p.m. and less frequently in the a.m., with younger bicyclists, and similar aged motorists.

Crash Type 212 – Motorist Left Turn – Opposite Direction

As is the case with the universe of crashes, crash type 212 is the third most common crash for urban crashes. This crash type occurs when a motorist turns left in front of a bicyclist, resulting in a crash. This crash type occurred 65 times and represented 6.24% of all urban crashes. The following tables compare characteristics of crash type 212 to the universe of urban crashes and attempt to identify any noticeable differences between the two.

Figure 15 shows the functional class of the roadway where the crashes occurred.

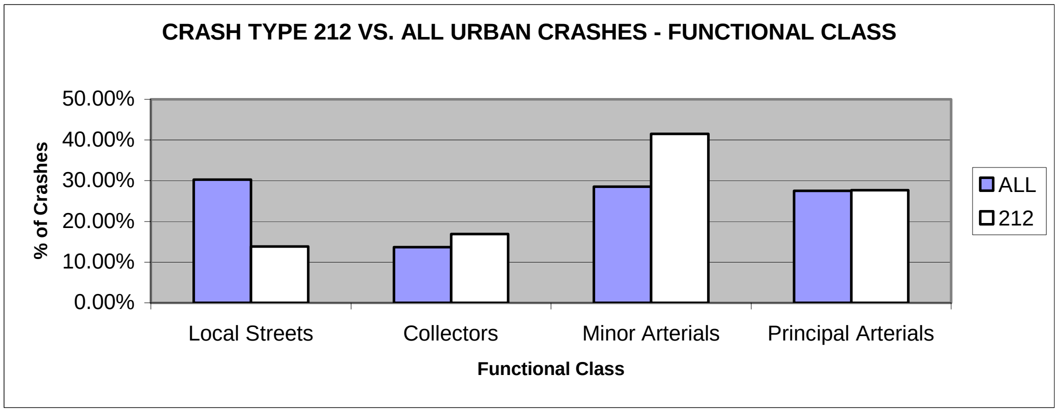


Figure 15

The figure shows that proportionately, crashes typed as 212 occur more commonly on minor arterials and less commonly on local streets, than the universe of urban crashes. They also occur more commonly on collectors and principal arterials, but by a small margin.

Figure 16 shows the time of day when these crashes occurred.

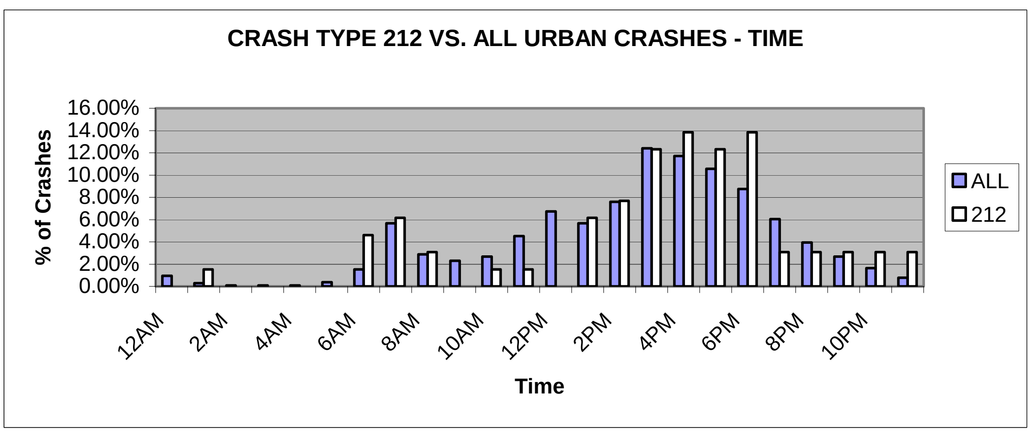


Figure 16

Crashes typed as 212 occurred more frequently than the urban universe of crashes during the p.m. peak hours of 4, 5 and 6 o'clock. Crashes typed as 212 also occurred more frequently during the a.m. peak hours than the urban universe of crashes. Crashes type 212, as shown by Figure 16, occurred most frequently during peak hours and less frequently during non-peak hours.

The following figures (Figures 17 & 18) look at the age of both the motorist and the bicyclist involved in the crash.

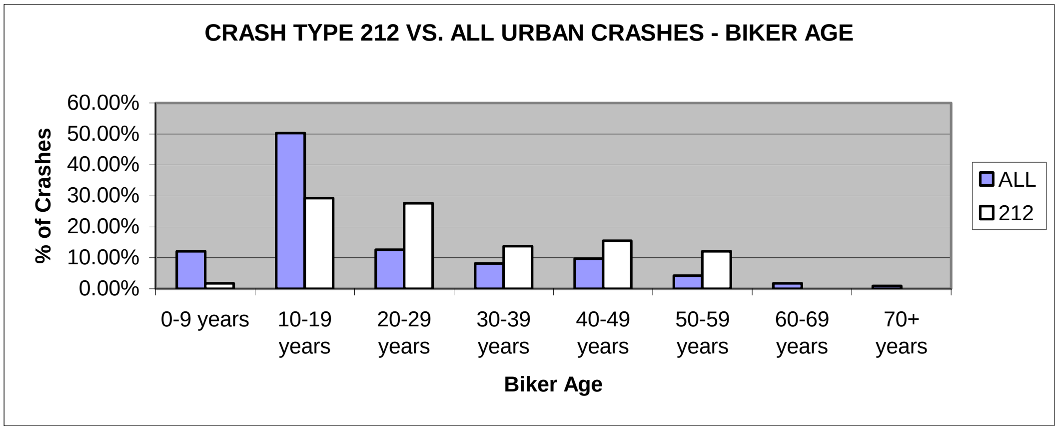


Figure 17

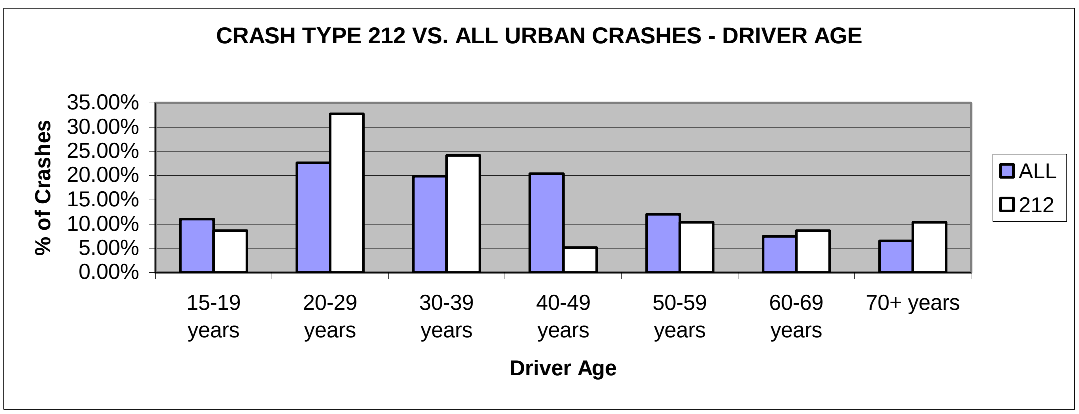


Figure 18

Figure 17 shows that crashes typed as 212 are uncommon amongst children and teenagers. Only 31% of crashes typed as 212 occurred with bicyclists under the age of 20 compared to 62% of the universe of urban crashes. Crash type 212 occurred much more frequently with adult bicyclists between the ages of 20 and 59. Motorists between the ages of 20 and 39 were involved in more crashes typed as 212 than they were for the universe of urban crashes, and motorists between the ages of 40 and 49 were involved in a far fewer percent of crashes typed as 212 than in the universe of urban crashes.

In summary, when compared to the universe of urban crashes, Crash Type 212 – Motorist Left Turn – Opposite Direction, occurs on more minor arterials and less on local streets, more frequently during peak hours of travel, with older bicyclists, and younger motorists.

Crash Type 151 – Motorist Drive-Out – Right Turn on Red

As is the case with the universe of crashes, crash type 151 is the fourth most common crash for urban crashes. This crash type occurs when a motorist stops at a red light, and then proceeds to turn right on the red without noticing the bicyclist, resulting in an accident. This crash type occurred 59 times and represented 5.67 % of all urban crashes. The following tables compare characteristics of crash type 151 to the universe of urban crashes and attempt to identify any noticeable differences between the two.

Figure 19 shows the functional class of the roadway where the crashes occurred.

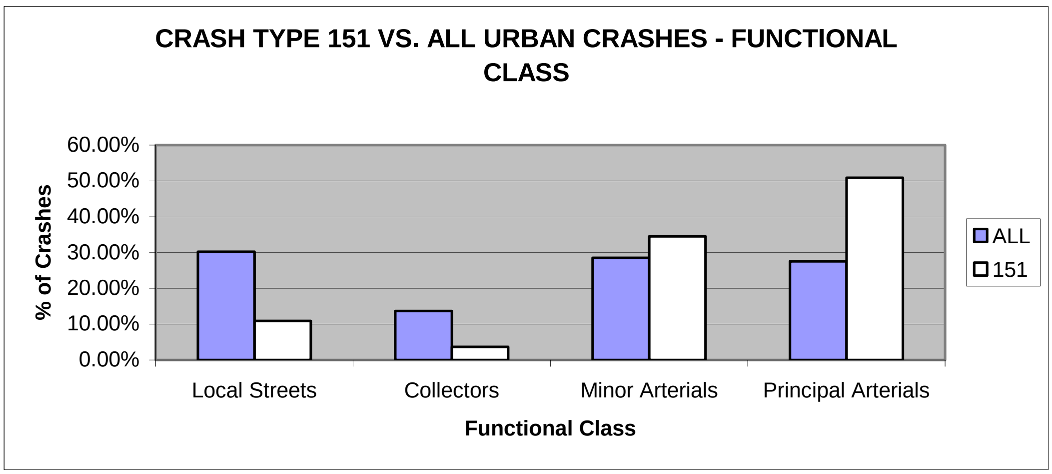


Figure 19

The figure shows that proportionately, crashes typed as 151 occur more commonly on minor and principal arterials, and less commonly on local streets and collectors, than the universe of urban crashes. More than 85% of crashes typed as 151 occurred on an arterial compared to only 56% of the urban crash universe, and only 15% of crashes typed as 151 occurred on local streets or collectors compared to 44% of the urban crash universe.

Figure 20 shows the time of day when these crashes occurred.

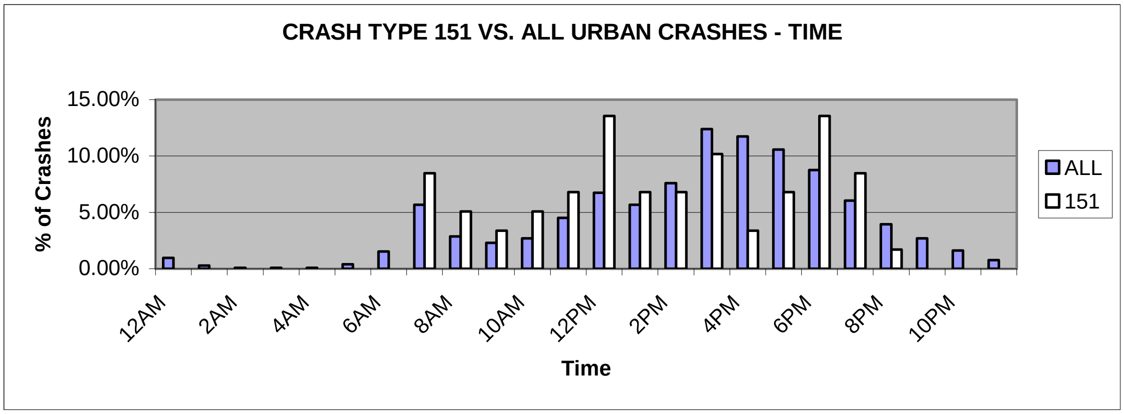


Figure 20

Crashes typed as 151 occurred more frequently than the urban universe of crashes during all hours from 7a.m. to 1p.m. Crashes typed as 151 also occurred more frequently than the universe of urban crashes during the p.m. hours of 6 and 7 p.m.. Crashes type 151 occurred less frequently during the early afternoon and early evening when compared to the universe of crashes.

The following figures (Figures 21 & 22) look at the age of both the motorist and the bicyclist involved in the crash.

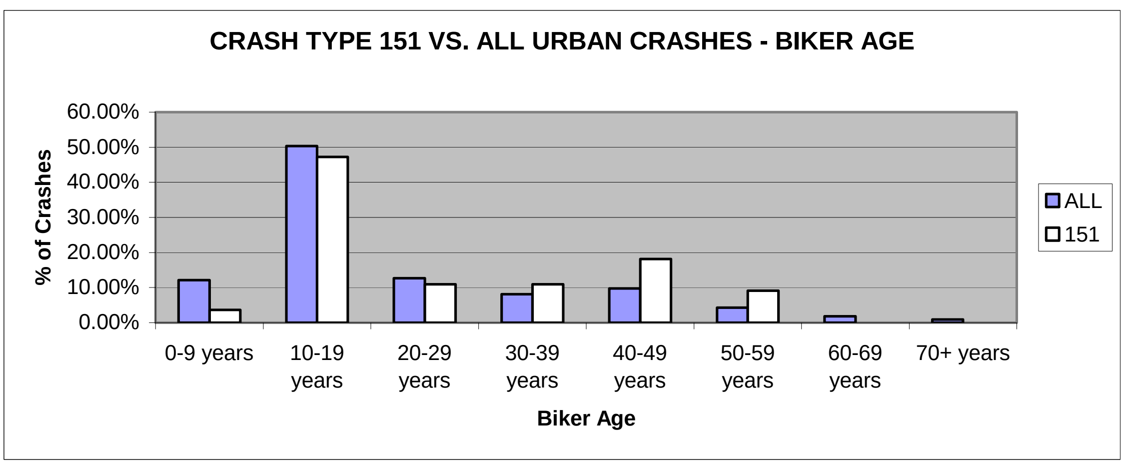


Figure 21

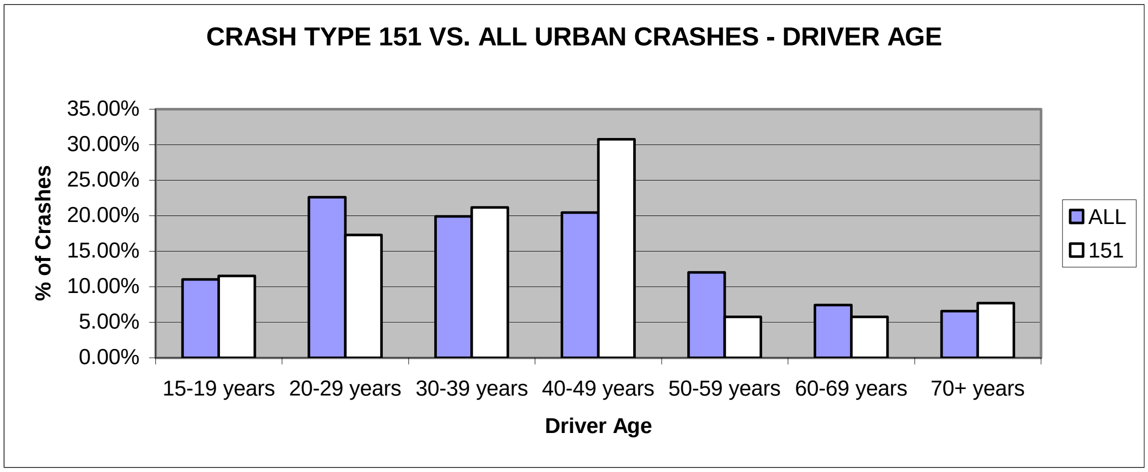


Figure 22

Figure 21 shows that crashes typed as 151 are just slightly less common amongst children and teenagers. Crash type 151 occurred much more frequently with adult bicyclists between the ages of 30 and 59. Motorists between the ages of 40 and 49 were involved in 31% of crashes typed as 151 compared to only 20% of the universe of urban crashes. There were no significant differences in motorist age between crashes typed as 15 and the universe of crashes for all other age groups.

In summary, when compared to the universe of urban crashes, Crash Type 151 – Motorist Drive-Out – Right Turn on Red, occurs on more arterials and less local streets and collectors, more frequently during morning and early afternoon hours, with older bicyclists, and middle-aged motorists.

Crash Type 322 – Motorist Ride-Out – Commercial Driveway/Alley

As is the case with the universe of crashes, crash type 322 is the fifth most common crash type for urban crashes. This crash type occurs when a motorist stops at a stop sign while leaving a driveway or alley, and then proceeds to turn into the roadway but strikes a bicyclist, resulting in an accident. This crash type occurred 56 times and represented 5.38 % of all urban crashes. The following tables compare characteristics of crash type 322 to the universe of urban crashes and attempt to identify any noticeable differences between the two.

Figure 23 shows the functional class of the roadway where the crashes occurred.

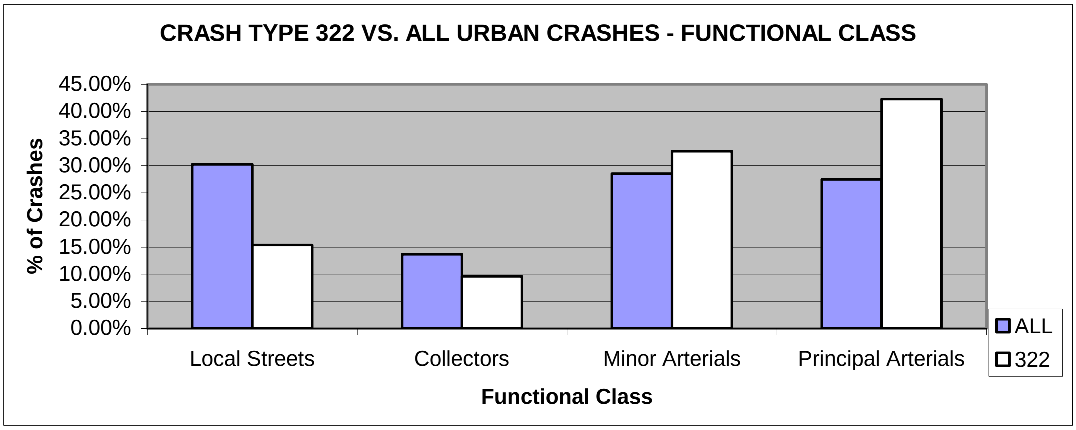


Figure 23

The figure shows that proportionately, crashes typed as 322 occur more commonly on minor and principal arterials, and less commonly on local streets and collectors, than the universe of urban crashes. 75% of crashes typed as 322 occurred on an arterial compared to only 56% of the urban crash universe, and only 25% of crashes typed as 322 occurred on local streets or collectors compared to 44% of the urban crash universe.

Figure 24 shows the time of day when these crashes occurred.

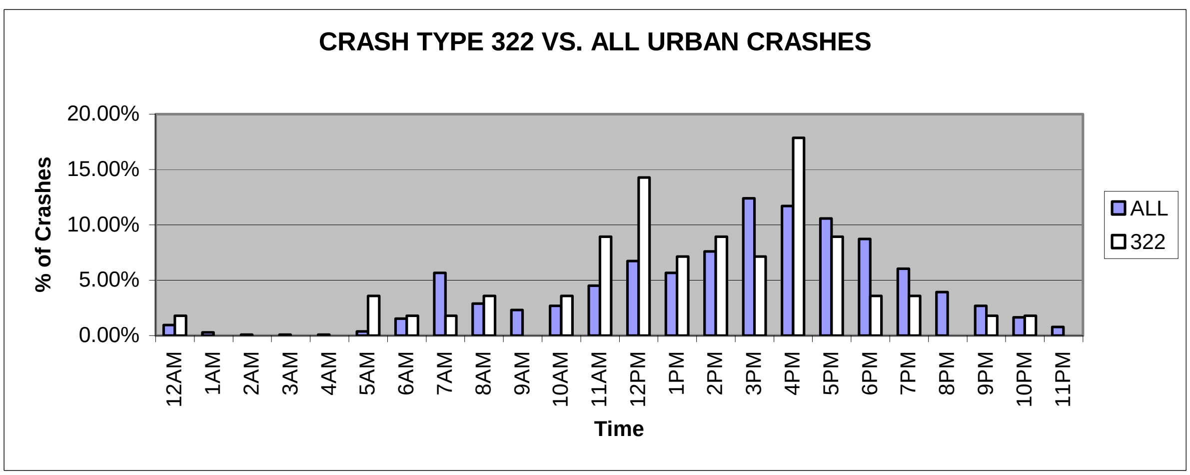


Figure 24

Crashes typed as 322 occurred more frequently than the urban universe of crashes during the late morning/early afternoon hours from 10a.m. to 2p.m. Crashes typed as 322 also occurred more frequently than the universe of urban crashes during the a.m. peak hours of 7 and 8 a.m.. Except for the 4 o'clock hour, crash type 322 occurred less frequently during the p.m. peak hours than did the universe of crashes.

The following figures (Figures 25 & 26) look at the age of both the motorist and the bicyclist involved in the crash.

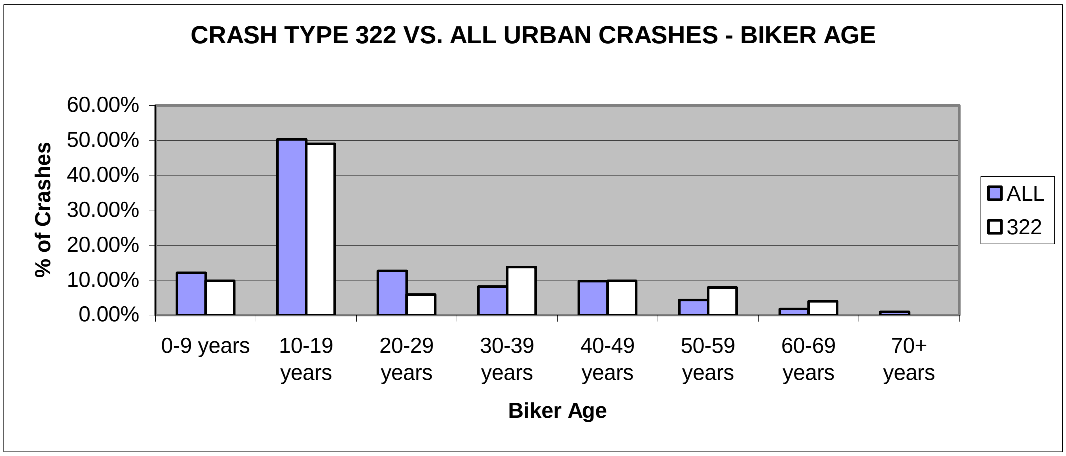


Figure 25

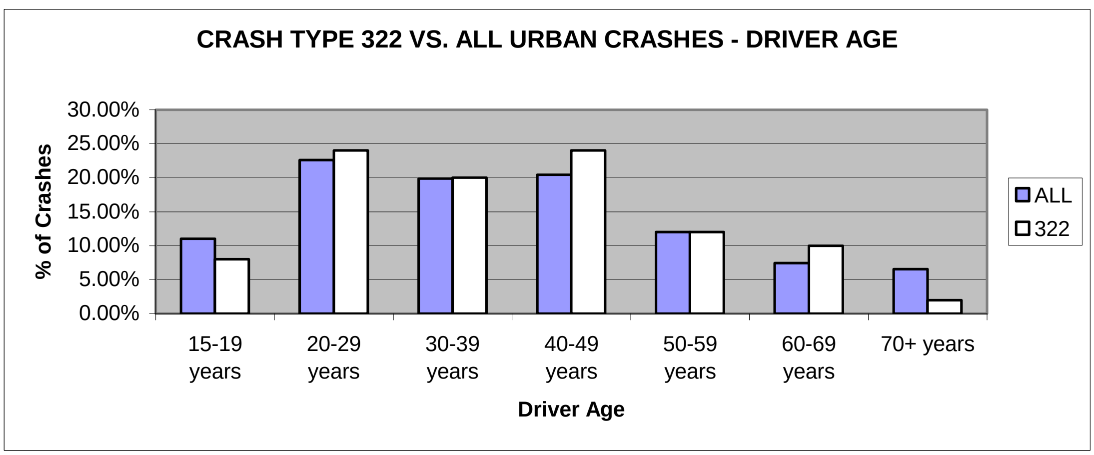


Figure 26

Figures 25 and 26 show that crashes typed as 322 are very similar to the universe of urban crashes for bicyclist and motorist age.

In summary, when compared to the universe of urban crashes, Crash Type 322 – Motorist Ride-Out – Commercial Driveway/Alley, occurs on more arterials and less local streets and collectors, more frequently during the late morning/early afternoon hours, and with similar aged bicyclists.

Crash Types – Rural Crashes

The crash typing of rural crashes identifies a high frequency of overtaking crashes occurring in a rural setting (Table 30). An overtaking crash occurs when the motorist and bicyclist are traveling parallel to one another and either the motorist or bicyclist strikes the victim from behind. The crash can result from a failure to notice the other operator, misjudged space between the other operator, and one of the vehicles swerving for an unknown reason. The motorist is most often at fault in overtaking crashes.

In 2002-04, three of the five most common crash types occurring in a rural setting involved a motorist overtaking a bicyclist. Overall, 66 of the 208 rural crashes (31.7%) were classified as motorist overtaking. These crash types are significantly more common in a rural setting than in an urban setting, as only 39 of the 1,041 urban crashes (3.7%) in 2003 occurred because of the motorist overtaking the bicyclist. Detailed analysis of the most common rural crashes is not included in this report because of the low number of rural crashes. Data samples must include at least 30 cases in order to obtain any statistical significance and for rural crashes, the most common crash type occurred only 25 times.

Table 30

Crash Type	Description	Count	% Of Crashes
231	Motorist Overtaking - Undetected Bicyclist	25	12.02%
232	Motorist Overtaking - Misjudged Space	23	11.06%
221	Bicyclist Left Turn - Same Direction	22	10.58%
141	Motorist Drive-Out - Sign Control	19	9.13%
235	Motorist Overtaking - Bicyclist Swerved	14	6.73%
311	Bicyclist Ride-Out - Residential Driveway	13	6.25%
144	Bicyclist Ride-Through - Sign Control	11	5.29%
212	Motorist Left Turn - Opposite Direction	8	3.85%
250	Head-On - Bicyclist	7	3.37%
111	Motorist Turning Error - Left Turn	5	2.40%
239	Motorist Overtaking - Other/Unknown	4	1.92%
318	Bicyclist Ride-Out - Non-Intersection Other	4	1.92%
321	Motorist Ride-Out - Residential Driveway	4	1.92%
990	Unknown/Insufficient Information	4	1.92%
121	Bicyclist Lost Control - Mechanical Problems	3	1.44%
142	Bicyclist Drive-Out - Sign Control	3	1.44%
255	Head-On - Motorist	3	1.44%

312	Bicyclist Ride-Out - Commercial Driveway/Alley	3	1.44%
700	Play Vehicle Related	3	1.44%
114	Bicyclist Turning Error - Left	2	0.96%
115	Bicyclist Turning Error - Right	2	0.96%
129	Bicyclist Lost Control - Other/Unknown Circumstances	2	0.96%
132	Motorist Lost Control - Oversteering/Improper Braking/Speed	2	0.96%
151	Motorist Drive-Out - Right Turn on Red	2	0.96%
211	Motorist Left Turn - Same Direction	2	0.96%
213	Motorist Right Turn - Same Direction	2	0.96%
222	Bicyclist Left Turn - Opposite Direction	2	0.96%
243	Bicyclist Overtaking - Parked Vehicle	2	0.96%
124	Bicyclist Lost Control - Surface Conditions	1	0.48%
134	Motorist Lost Control - Surface Conditions	1	0.48%
147	Multiple Threat - Sign-Controlled Intersection	1	0.48%
157	Bicyclist Failed to Clear - Multiple Threat	1	0.48%
214	Motorist Right Turn - Opposite Direction	1	0.48%
223	Bicyclist Right Turn - Same Direction	1	0.48%
225	Bicyclist Ride-Out - Sidewalk	1	0.48%
280	Parallel Path - Other	1	0.48%
322	Motorist Ride-Out - Commercial Driveway/Alley	1	0.48%
357	Multiple Threat - Midblock	1	0.48%
520	Bicyclist Intentionally Caused	1	0.48%
800	Unusual Circumstances	1	0.48%
TOTAL		208	

IN-DEPTH ANALYSIS – RURAL ROADWAYS

A few major factors that affect the comfort and safety of cyclists on all roadways are: speed differential between bicyclists and motorists, the amount of separation between bicyclists and motorists, and the amount of traffic. These factors are often part of formulas to gauge the "level of service" of bicyclists, but they are believed to also have an impact on the safety of bicyclists. If associations are found between crashes and roadway characteristics, the different designs of roadways can be considered that will include those treatments that will have a positive affect on the safety of bicyclists. In order to delve into these questions, bicycle crashes were examined for rural roadway widths, volumes of traffic, presence of paved shoulders, and bicycle suitability ratings.

Roadway Width:

Data for rural roadways was examined separately for rural state highway and rural local roads (county highways and town roads). The vast majority of local roads fall into 20 foot, 22 foot, and 24 foot widths (Table 31). Bicycle – vehicle crashes on roadways with these widths accounted for just over 85% of all crashes on the local road system.

Table 31 – Crashes and Local Roads

Roadway Width	# Of Crashes	Miles of Roadway*	Crashes per 1,000 Miles of Roadway	Total ADT	Crashes per Million ADT	% Overtaking	ADT of Crashes/ADT of Roadway Class
20 feet	40	22,980	1.7	2,718,534	14.7	38%	429/118: 3.6
22 feet	53	24,055	2.2	8,534,714	6.2	42%	963/355: 2.7
24 feet	29	8,490	3.4	6,716,439	4.3	24%	1517/791: 1.9

*Estimate

The crash rate, based on crashes per 1,000 miles of roadway, increased as the roadway width increased. However, when the total amount of daily traffic was accounted for, the rate reversed. Twenty-four foot wide local roads had only a third the crash rate of 20-foot wide roadways. It is important to note, that the average 20-foot wide local road has lower traffic volumes than the average 24-foot wide roadway, thus far fewer conflicts, and therefore may be more appealing to bicyclists. Depending on traffic volume, these narrower roads may actually be safer for bicycling because of the fewer potential conflicts. However, the data are indicating that given the same amount of traffic, a 24-foot wide road will have a lower incidence of crashes than 20 and 22-foot roadways.

With respect to crash types, of particular concern for rural crashes are overtaking type crashes. These tend to be very serious, more often fatal in rural areas (4 out of 68 overtaking crashes on rural roads were fatal), and represent a high percentage of all rural crash types. For example, 42% of crashes on 22-foot wide local roads were overtaking type crashes compared to 6.7% for urban and rural crashes combined. The percent of overtaking crashes was comparable for 20 and 22-foot roadways, but did drop significantly for 24' wide roadways. This could be because of the additional width that motorists have when passing bicyclists.

The crash rate (based on vehicle miles traveled) for local roads is high compared to the state highway system. One reason why there may be a relatively high crash rate for 22 and 24-foot wide roadways on local roads is because of a relatively high percent of crashes occurring in higher ADT ranges. This is understandable because of the increased number of conflicts with higher traffic volumes. The last column in Table 31 indicates the average ADT of crashes compared to the average ADTs of roadways by 22 and 24-foot widths. The greater the ratio, the more likely crashes can be attributed to the higher ADTs. For example, the average ADT on 22-foot wide roadways where bicycle – vehicle crashes occurred was 963. However, the average ADT for all 22-foot wide roadways was only 355, indicating that a relatively high proportion of the crashes were occurring because of the increased conflicts in the higher ADT ranges. To some degree, this is expected, but these findings highlight the relationship between the width of the roadway and the volume of traffic.

Table 32 – State Highways

2-Lane Rural State Highways	# Of Crashes	Miles of Roadway*	Crashes per 1,000 Miles of Roadway	Total ADT	Crashes per Million ADT	% Overtaking
All	45	8,854	5.1	39,152,388	1.15	31%
22 FT Roadway	7	1,457	4.8	2,329,743	3.00	14%
24 FT Roadway	31	6,629	4.7	31,865,603	0.97	35%
22 FT No Pvd Shldr*	2	1,103	na	1,438,312	na	na
24 FT No Pvd Shldr*	1	1,083	na	3,102,795	na	na
3 FT Pvd Shldr - All	27	4,713	5.7	19,931,277	1.35	52%
> 3 FT Pvd Shldr - All	9	1,523	5.9	11,774,313	0.76	22%

*Miles of Roadway are an Estimate. 22' and 24' wide roadways without paved shoulders have very, very low observations.

For a 3-year period from 2002 to 2004, 45 bicycle – vehicle crashes occurred on 22-foot and 24-foot wide rural state highways, regardless of the presence or width of a shoulder. This represents 88.2% of all crashes occurring on rural state highways. The total number of bicycle – vehicle crashes on the state highway system was lower than those occurring on the local system, but the rate is slightly higher on a per mile of roadway basis.

Twenty-four foot wide roadways (two 12 foot lanes) have a comparable crash rate (4.8 per 1,000 miles of roadway) to 22 foot wide roadways (4.7 per 1,000 miles) based on miles of roadway, but a significantly lower crash rate when crashes are related to VMT (3.0 per million VMT versus 1.0). The crash rate for 24-foot wide roadways was actually quite low. The rate of 1.0 crash per million VMT was less than 25% of the rate for local roads (4.3 crashes per million miles of travel).

Paved vs. Non-paved Shoulders

Seventy-five percent of the 2-lane state highway system has paved shoulders. Not surprisingly, because of the low percentage of state highways without paved shoulders, a low percentage of crashes occurred on these highways. Because so few crashes occurred on very few miles of non-paved shoulder state highways, the findings are tenuous. Another category difficult to analyze is 3-foot paved shoulders with 11-foot travel lanes. Only 236 miles of state highway fall into this category, so it was not analyzed.

As noted above, the non-paved shoulder category of state highways does not have many miles of state roadway and there were only three crashes occurring on them. The crash rate based on VMT was .32 per million VMT for 24-foot roadways and 1.39 per million for 22-foot roadways. This contrasts with 4.3 per million for 24-foot wide local roads. The average ADT for 22-foot roadways was low for non-paved shoulder state highways – 1,304 ADT, but higher for 24-foot roadways – 2,865 ADT. The low ADTs certainly had an influence on the low crash rates. Furthermore, non-paved shoulder state highways are in very rural and remote parts of the state. They are more likely to be farther from urban areas and the amount of bicycle traffic may be lower. Local roads within these roadway widths are more likely to be in close proximity to urban centers attracting more cyclists.

The crash rate for roadways with 3-foot paved shoulders was 1.35 per million VMT, still low when compared to the local roads, but actually higher than the blended average rate of 22 and 24-foot wide non-paved shoulder highways. A relatively high percentage of these crashes were overtaking crashes. Also, the average ADT of the roadways where the crashes occurred was 6,000 compared to an average for all roadways in this category of 4,230. This indicates that much higher than average volumes of traffic are coming into play and contributing to the crashes. The crash rate per million VMT dropped to .76 with a wider paved shoulder. The average ADT of these crashes was 8,380, just slightly higher than the average ADT (7,731) for all roadways with a greater than 3-foot paved shoulder. Overtaking crashes also decreased to just 22% of all crashes, down from 52% (all state highways with 3-foot paved shoulders), indicating that wider paved shoulders may be an effective countermeasure.

Bicycle Crash Conditions

The two conditions that are believed to have the largest safety effect on bicyclists' safety on high speed roads (55mph) in rural areas are width of the roadway and volume of motor vehicle traffic. Each of these factors were evaluated separately earlier in this report, but their co-relationship's impact on bicycle crashes was not. A bicycle conditions model currently exists and is used by WisDOT to evaluate bicycle conditions for cycling. The two main variables used in this model are roadway width (including paved shoulders) and volume of traffic. Bicycle crashes were plotted on these maps for the state and county trunk systems (see figures 27 and 28). More crashes were expected as the conditions for the roadways declined using the model's categories.

Indeed this was the case with both the county trunk and state highway systems. The crash rate was more than triple for the category of least desirable state highways when compared to the most suitable highways. The disparity was even more dramatic for the county trunk system where the crash rate was almost 10 times greater for the least desirable county highways compared to the most suitable category (see Tables 33 and 34).

Table 33

STN Rural Crashes					
Rating	**Condition**	**Count**	**%**	**Mileage**	**Crash Rate**
1	Suitable	7	14.29%	3323.20	2.11
2	Moderate	8	16.33%	1810.07	4.42
3	High Traffic/Wide Paved Shoulders	2	4.08%	140.60	na
4	Least Desirable	28	57.14%	4303.35	6.51
5	Unrated	4	8.16%	1245.17	na

Table 34

County Trunk Rural Crashes					
Rating	**Condition**	**Count**	**%**	**Mileage**	**Crash Rate**
1	Suitable	22	32.84%	14117.06	1.56
2	Moderate	7	10.45%	1781.69	3.93
3	Least Desirable	38	56.72%	2464.10	15.42

na – not enough data to determine a meaningful crash rate

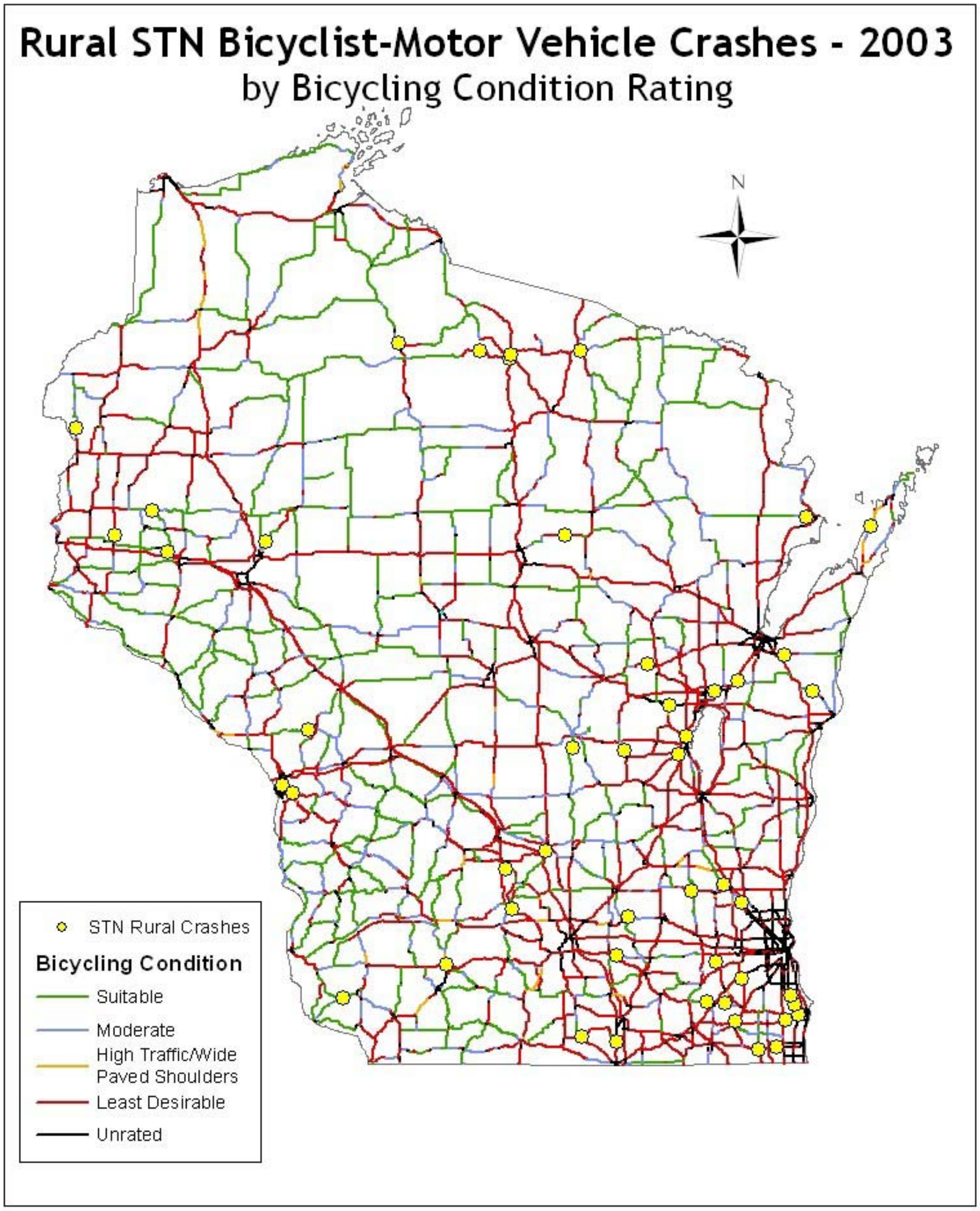

Rural STN Bicyclist-Motor Vehicle Crashes - 2003
by Bicycling Condition Rating
N
STN Rural Crashes
Bicycling Condition
Suitable
Moderate
High Traffic/Wide Paved Shoulders
Least Desirable
Unrated

Figure 27

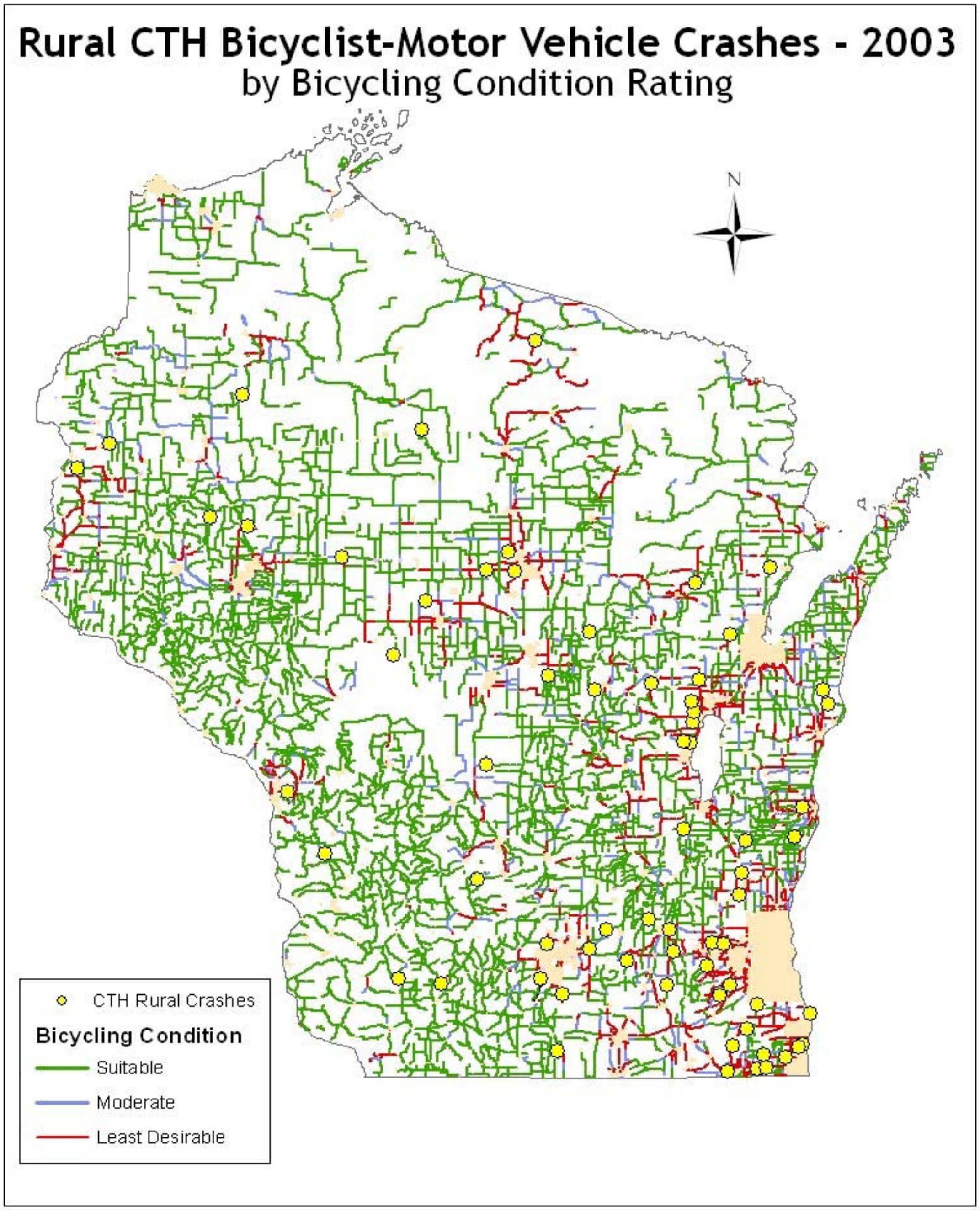

Rural CTH Bicyclist-Motor Vehicle Crashes - 2003
by Bicycling Condition Rating
N
CTH Rural Crashes
Bicycling Condition
Suitable
Moderate
Least Desirable

Figure 28

In summary, when the two factors of width and traffic were combined, there was an even stronger association with bicycle crashes than when either of these factors were related to bicycle crashes separately. Future studies could look to see if there are any groupings of bicycle crashes at different combinations of width and traffic. The rating model's breakpoints could then be modified in consideration of the increase in bicycle crashes if there are any noticeable groupings of crashes. At least several years of additional data on rural crashes should be gathered to help determine any patterns.

IN-DEPTH ANALYSIS – URBAN STREETS

The vast majority of crashes occurred on urban streets. This is not necessarily because urban streets are inherently more dangerous for cycling, but because there is more traffic and more bicycling occurring, which increases the overall level of exposure for bicyclists. In addition to many of the characteristics of crashes that have already been looked at in a cursory fashion, this section will study two features of urban streets that potentially could be highly correlated with bicycle crashes. The first feature is the presence of "*sidepath*" facilities. The second characteristic analyzed is not so much a feature of a roadway as it is a combination of characteristics that results in categorizing streets. This is referred to the *functional classification* of a street.

Sidepath Crashes

The word "sidepath" refers to the movement of bicyclists adjacent to a roadway on a freestanding facility. In most cases, the sidepath is either a sidewalk or a crosswalk that forms a connection between two sidewalks. In other cases, it is a path intended for bicyclists and pedestrians. Often a separated path is viewed by officials and members of the public as a premier facility to be built adjacent to a street. However, many of the potential locations for these paths are actually hazardous because of conflicts with intersections and driveways. The proposed placement of these paths is identical in most cases to where sidewalks would be built, however, a path would often be built wider for two-way bicycle use.

Three hundred and five of the 1,112 bicycle crashes (27.4%) in 2003 were classified as sidepath crashes where the bicyclist and motorist crashed, most of the time as they entered an intersection (Table 35). These crashes have been analyzed both as a group and separately by where the bicycle entered the intersection (or crossed a driveway) from a sidewalk or a path.

Table 35

Crash Type	Count	% Of Crashes		Crash Type	Count	% Of Crashes
141	71	23.28%		321	3	0.98%
151	39	12.79%		113	2	0.66%
322	23	7.54%		224	2	0.66%
212	16	5.25%		250	2	0.66%
144	14	4.59%		328	2	0.66%
142	13	4.26%		600	2	0.66%
155	12	3.93%		800	2	0.66%
160	12	3.93%		114	1	0.33%
121	11	3.61%		122	1	0.33%
112	10	3.28%		123	1	0.33%
211	10	3.28%		148	1	0.33%
213	9	2.95%		180	1	0.33%
214	8	2.62%		218	1	0.33%
152	6	1.97%		221	1	0.33%
225	5	1.64%		222	1	0.33%
990	5	1.64%		235	1	0.33%
153	4	1.31%		318	1	0.33%
156	4	1.31%		357	1	0.33%
143	3	0.98%		380	1	0.33%
312	3	0.98%				
				TOTAL	305	

Of the 305 sidepath crashes, 303 occurred in an urban environment. Therefore, 29% of all urban crashes were sidepath related. The two rural sidepath crashes occurred when the bicyclist entered the roadway from an adjacent bike path.

The most common crash type for sidepath crashes is crash type 141 – Motorist Drive-Out – Sign Control. As expected, all 71 of these crashes are sidepath-crosswalk crashes and occurred because the motorist stopped at the stop sign, but then proceeded into the crosswalk as the bicyclist was crossing. These 71 sidepath crashes account for 45% of the Motorist Drive-Out – Sign Control crashes.

The next most common sidepath crash is crash type 151 – Motorist Drive-Out – Right Turn on Red. Thirty-nine of these sidepath crashes occurred. Thirty-eight have been classified as sidepath-crosswalk crashes and the remaining crash occurred with the bicyclist in a bike lane (sidepath-bike lane/path). These 39 sidepath crashes account for 65% of the Motorist Drive-Out – Right Turn on Red crashes.

Table 36 identifies the types of roadways, as defined by the MV4000 Report, on which these crashes occurred.

Table 36

Highway Class	Count	% Of Crashes
City Street Urban	231	75.74%
City Street Rural	10	3.28%
Town Road Rural	3	0.98%
STH Urban	56	18.36%
STH Rural	5	1.64%
TOTAL	305	

Due to the urban nature of the crashes, 231 (76%) occurred on "City Street Urban" roadways, and 56 (18%) occurred on "STH Urban" roadways. The other 18 crashes occurred on roadways defined as rural, but most were in very small towns that although are classified as rural, have urban characteristics present (i.e. sidewalks, curbs, etc…).

Sidepath Crashes – Crosswalk

The most common sidepath crash occurred within a crosswalk. Table 37 shows the total sidepath-crosswalk type crashes and the types of crashes these were.

Table 37

Crash Type	Count	% Of Crashes		Crash Type	Count	% Of Crashes
141	71	31.84%		112	2	0.90%
151	38	17.04%		224	2	0.90%
144	14	6.28%		990	2	0.90%
142	12	5.38%		113	1	0.45%
155	12	5.38%		121	1	0.45%
160	12	5.38%		148	1	0.45%
212	11	4.93%		180	1	0.45%
213	8	3.59%		218	1	0.45%
214	7	3.14%		222	1	0.45%
152	6	2.69%		322	1	0.45%
211	6	2.69%		357	1	0.45%
153	4	1.79%		800	1	0.45%
156	4	1.79%				
143	3	1.35%		TOTAL	223	

Once again, the most common crash types are crash types 141 and 151 respectively.

Table 38 shows the type of roadway in which the sidepath-crosswalk crashes occurred. The truly urban roadways, "City Street Urban" and "STH Urban", were the locations of 95% of the sidepath-crosswalk crashes. This is up 1% from the entire group of sidepath crashes and is understandable because truly urban environments are more likely to have crosswalks at intersections.

Table 38

Highway Class	Count	% Of Crashes
City Street Urban	167	74.89%
City Street Rural	8	3.59%
Town Road Rural	1	0.45%
STH Urban	46	20.63%
STH Rural	1	0.45%
TOTAL	223	

Sidepath Crashes – Sidewalk

Sidepath-sidewalk crashes are the next most common type of sidepath crash. Sixty-nine of these crashes occurred in 2003 and Table 39 shows all sidepath-sidewalk crashes by crash type.

Table 39

Crash Type	Count	% Of Crashes		Crash Type	Count	% Of Crashes
322	21	30.43%		114	1	1.45%
121	10	14.49%		122	1	1.45%
112	8	11.59%		123	1	1.45%
225	5	7.25%		212	1	1.45%
312	3	4.35%		213	1	1.45%
321	3	4.35%		235	1	1.45%
990	3	4.35%		250	1	1.45%
211	2	2.90%		380	1	1.45%
328	2	2.90%		800	1	1.45%
600	2	2.90%				
113	1	1.45%		TOTAL	69	

The most common for sidepath-sidewalk crash is crash type 322 – Motorist Drive-Out – Commercial Driveway/Alley. Over 30% of sidepath-sidewalk crashes are of this nature. These crashes result when a collision occurs between a bicyclist riding on a sidewalk or path and a vehicle exiting a parking lot. The bicyclists makes contact with the motor vehicle at either the side or front of the vehicle. The second most common sidepath-sidewalk crash is crash type 121 – Bicyclist Lost Control – Mechanical Problems. The majority of these crashes occurred, according to the MV4000 Reports, because a bicyclist could not stop in time due to faulty brakes. This is an unusual descriptor of the crash since bicyclists who are legally using sidewalks, are supposed to be provided the right of way by vehicles crossing sidewalks.

Table 40 shows the type of roadway in which sidepath-sidewalk crashes occurred.

Table 40

Highway Class	Count	% Of Crashes
City Street Urban	56	81.16%
City Street Rural	2	2.90%
STH Urban	8	11.59%
STH Rural	3	4.35%
TOTAL	69	

Ninety-three percent of sidepath-sidewalk crashes occurred in a truly urban environment. Seven percent of these crashes occurred in smaller towns that have an urban feel to them within the town center. The increase in smaller urban area crashes may be attributed to a larger presence of sidewalks adjacent to main roads throughout small, isolated towns.

The vast majority of these crashes are occurring on major streets. Just 31% of the state's roadway system is classified as collectors or arterials, yet 75% of all sidepath crashes are occurring on them (Table 41).

Table 41

Functional Class	Count	% Of Crashes
Local Streets	69	24.56%
Collectors	30	10.68%
Minor Arterials	82	29.18%
Principal Arterials	100	35.59%
TOTAL*	281	

*Total Does Not Equal 305 Because of Missing Data

Other Bikeway Crashes - Bike Lane/Intersection Crashes

Another type of crash involving a bikeway is bike lane-intersection crashes. Bike lanes are quite uncommon in the state. They are rarely marked completely through an intersection, but cyclists involved in these crashes were in either a bike lane or moving in or out of bike lane at an intersection. Only 13 of these crashes occurred and are shown in Table 42.

Table 42

Crash Type	Count	% Of Crashes		Crash Type	Count	% Of Crashes
212	4	44.44%		221	1	11.11%
211	2	22.22%		250	1	11.11%
142	1	11.11%		318	1	11.11%
151	1	11.11%		322	1	11.11%
214	1	11.11%				
				TOTAL	13	

The most common bike lane crash is crash type 212 – Motorist Left Turn – Opposite Direction. These crashes occur when the bicyclist and motorist are traveling on parallel paths, heading towards one another, and the motorist turns left either onto another roadway or into a driveway. All four of these crash types that occurred in 2003 occurred in the City of Madison. Madison also had the highest mileage of bike lanes in 2003.

Table 43 shows the type of roadway in which bike lane crashes occurred.

Table 43

Highway Class	Count	% Of Crashes
City Street Urban	8	61.54%
City Street Rural	2	15.38%
SHT Urban	2	15.38%
STH Rural	1	7.69%
TOTAL	13	

Due to the small sample size, no significant results can be obtained from the table showing the types of roadways in which the bike lane crashes occurred. However, as is the case with all the sidepath crashes, the majority of the crashes occurred in a truly urban environment.

Functional Classification

Having the functional classification of the urban street system provides meaningful insights into bicycle-vehicle crash location. Crashes most commonly occurred on the arterial street system, where over 56% of the crashes occurred. Unfortunately, the amount of cycling on the street system is not known, but it gives a clear indication that cyclists are encountering crash problems on these streets. When collector streets are included, over 70% of all crashes are occurring on urban streets that are functionally classified as collectors and above. Planners, engineers, and local officials often ask about the need to accommodate cyclists on these busier streets. Connections for bicyclists along these busy streets are important for transportation purposes and these busy streets may be the only way to access parts of communities or bridge over barriers. Having a high percentage of crashes on arterial streets is evidence that usage is occurring on these streets and that the crash problem is over-represented on arterial streets. Almost 68% of all urban streets are functionally classified as local streets (most of these are residential). If cycling were occurring in direct relation to proportion of streets in each classification, just 22.1% of the crashes would be occurring on the arterial street system.

Table 44

Urban Functional Classification	Crashes	%
Urban		
Local Streets	294	30.10%
Collectors	133	13.60%
Minor Arterials	281	28.80%
Principal Arterials	267	27.30%
Expressways	2	0.30%
Total Urban	977	

REVIEW OF MAJOR FINDINGS

Based on the preliminary findings of previous smaller studies, some of this study's findings are not surprising. In another regard, the study produced significant new contributions to crash evaluation in the state. This study made an enormous contribution by determining the crash types for all bicyclist- motorist (bicycle – vehicle) crashes during an entire year. It also researched the characteristics of roadway width in more depth than in previous works. Additionally, the evaluation of sidepath crashes was not done on a statewide basis until this study was performed. Here are the major findings of the report:

- Bicycle – vehicle crashes are declining in the State of Wisconsin. From 1999 – 2004, annual crashes have decreased by 14%. Ideally, this report will contribute to a continual reduction in crashes by increasing bicyclist awareness, providing countermeasures to avoid common crashes, and increasing education amongst bicyclists and motorists.
- Bicycle – vehicle crashes are almost twice as common during workweek days than on the weekend days. The majority of workweek crashes occur during the a.m. and p.m. peak travel hours. The lower number of crashes occurring on weekends may indicate that recreational bike trips occur more frequently on recreational trails or low volume roadways where exposure is less.
- Many bicycle – vehicle crashes had similar characteristics. A large concentration of crashes occurred within one of, or a combination of, the following environments: in an urban city, at an intersection, or on an urban city street or arterial roadway. Eighty-three percent of crashes occurred in a city (MV4000 Report), 93.6% of crashes occurred in an urban area (MV4000 Report), 65.7% of crashes occurred at an intersection (PBCAT), 71.7% of crashes occurred on a city street (MV4000 Report), and 56.1% of crashes occurred on an arterial street.
- Unfortunately, alcohol was a factor in some of the crashes. The MV4000 data does not declare whether the driver or bicyclist was under influence, only if alcohol was a factor in the crash. 4.2% of urban crashes reported alcohol as being involved and 4.6% of rural crashes reported alcohol as being involved. This is

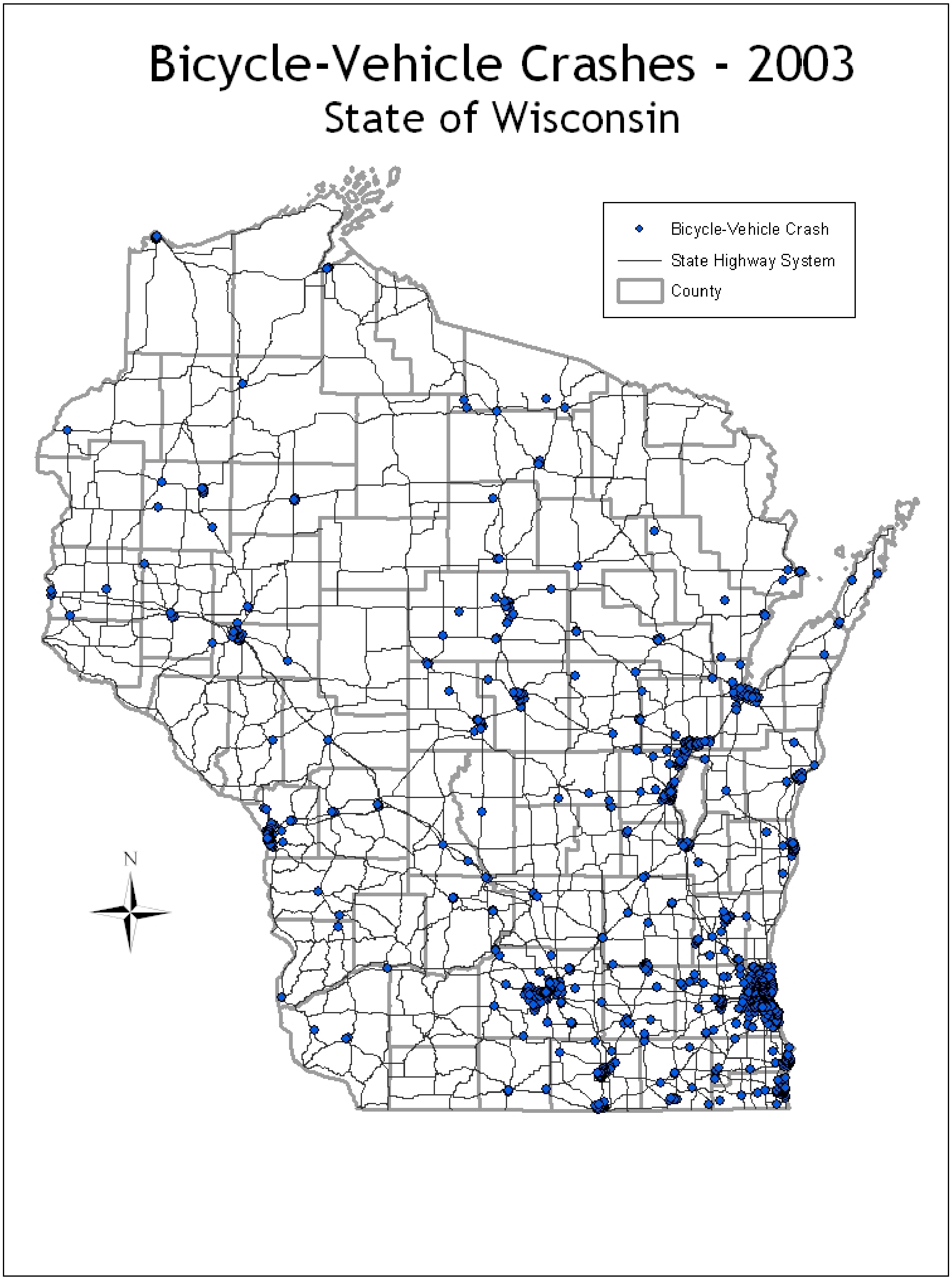
slightly lower than national percentages from the *Crash Types of the Early 1990's* report and compares to a 7.0% alcohol involvement of all Wisconsin crashes.

- Bicycle – vehicle crashes occurred mainly during daylight hours, and when they did occur at night, most were in a location with lighting. Over 83% of crashes occurred during daylight hours, and of the 12.3% of crashes occurring at night, only one out of every ten occurred without some sort of lighting present.
- Male bicyclists were involved in almost 75% of all bicycle – vehicle crashes. Even crashes involving children reported over 70% of the bicyclists being male.
- Almost 80% of rural bicycle – vehicle crashes occurred on roadways with posted speed limits of 55 miles per hour. Crashes occurring at such high rates of speed will increase the likelihood of a bicyclist injury or death. This is evident in the higher percentage of rural crashes resulting in fatalities than in urban crashes.
- Four out of the top five crash types indicate that the motorist made the critical error. This may indicate that motorists are not fully aware of bicyclists on the roadway and that increased education is necessary.
- Urban areas and urban streets have much higher crash rates than rural areas based on all indices examined - miles of roadway, bicycle miles traveled, and vehicle miles traveled. Although crash rates were higher for urban areas, the rate of fatal crashes was double for rural crashes compared to urban crashes based on bicycle miles traveled.
- Milwaukee County has the highest average crash rate when bicycle miles traveled and vehicle miles traveled are averaged together. The rate is three times that of the lowest counties of Brown, Marathon, and Wood.
- The city of Madison has a low average crash rate based on bicycle miles traveled. A scattering of other cities – Appleton, Green Bay, and Wausau also have relatively low average crash rates based on bicycle miles traveled, but none of these communities come close to the total bicycle miles traveled as demonstrated by Madison.
- When bicycle-vehicle crash rate is compared to the overall crash rate for all vehicles, the rate was twice as high for bicycle-vehicle crashes compared to all vehicle crashes. The bicycle crash rate was based on bicycle miles traveled, while

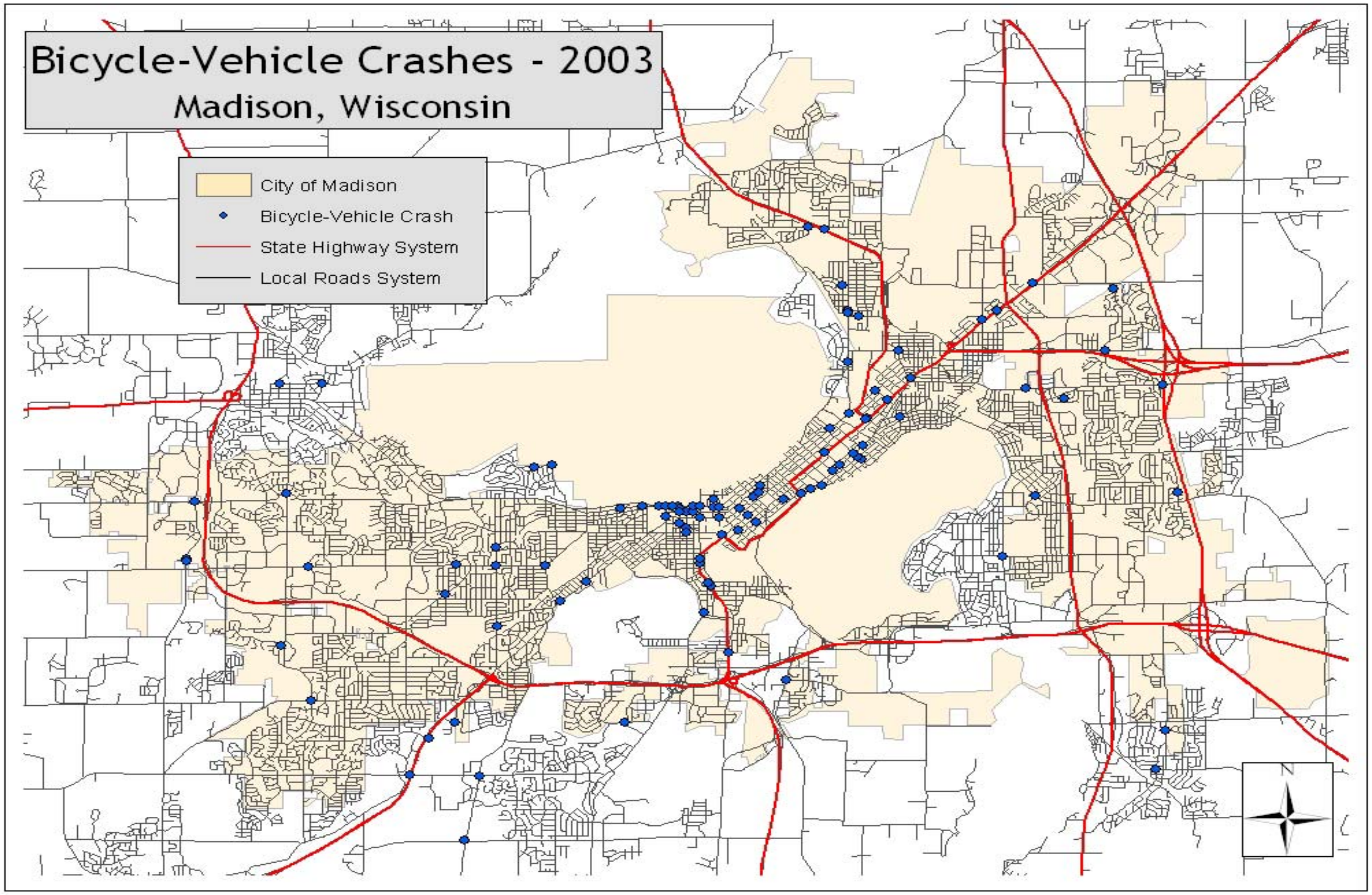
the comparison rate for total vehicle crashes was based on total vehicle miles traveled.

- For local rural roads, the greater the width, the lower the bicycle-vehicle crash rate. Twenty foot roadways had a crash rate that was double the crash rate of 22 foot roadways, but the 22 foot roadways had a rate that was over 40% higher then 24’ roadways. Overtaking-type crashes were significantly lower for 24’ roadways.
- Rural state highways had much lower bicycle-vehicle crash rates then local roads. Similar to local roads, 24-foot roadways had significantly lower crash rates then 22-foot roadways. Interestingly, having three foot paved shoulders did not improve the crash rate among these widths of roadways. However, the crash rate did significantly lessen when five paved shoulders were added (compared to three foot paved shoulders).
- Sidepath crashes are common crashes in urban areas. Twenty-nine percent of all urban crashes were recorded as such. Motorist drive-out from both sign and signal-controlled intersections are by far the two most common crash types. How significant a problem this is, is difficult to ascertain without knowing the frequency of bicycle use on sidepaths/walks and their connecting crosswalks.
- The use of the Pedestrian and Bicycle Crash Analysis Tool (PBCAT) in its present form was effective and constructive. However, each crash record’s diagram had to be evaluated by viewing it on microfiche which elongated the evaluation process. The geocoding process was also found to be a worthwhile and an essential step. By pinpointing the location of crashes, other data files with these reference points could be brought in to cross-reference important roadway characteristics and highway operational data. A methodology that explains this process was developed as part of this study and is available in the form of a mini-manual.

APPENDIX



Bicycle-Vehicle Crashes - 2003
State of Wisconsin
Bicycle-Vehicle Crash
State Highway System
County
N


Bicycle-Vehicle Crashes - 2003
Madison, Wisconsin
City of Madison
Bicycle-Vehicle Crash
State Highway System
Local Roads System
N

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