LTU
CITY OF LINCOLN TRANSPORTATION AND UTILITIES

LINCOLN
Crash Data Analysis

ACCREDITED AGENCY
APWA

CONTENTS

> *“Transportation is fundamental to our success as a world class city. The reliability of Lincoln’s transportation system is second only to its safety. Our continued analyses of data and implementation of safety improvements is vital to maintain our vision of mobility, economic development, and opportunity for all.”*
>
> **Lonnie Burklund**
> Assistant Director – Transportation

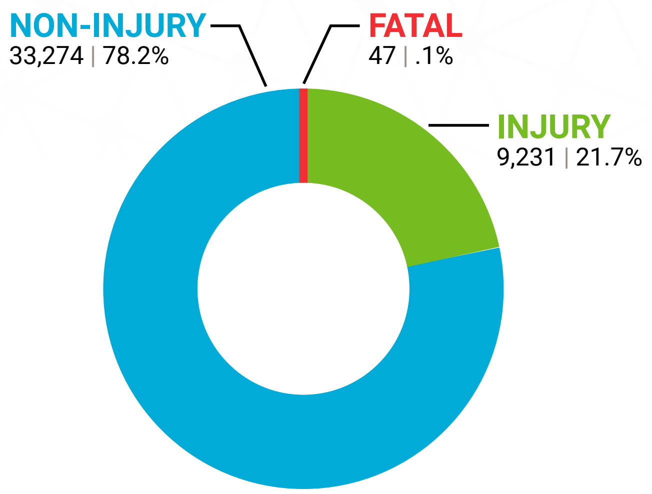
INTRODUCTION

In the US alone, over 6.3 million crashes occur annually. These unfortunate events result in nearly 40,000 fatalities per year on our public transportation system—this equates to approximately 100 deaths per day. While not widely publicized, this has an enormous impact on our society and those directly involved.

The City of Lincoln has traditionally had a very safe transportation system. The Lincoln Transportation and Utilities Department (LTU) takes a very proactive approach to the analysis of crash data, and development of engineering solutions to improve the safety of streets and intersections. This five-year compilation of analysis is another summary of information that will help develop programs and projects aimed at safety enhancements.

From 2012 through 2016, there were a total of 42,552 crashes in the City of Lincoln. This includes 47 fatal crashes and 9,231 crashes that resulted in an injury (**Figure 1**). During this time period, on average, a crash happened in Lincoln every 58 minutes. A crash involving injury occurred every 4 hours and 43 minutes. Crashes resulting in a fatality averaged once every 39 days. Impacts of crashes add up. The total estimated societal cost of crashes during this five year period equals $1.57 billion—an average of $313 million each year[1] (**Figure 2**). Economic costs are not inclusive of added congestion caused by crashes. To address this burden, the City of Lincoln has a mission to dramatically reduce the cost and impact of crashes by decreasing the amount of fatal and injury related crashes.

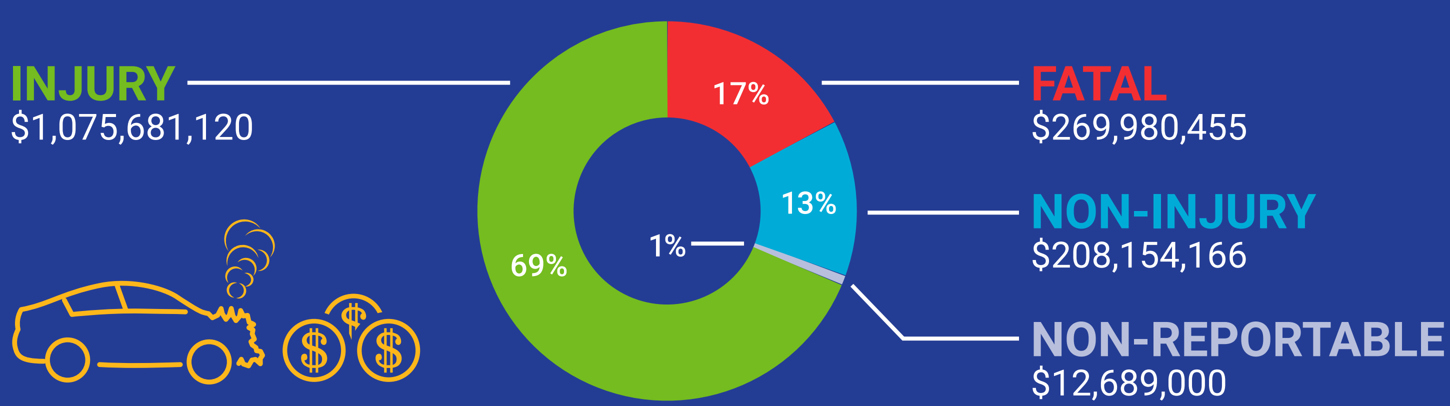
Figure 1: Crashes by Severity (2012-2016)



The City of Lincoln maintains and updates a citywide crash data analysis as a primary tool to address the engineering component of this mission.

1 Fatality $5,744,265; Injury $116,315; Property Damage Only (PDO) $10,141; Non-reportable PDO $1,000

FIGURE 2: CRASH COST BY SEVERITY (2012-2016)



This report summarizes crash trends across all streets and provides location-specific safety evaluations and project recommendations. Updating and maintaining this data analysis provides insights into the effectiveness of past programs and informs the City if changes need to be made to address emerging crash trends.

> ***Lincoln has a mission to dramatically reduce the cost and impact of crashes by decreasing the amount of fatal and injury related crashes per capita.***

Objective and Approach

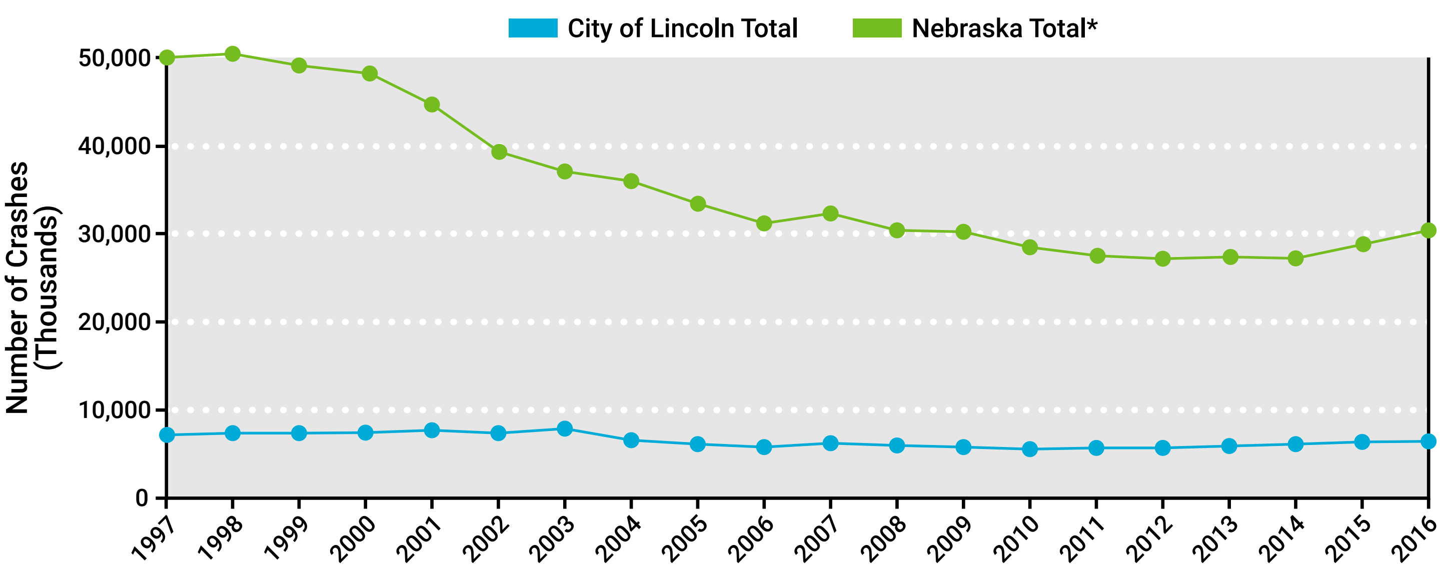
This crash data analysis evaluates city-wide crash history, identifies locations for further study and recommends traffic safety improvements. At each location, a detailed review of site-specific crash history and unique characteristics resulted in one or more traffic safety improvement recommendations. Implementing recommended improvements is expected to reduce the frequency and/or severity of crashes at these locations and provide measurable, positive outcomes for the City and traveling public.

CITY-WIDE CRASH HISTORY

Crash patterns in Lincoln, the State of Nebraska, and the nation have changed over time. Up until 2011 the dominant crash trend was generally flat with a slight decrease in crashes over time in Lincoln. Yet, in the last five years both the City of Lincoln and the State of Nebraska have seen an increase in the frequency of crashes, which mirrors recent population growth and increased travel (**Figures 3** and **4**). Understanding these patterns helps the City make targeted investments to improve safety city-wide. City-wide crash history is discussed in greater detail in **Chapter 2**.

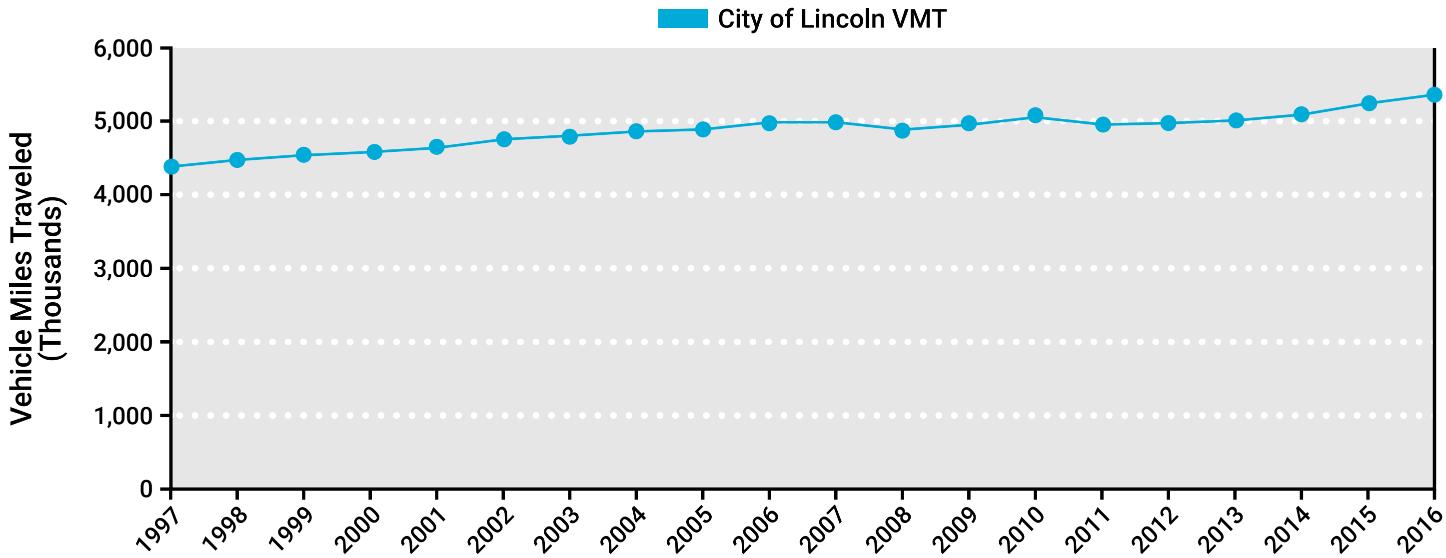
Another goal for Lincoln's traffic safety program is to reduce crashes involving bicycles and pedestrians. In Lincoln, from 2012–2016 there were 1,349 crashes involving a pedestrian or bicyclist. That represents three percent of all crashes. However, most pedestrian and bicycle crashes result in an injury, and account for 12 percent of all severe crashes (**Figure 5**). Because of the likelihood of an injury when a pedestrian or bicyclist is involved in a crash, **Chapter 3** of the crash data analysis includes a dedicated investigation into pedestrian and bicycle crash trends.

Figure 3: Historical Crash Trends (City of Lincoln vs. Nebraska)



* Non-Reportable crashes removed for comparison to statewide crash totals.

Figure 4: Annual Vehicle Miles Traveled (VMT)



IDENTIFY LOCATIONS FOR FURTHER STUDY

To achieve plan objectives, this study included a review of all intersections and corridors within City of Lincoln limits. To provide the best return on investment, resources were prioritized on streets and intersections with highest crash exposure. This study provides a targeted list of intersections and corridors that exhibit the targeted crash patterns over the last five years. Through the network screening process, 25 intersections and three corridors were selected for further study. The intersection screening process is documented in **Chapter 4**. Details of the corridor selection process are documented in **Chapter 5**.

RECOMMEND TRAFFIC SAFETY IMPROVEMENTS

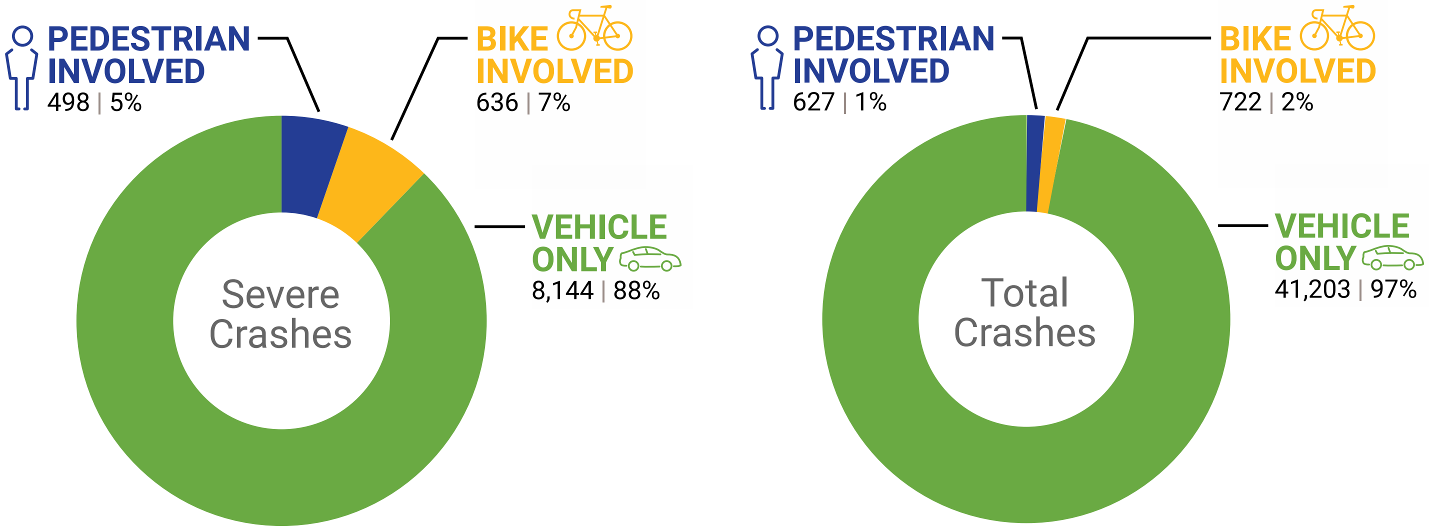
As part of the emphasis on locations with targeted crash patterns, the study also identified potential improvements to improve location-specific crash trends. Given the strategic nature of this crash data analysis, a focus was placed on locations that could be improved through a combination of geometric improvements, improvements to traffic control devices, changes to policy, or enhanced maintenance within a near-term (less than 5 years) or mid-term (5 to 10 years) timeframe. Recommended safety improvements are included in **Chapters 4** and **5**, respectively.

Acknowledgments

This project was made possible through the efforts and contributions of several staff and working groups. We thank the following teams for their assistance and input:

- City of Lincoln
  - Traffic Engineering Division
  - Technology Services
  - GIS Management
  - Communications & Public Affairs
- Nebraska Department of Transportation

Figure 5: **Crashes by Mode of Travel (2012-2016)**



CHAPTER 2: HISTORICAL CRASH DATA

The Lincoln Crash Data Analysis seeks to provide a data-driven assessment of traffic safety across the entire city. To accomplish that objective, effort was invested in the analysis of crashes. Prior city-wide crash studies analyzed between a single year and three year's worth of crashes. To follow industry best practices, the Lincoln Crash Data Analysis was developed using the latest, detailed, five full years of crash data (January 1, 2012 through December 31, 2016). Because crash trends change over time, using multiple years provides greater insight into long-term and emerging crash trends.

Crash trends tell a story of the city's transportation system safety performance. Like any story, the key questions the reader wants answered are: **who**, **what**, **when**, **where**, and **why**. The nature of crash data is one that can leave some of these questions as difficult to answer. The **who** are travelers in Lincoln, but the data analyzed lacks driver socioeconomic data, so age, gender, race, employment status, income level cannot be further analyzed. Crash data also gives us only a partial picture into the **why**. As each facet of the data is discussed, the insight of the project team is provided as to possible rationale behind trends, but the full picture of **why** crashes patterns occur as they do is complex and cannot be completely established from data analysis alone. The remainder of this chapter will focus on **when**, **where**, and **what**.

When

One of the first crash trends analyzed was the year-to-year frequency and severity of crashes over the past 20 years, as seen in **Figure 6**, which relates to the **when** of understanding crash data trends.

Prior to 2011, Lincoln was experiencing a decreasing trend in crashes mostly due to a decline in property damage only (PDO) crashes, but also due to modest reductions in fatal, injury and non-reportable crashes (PDO crashes estimated under $1,000). Starting in 2012, the annual total of crashes in Lincoln has increased each year, as the vehicle miles traveled has

Figure 6: Historical Crash Trends (City of Lincoln)

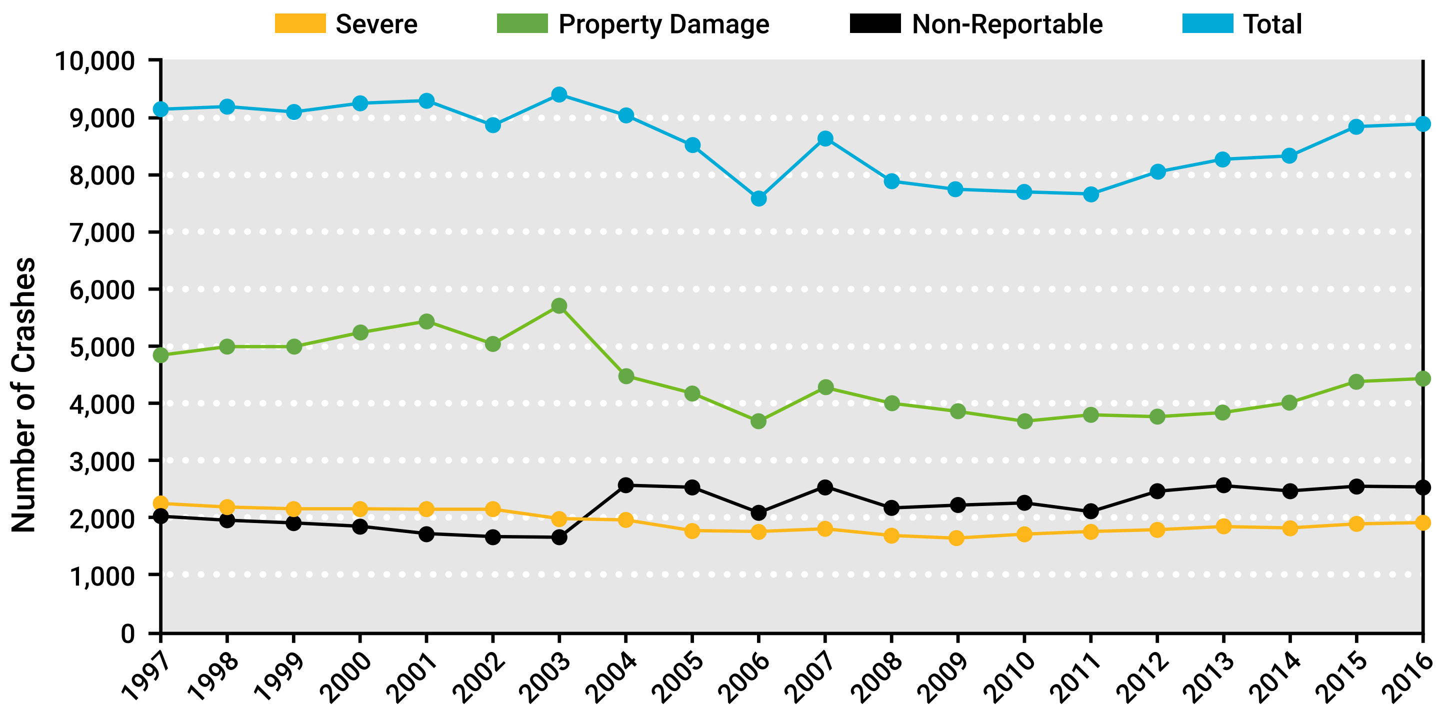
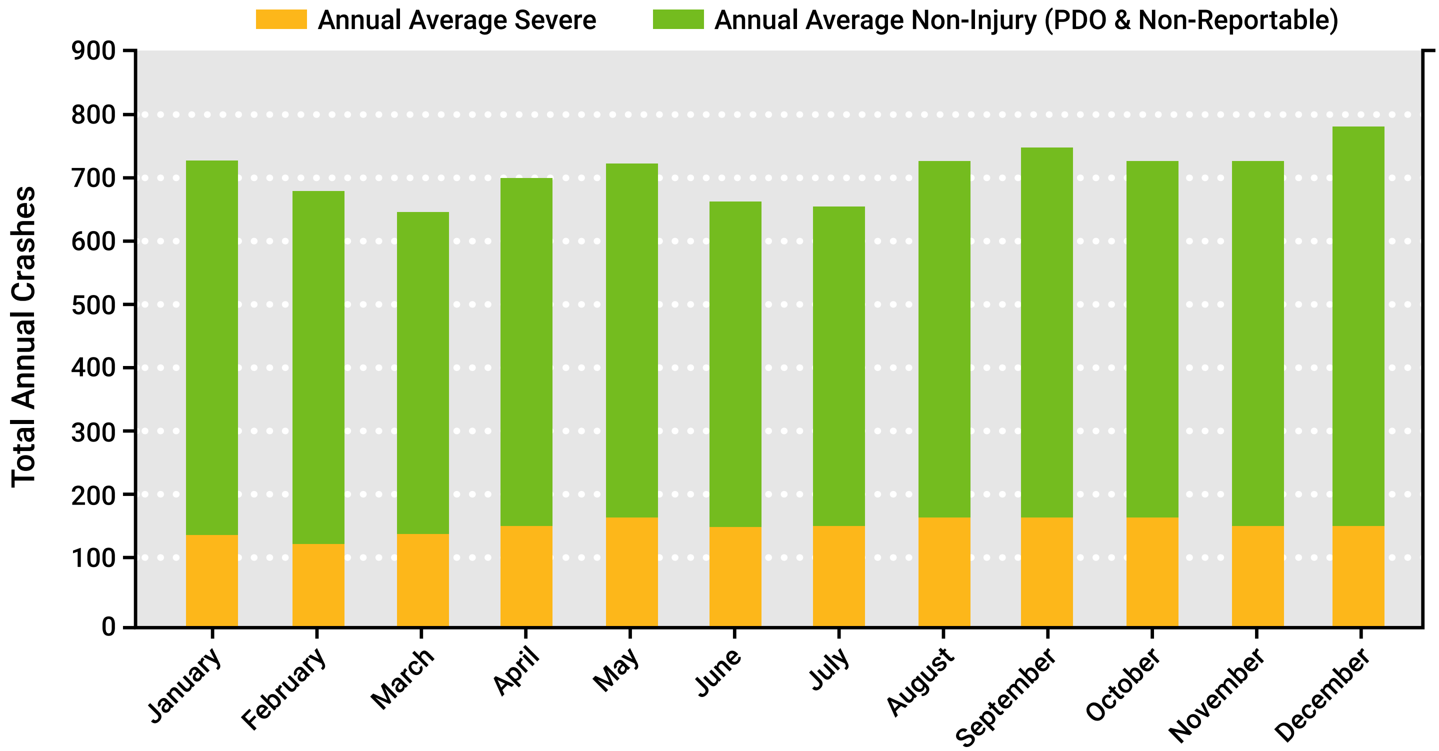


Figure 7: **Annual Severe & Non-Injury Crash Frequency by Month of Year**



also increased each year since 2012. From 2012 to 2016, there was a 10 percent increase in crashes across the City. This includes a 15 percent increase in PDO crashes while fatal and injury crashes increased 6 percent. Even though crashes in Lincoln have been increasing since 2012, this is similar to the statewide trend. Crashes across Nebraska reached a low in 2012 and changed little through 2014[2]. But since 2014, the number of crashes across Nebraska increased each year. In fact, crashes in Nebraska increased 11 percent from 2012 to 2016. This included a 12 percent increase in PDO crashes and 10 percent increase in fatal and injury crashes. While Lincoln reflects the statewide trend, the City set a goal to reduce the frequency and severity of crashes through targeted implementation of safety countermeasures.

Diving deeper into the **when** of crashes, further investigation considered the cyclical pattern of crash activity. This analysis began with reviewing the 5 years of crash data broken down by month (**Figure 7**).

The figure shows similar patterns in each month. In winter months, severe crashes (any crash resulting in an injury or fatality) decrease slightly compared to summer months. Also, fall and winter months experience slightly more crashes than summer months.

Once the variability by month was investigated, crashes were broken down by day of the week. **Figure 8** shows the impacts of both severe crashes and non-injury crashes by day of the week. Day of the week has much greater impact on crashes in Lincoln than month of the year. The first trend is reduced crashes on the weekend. During the week, the highest crash activity occurs on Fridays.

Crash trends were also reviewed by time of day. Crash activity depends strongly on the amount of traffic present. It is common for afternoon peak period travel to lead to higher crash levels than other parts of the day, as is the case in Lincoln (**Figure 9**).

2 http://dot.nebraska.gov/safety/crash/

Figure 8: Annual Severe & Non-Injury Crash Frequency by Day of Week

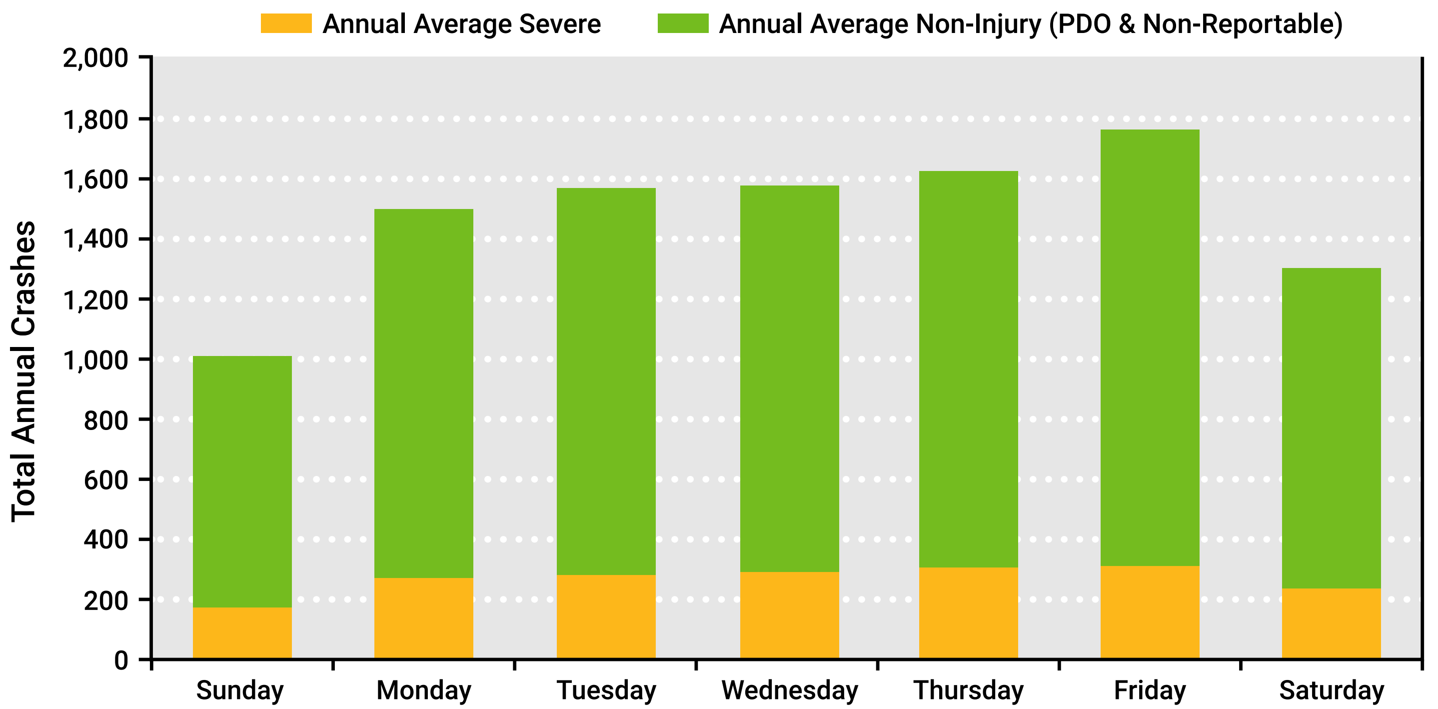


Figure 9: Annual Severe & Total Crashes by Time of Day

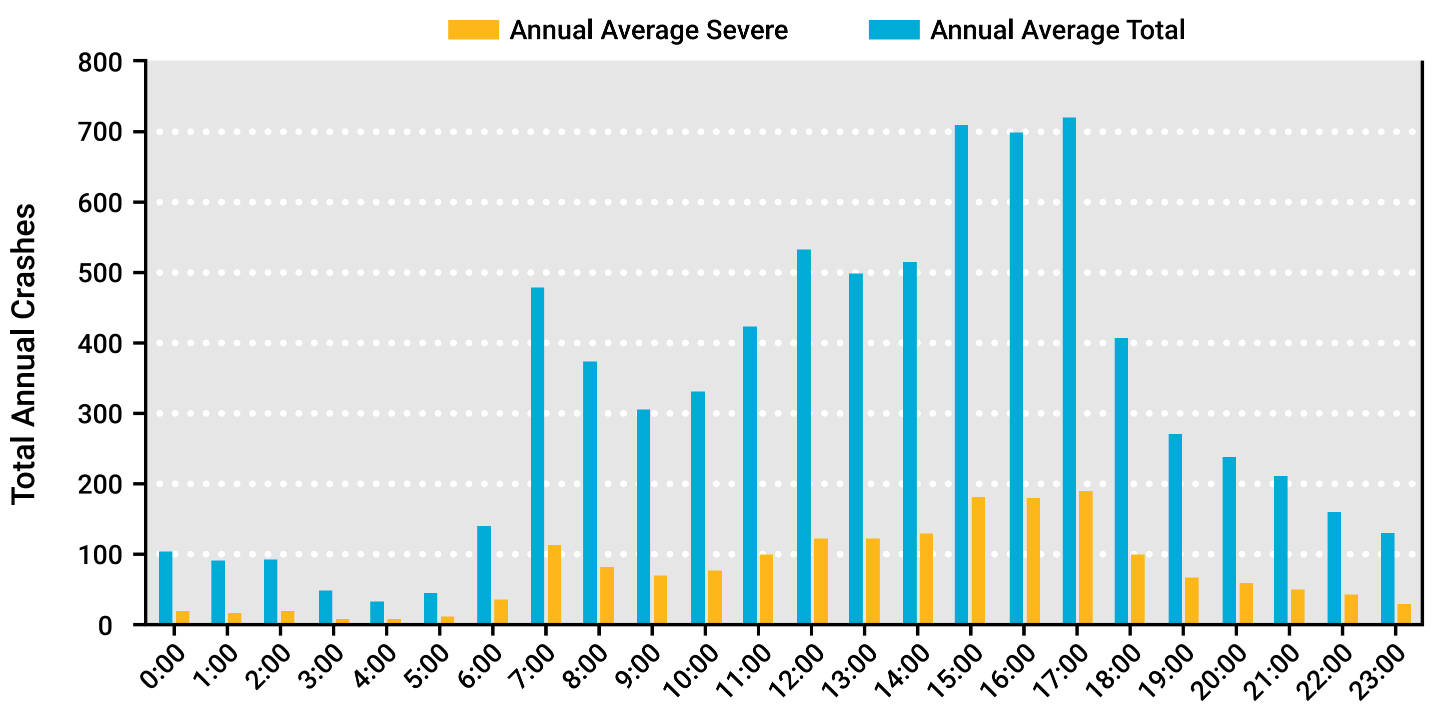


Figure 10: **Crashes by Light Condition, All Crashes**

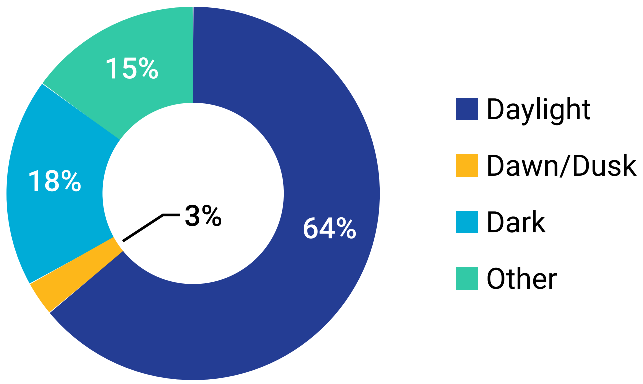
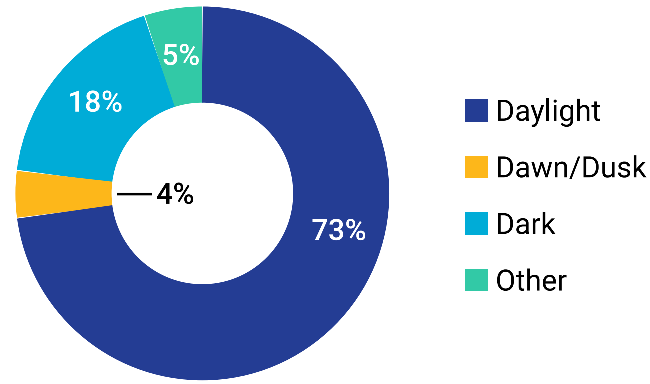


Figure 11: **Crashes by Light Condition, Severe Crashes**



The time of day trend in Lincoln shows higher levels of crash activity occur between 7 AM and 7 PM with highest peak during the evening peak period – 3 PM to 6 PM. That evening peak combined with a more moderate peak in crashes during the 7 AM to 8 AM hour suggest that countermeasures that reduce commuter congestion could produce safety benefits. The next highest concentration of crashes occurs from noon to 3 PM.

In addition to time of day, the light condition was reviewed for Lincoln crashes (Figure 10 and Figure 11). A majority of all reported crashes (64%) occurred during daylight conditions. For severe crashes, the percentage of daylight crashes increased to 73%. Dark conditions was the second most reported condition, with 18% for all crashes and severe crashes. This means severe crashes were three times more likely to happen in daylight conditions than any other light condition.

All of these prior charts confront the issue of **when** crashes occur and any connection the **when** might have to how to improve transportation safety in Lincoln. Focusing on **when** crash activity is highest, safety countermeasures should focus on weekday afternoon peak hours. Total crashes and severe crashes are highest from 3 pm to 6 pm and making changes that address that time frame cuts into one quarter of the City's crashes, so solutions that reduce queue lengths and provide drivers with improved crossing opportunities should be considered because they can benefit both the morning and afternoon peak periods.

Why

Table 1 summarizes several factors that are recorded in Lincoln's crash records and that may have contributed to crashes. This analysis of special factors shows that alcohol related crashes make up 4% of crashes and 6% of severe crashes. What is more significant is the number of crashes related to driver distraction. Distracted crashes make up 15.5% of total crashes as well as 15.5% of severe crashes. The combined effect is that one in five crashes

Table 1: **Annual Severe & Total Crash Frequencies by Special Factor**

	Severe Crashes		Total	
	Average Annual	Percentage	Average Annual	Percentage
Motorcycle	80	4.3%	120	1.4%
Work Zone	66	3.5%	274	3.2%
Alcohol	111	6.0%	351	4.1%
Distracted	290	15.6%	1315	15.5%

involve alcohol or distracted driving. The involvement of driver behavior in past crashes presents an opportunity to engage stakeholders and promote increased education and enforcement.

Additionally, crashes in work zones account for just over 3% of crashes, both total and severe. Motorcycles were involved in 1.4% of all crashes, but the percentage increased to 4.3% when considering only severe crashes. This illustrates how motorcyclists are susceptible to injury when involved in a crash.

Where and What

Shifting from the topics of **when** and **why** crashes occurred, the project team looked further into the **where** and **what** of crash activity in Lincoln. The **what** refers to crash type; Figure 12 provides the details.

The five most frequent crash types in Lincoln are (in order): rear end, right angle, parked, turning, and ran off road. The most prominent of those types is the rear end crash, which also ends up being the most frequent crash type for severe crashes. The second most common crash type and fourth most common crash type have similar traits. In both cases, traffic is making a crossing maneuver, which means that the crashes are likely at an intersection or other access point.

In understanding the nuance behind the **what**, safety analysis must consider that the street itself changes between crash locations. The best diagnosis of the **what** of crash history occurs at a single intersection or mid-block segment, which delves into the **where** part of the story. Answering the **where** in examining crash patterns was accomplished by investigating the general location of crashes. To inform the plan, the city-wide crashes needed to be divided between crashes that occur at intersections and those that occur on street segments between intersections. Figure 13 shows the split of crashes between street segments and intersections and Figure 14 looks at the same breakdown for severe crashes, or those crashes that result in an injury or fatality.

Clearly a greater safety emphasis can be placed by the City on intersections as they experience more crashes and a good deal

Figure 12: Annual Severe & Total Crash Frequencies by Crash Type versus Average Crash Frequency

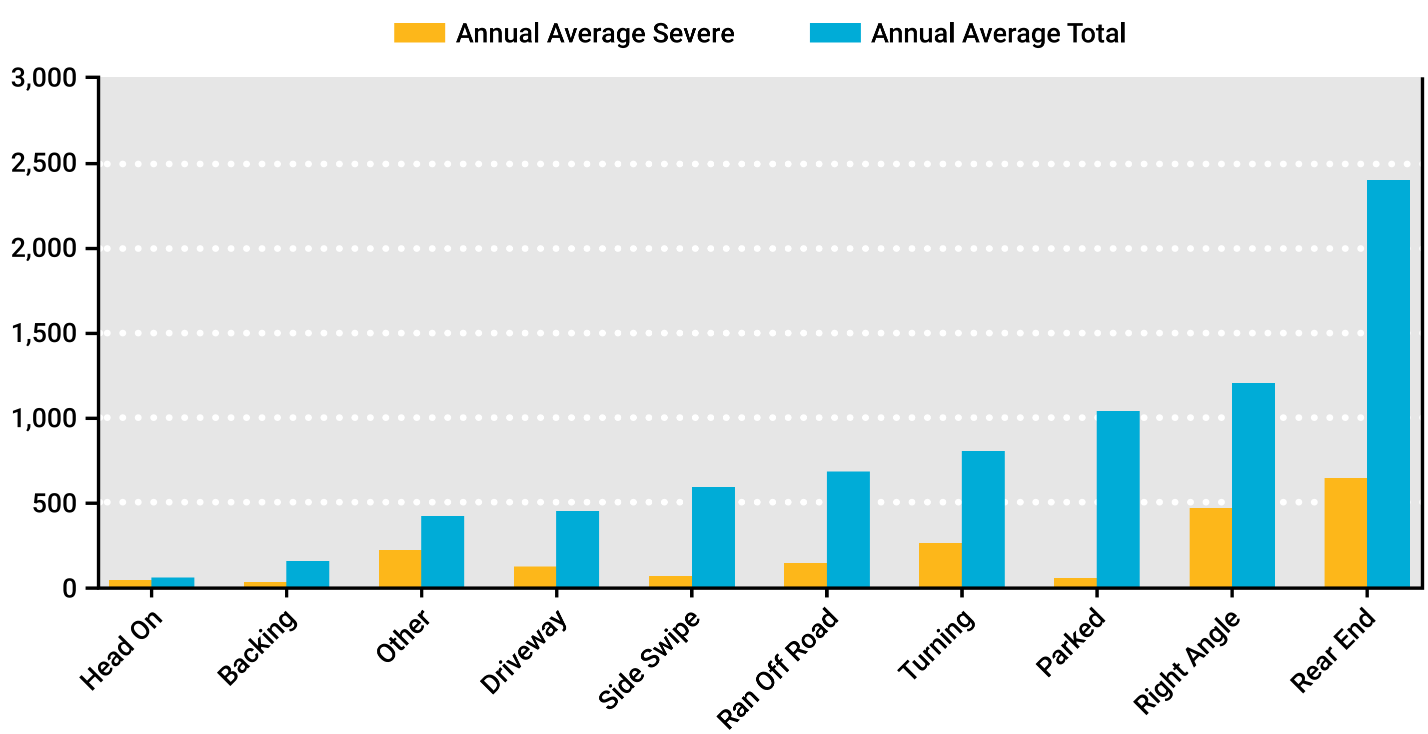


Figure 13: **Comparison of Intersection & Street Segment Crash Frequencies, All Crashes**

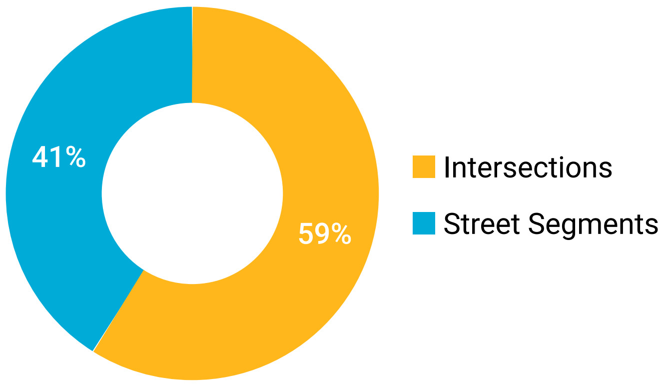
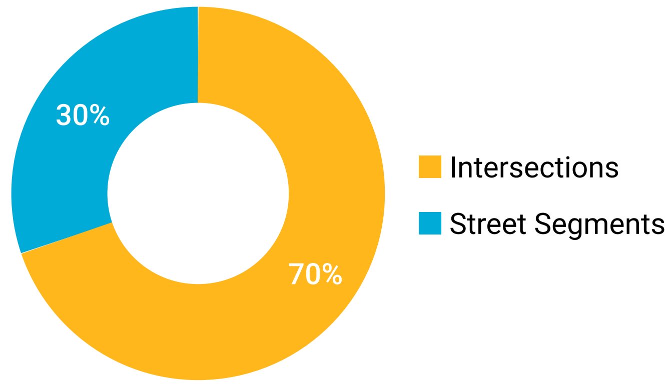


Figure 14: **Comparison of Intersection & Street Segment Crash Frequencies, Severe Crashes**



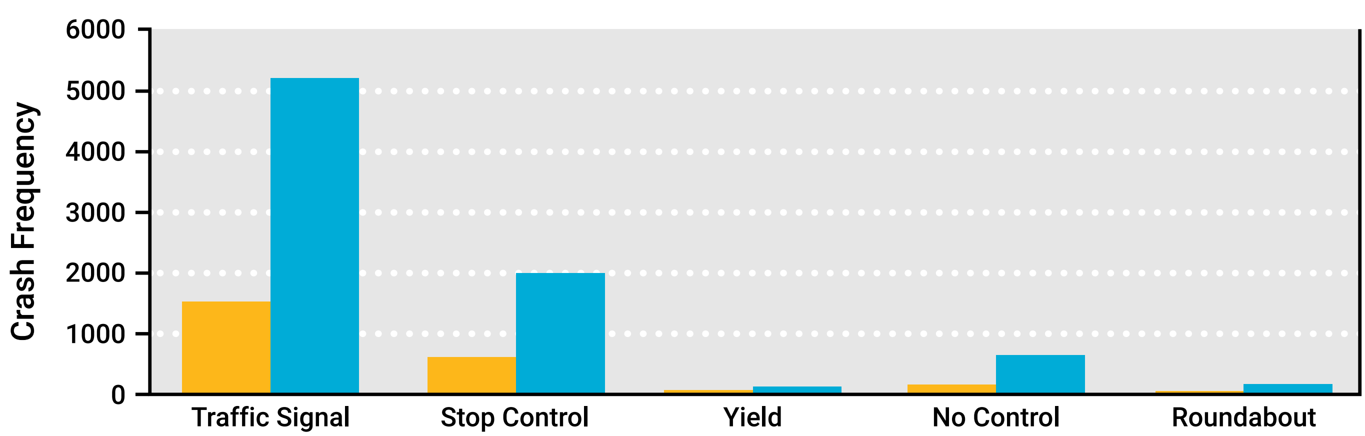
more severe crashes. Intuitively, a greater number of crashes at intersections would be expected due to the crossing of streams of traffic. As such, the resulting plan focuses more heavily on intersections, but does not overlook countermeasures that apply to segments.

Digging deeper into the **where**, the intersection crashes were examined to see which types of intersections experience the largest concentrations of crashes. The two characteristics of intersections considered in this analysis were the traffic control type at the intersection and the functional class of the crossing streets. **Figure 15** looks at the crash frequencies by each traffic control device.

The crash frequency reveals that intersection crashes are most common at traffic signals and stop controlled intersections. However, there are many more stop controlled intersections in Lincoln than signalized intersections. Therefore, once controlled for exposure the average crash rate is lower at stop controlled intersections

Crash frequencies were also analyzed by functional class of the intersecting streets. A majority of severe intersection crashes, 89%, occur at intersections where at least one of the intersecting streets is a major type street and 52% occur at the intersection of two major streets. As such, analyzing the crash type distribution of major streets can provide insights into crash types that affect the most Lincoln travelers. The only other functional class type with a large share of intersection crashes are local streets. Local street intersections see

Figure 15: **Annual Average Severe & Total Intersection Crash Frequencies by Traffic Control Type**



	Traffic Signal	Stop Control	Yield	No Control	Roundabout
Severe	1535	625	30	170	25
Total	5,225	2,015	120	660	165

Figure 16: **Crash Types at Signalized Intersections of Two Major Streets, All Crashes**

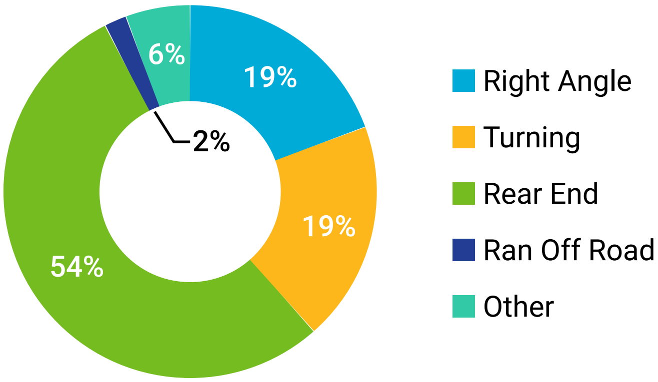


Figure 17: **Crash Types at Stop-Controlled Intersections of Two Major Streets, All Crashes**

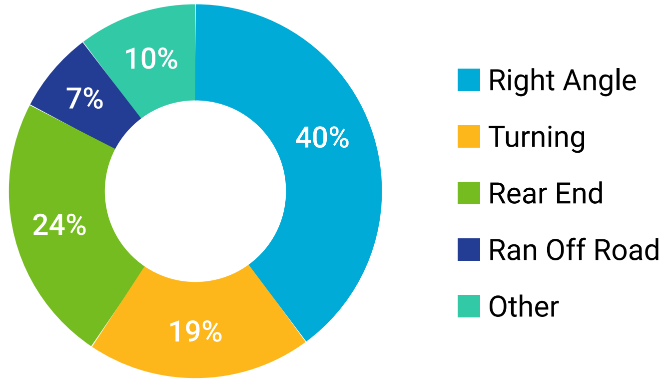


Figure 18: **Crash Types at Signalized Intersections of Major and Collector Streets, All Crashes**

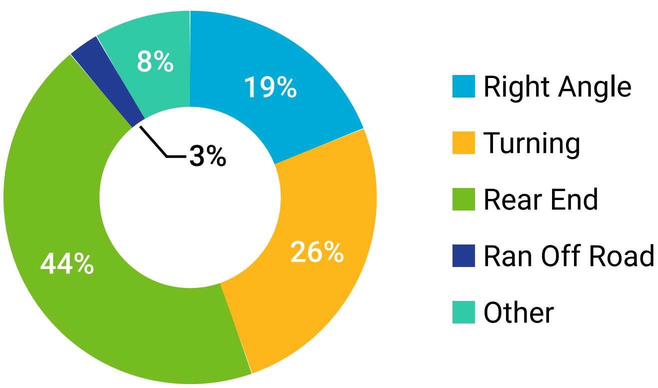


Figure 19: **Crash Types at Stop-Controlled Intersections of Major and Collector Streets, All Crashes**

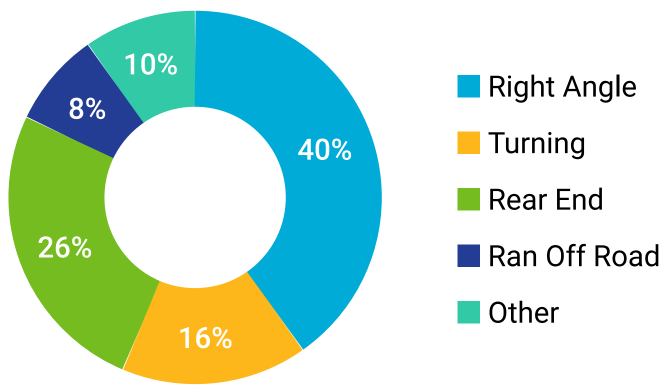


Figure 20: **Crash Types at Signalized Intersections of Major and Local Streets, All Crashes**

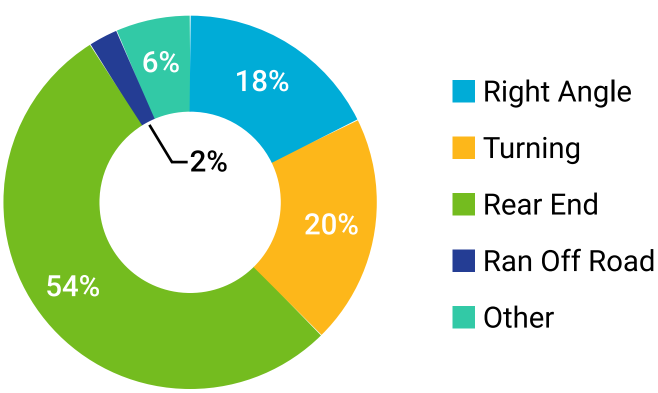
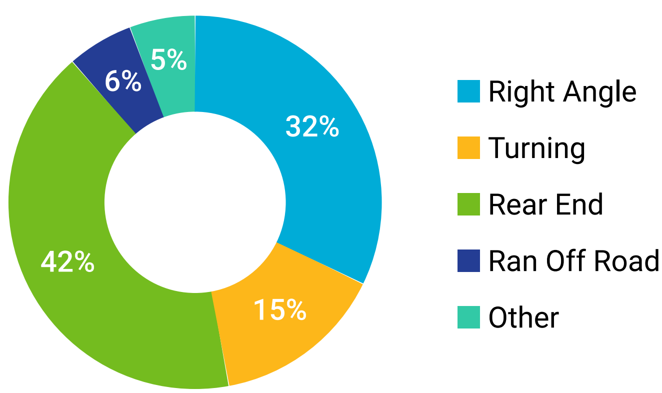


Figure 21: **Crash Types at Stop-Controlled Intersections of Major and Local Streets, All Crashes**



most of their crashes where they intersect major streets, where local traffic intersects a street with much higher traffic volumes and higher speeds. The remaining categories make up a lower relative frequency of crashes, but may include some problem locations. The following six figures look at the interrelated patterns of crash type, functional class, and traffic control.

Figures 16-21 show the balance of how crash patterns change due to intersection function and design. First, rear end crashes are higher at traffic signals than at stop-controlled intersections by 12% to 30%. Second, at major/major and major/collector stop-controlled intersections, right angle crashes account for roughly 15% more crashes than rear end crashes. However, that pattern does not hold true for major / local street stop-controlled intersections which see 42% rear end crashes and 32% right angle crashes. The third significant crash type is turning crashes, which make up 15% to 26% of crashes depending on the cross street functional class and control type.

After establishing key intersection crash patterns, additional analysis of street segments was conducted. As previously discussed, street segments experience 41% of crashes city-wide and 30% of severe crashes. The first exercise to better understanding those segment crashes is in looking at the crash frequency by the number lanes the street carries.

Figure 22 and **Figure 23** show a distribution of crashes by cross section that is predominately two-lane streets or divided streets with four or more lanes. Combined, these two cross sections account for 77% of total crashes and 73% of severe crashes. These are also the two most common street types in the City of Lincoln. Therefore, to normalize the amount of crash activity using volume, **Figure 24** was developed to look at segment crash rates of each cross section type present in the City's system.

The crash rate breakdown allows for a refined understanding of the two-lane and four or more lane (divided) crash frequency pattern. The City

Figure 22: Street Segment Crashes by Cross Section, All Crashes

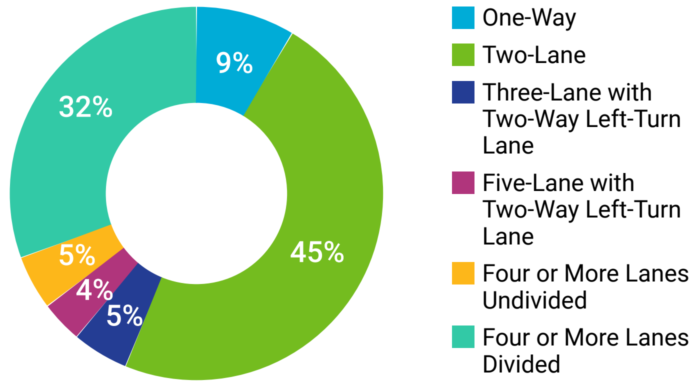
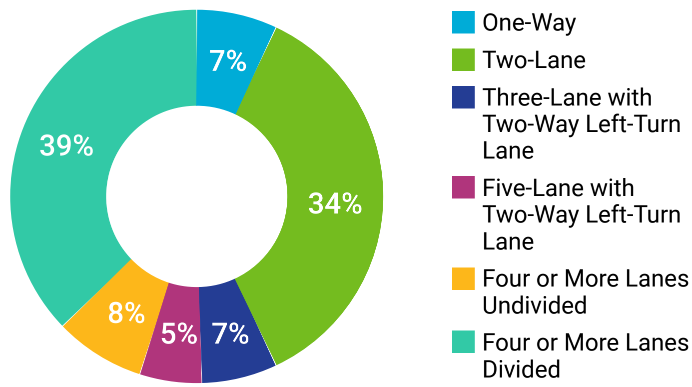


Figure 23: Street Segment Crashes by Cross Section, Severe Crashes

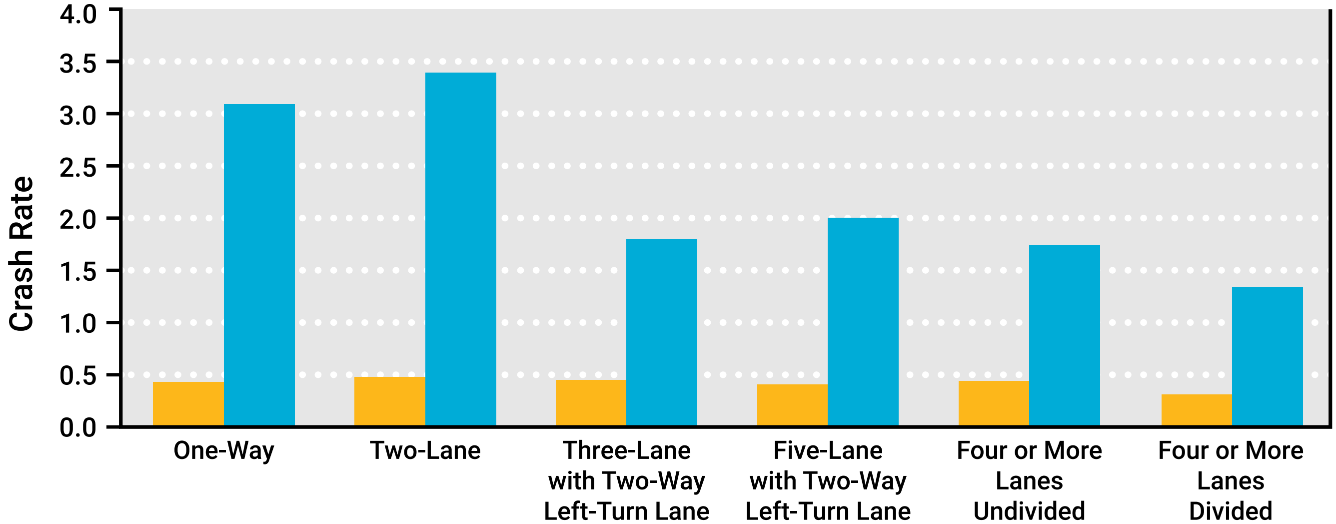


has many more two-lane cross sections than any other street type, but these tend to carry relatively low volumes, which is why two-lanes have the highest total crash rate in Lincoln.

One-way streets have the second highest total crash rate and the remaining cross sections have similar total crash rates, although the rate for four or more lanes (divided) is the lowest. Comparing the different cross sections, the severe crash rates are similar. Two-lane, three lane (with center turn lane) and four or more lanes (undivided) have the highest crash rates but with very small differences between each. Similar to total crash rate, four or more lanes (divided) has the lowest severe crash rate of all cross section types.

The segment characteristic related to cross section that requires further analysis is crash

Figure 24: **Annual Average Severe & Total Crash Rate by Cross Section Type**



	One-Way	Two-Lane	Three-Lane with Two-Way Left-Turn Lane	Five-Lane with Two-Way Left-Turn Lane	Four or More Lanes Undivided	Four or More Lanes Divided
Severe	0.43	0.48	0.47	0.42	0.46	0.31
Total	3.08	3.41	1.84	2.03	1.74	1.36

activity relative to functional class. **Figure 25** and **Figure 26** were developed to assess which functional classes of streets experience greater crash activity.

The pattern of crashes by functional class changes between total crashes and severe crashes. For total crashes, major streets still experience a majority of crashes, but 25% of all crashes occur on local streets. When focusing on severe crashes, the share of local street crashes drops from 25% to 11%. **Figure 25** and **Figure 26** when compared with **Figure 22** and **Figure 23** suggest that the local street crash problem and two-lane cross section crash pattern are related. However, with the severe local street crash frequencies being lower than the severe two-lane street crash frequency, the data suggests that a number of crashes occur on two-lane cross section streets that are also considered major or collector streets.

In order to link the **where** of segment crashes with the **what**, a breakdown of crash types was developed for just segment crashes.

Figure 27 and **Figure 28** show that segment crash types include a different mix of crash types than intersections: side swipes, parked vehicle, driveway-related, and run off road crashes. For total crashes, segment crashes were heavily concentrated on parked vehicle

Figure 25: **Street Segment Crashes by Functional Classification, All Severities**

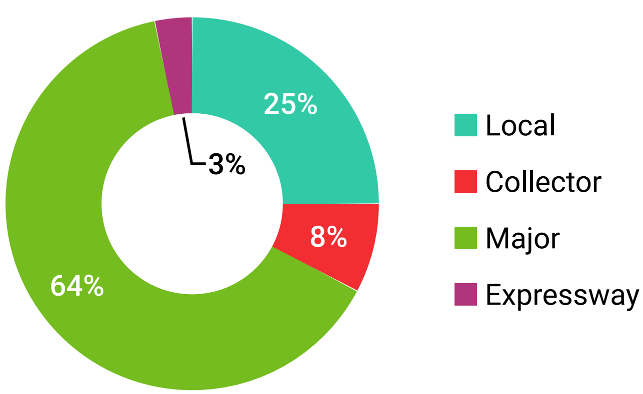


Figure 26: **Street Segment Crashes by Functional Classification, Severe Crashes**

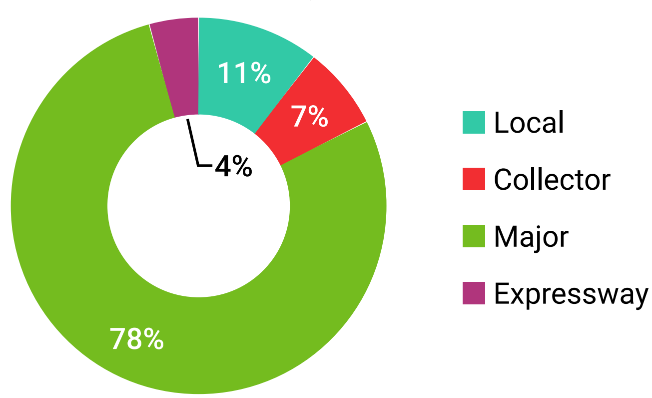


Figure 27: **Street Segment Crashes by Crash Type, All Severities**

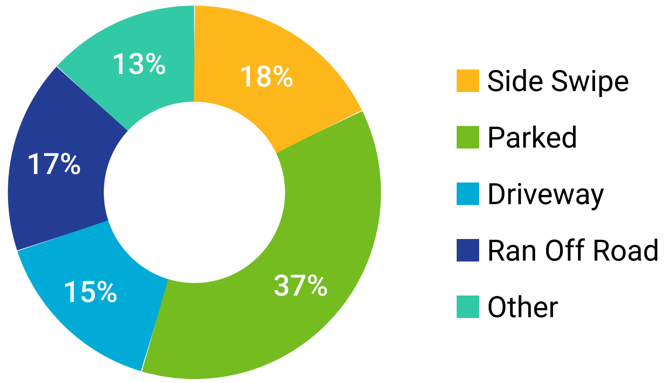
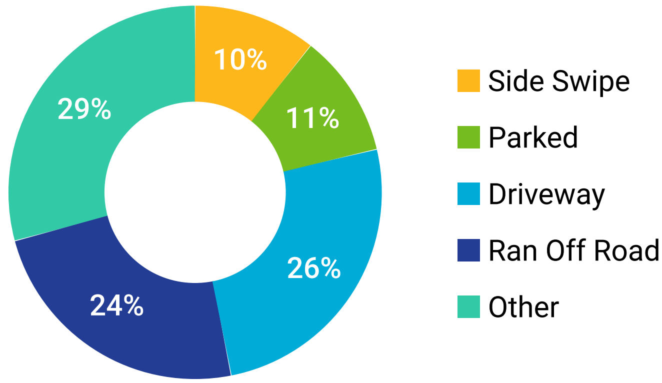


Figure 28: **Street Segment Crashes by Crash Type, Severe Crashes**



crashes. The most likely explanation is that vehicles are trying to maneuver into adjacent on street parking stalls and hitting a vehicle or clipping a parked vehicle while trying to maintain or change lanes. Whatever the reason, both parked vehicle crashes and side swipe crashes tend to have a low likelihood of injury. On the other hand, driveway crashes and run off road crashes exhibited a lower frequency (combined 32% of segment crashes), but higher severity (a combined 50% of segment crashes).

Summary

The overall combination of **where** with **what** creates a focus for targeted mitigation.

- The City should consider its major street intersections to be a primary priority because those intersections account for 89% of all crashes.
- The data shows that at those major intersections, countermeasures that address rear end and angle crashes would support appreciable crash reductions.
  - Rear end crashes indicate unexpected slow traffic, so improvements to congestion, greater visibility, and reductions in speed differential are all strategies that could lead to a reduction in rear end crashes.
  - For angle and turning crashes, improvements to intersection signal timing, sight distance of opposing traffic, and traffic control improvements can all play a role in offsetting these major intersection crash patterns.
- Another key focus area is the number of crashes occurring on street segments.
  - Looking at total crashes, the most frequently occurring crash type is crashes involving parked vehicles.
  - Focusing on severe crashes, segment countermeasures must reduce the potential for injuries due to driveway-related collisions and run off road crashes.
  - Countermeasures that mix policy and design on the provision of access and parking may support lower crash frequencies and severe crash frequencies on Lincoln street segments.

CHAPTER 3: PEDESTRIAN & BICYCLE CRASH PATTERNS

As established in the Introduction, recent pedestrian and bicycle crash patterns represent an opportunity to improve Lincoln traffic safety. In the last five years, bicycle and pedestrian crashes have represented roughly 12% of all severe crashes (Figure 5). That pattern is over represented because pedestrian and bicycle crashes account for only 3% of total crashes.

The increase in pedestrian and bike severe crash frequency compared to total crash frequency is driven by nearly 92% of all pedestrian and bicycle crashes resulting in an injury.

Pedestrian and bicycle crash patterns were reviewed using a method similar to the analysis of all crashes city-wide. In many cases, pedestrian and bicycle crash patterns were similar to total crash patterns, for which the findings of those breakdowns are not repeated. Yet, in cases where pedestrian and bicycle crash patterns diverged from the overall crash trend, the cause or **why** behind that divergence was investigated.

When and Why

Pedestrian and bicycle crashes were investigated for monthly variations. Unlike total crashes, pedestrian and bicycle crashes begin to decrease in October and continue to decrease through the winter months, reaching a low in February, as seen in Figure 29.

Crash variation was also investigated by day of week for pedestrian and bicycle crashes (Figure 30).

The largest difference in crash patterns for pedestrian and bicycle crashes compared to total crashes is the lower frequency of crashes on Friday relative to other days of the week.

Pedestrian and bicycle crashes were also found to deviate from total crash patterns in some aspects of the time of day distribution (Figure 31).

Figure 29: Average Annual Total & Severe Pedestrian and Bike Crashes by Month of Year

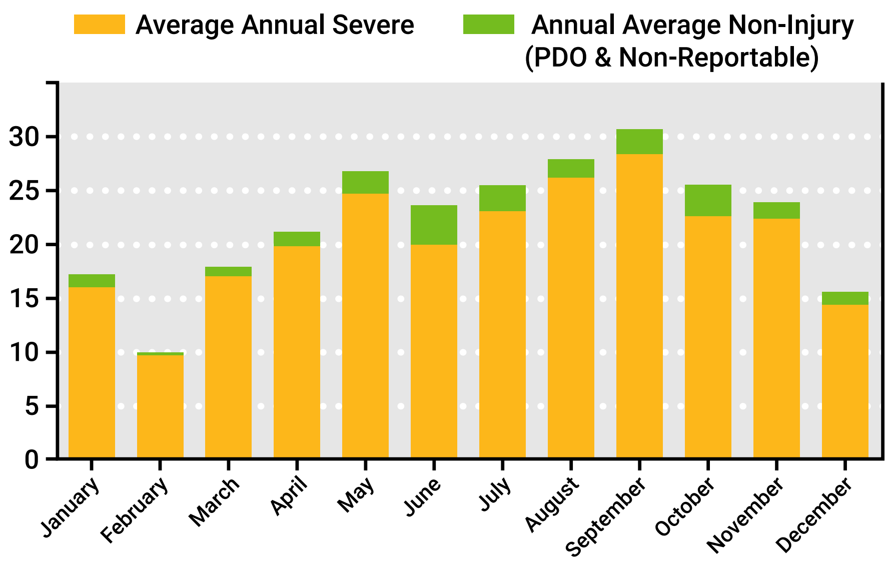


Figure 30: Annual Severe & Non-Injury Pedestrian and Bike Crashes by Day of Week

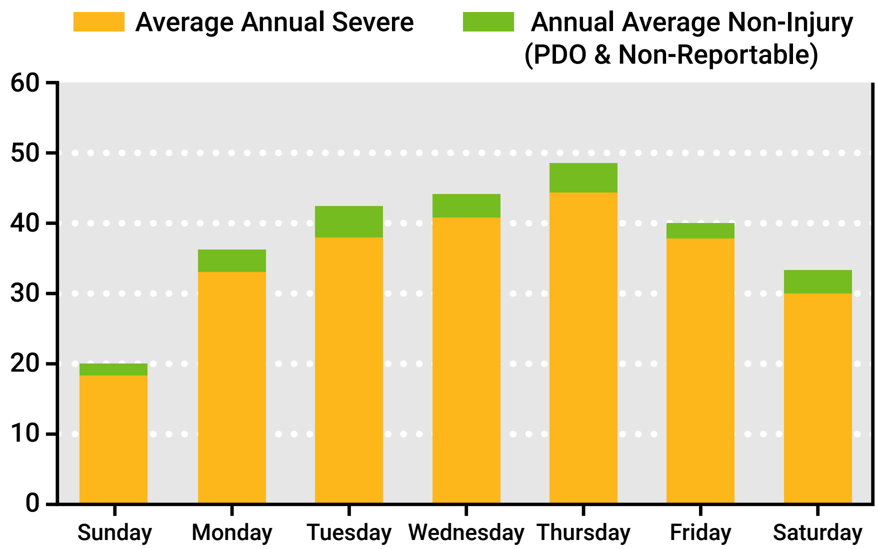
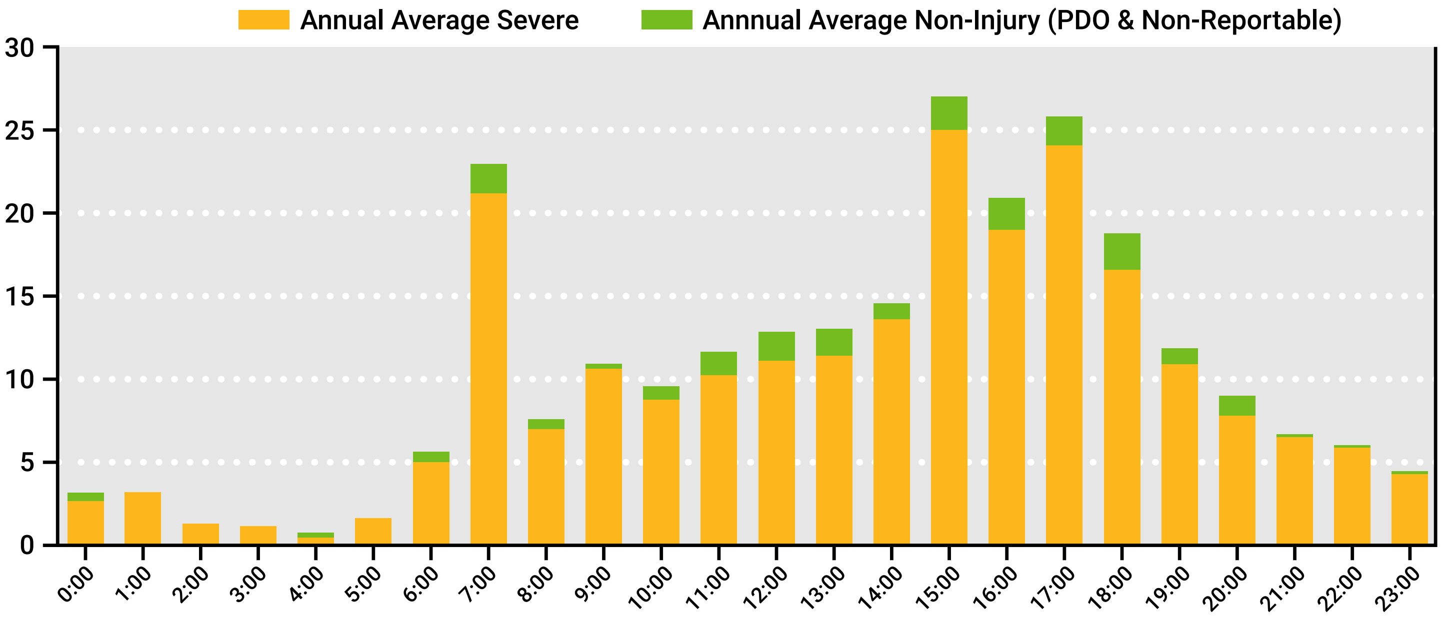


Figure 31: **Annual Severe & Non-Injury Pedestrian and Bike Crashes by Time of Day**



The total crash pattern showed much higher crash levels for autos-only during the midday than pedestrian and bicycle involved crashes. Pedestrian and bicycle involved crashes have similar high AM and PM peak period frequencies (although pedestrian and bicycle crashes have a much stronger morning peak hour), suggesting pedestrians and bicyclists are most at risk when auto traffic levels are higher.

Where

Where pedestrian and bike crashes occurred varied between intersection crashes and segment crashes, by functional class, by control type, and by number of lanes in the street segment cross section.

The first **where** factor considered was breakdown between intersection and segment.

Pedestrian and bicycle crashes are more heavily concentrated around intersections than total crashes (**Figure 32** shows 67% of vehicle crashes with pedestrians and bicyclists were at intersections compared with **Figure 13** that shows 59% of all vehicle crashes occurring at intersections). However, the trend for severe crashes changes since severe pedestrian and bike crashes at intersections is a slightly lower percentage than all severe vehicle crashes

Figure 32: **Comparison of Intersection versus Segment Average Annual Pedestrian & Bike Crash Frequencies, All Crashes**

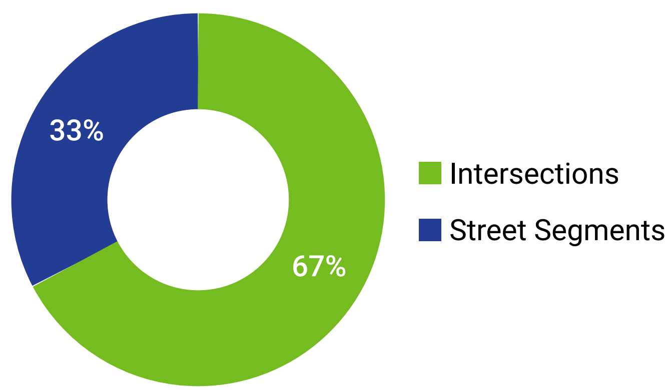
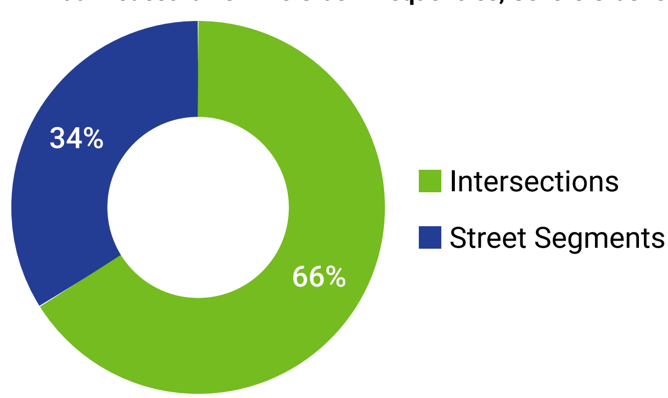


Figure 33: **Comparison of Intersection versus Segment Average Annual Pedestrian & Bike Crash Frequencies, Severe Crashes**



(**Figure 33** shows 66% of severe pedestrian and bicycle crashes at intersections compared with **Figure 14** that shows 70% of all severe vehicle crashes occurring at intersections). Those differences considered, still the most prominent location for pedestrian and bike crashes is the intersection.

Breaking the crash patterns down at intersections further, the number of pedestrian and bicycle crashes were reviewed by intersection facility type.

Figure 34: Average Number of Pedestrian and Bicycle Crashes in Five Years (crashes per intersection)

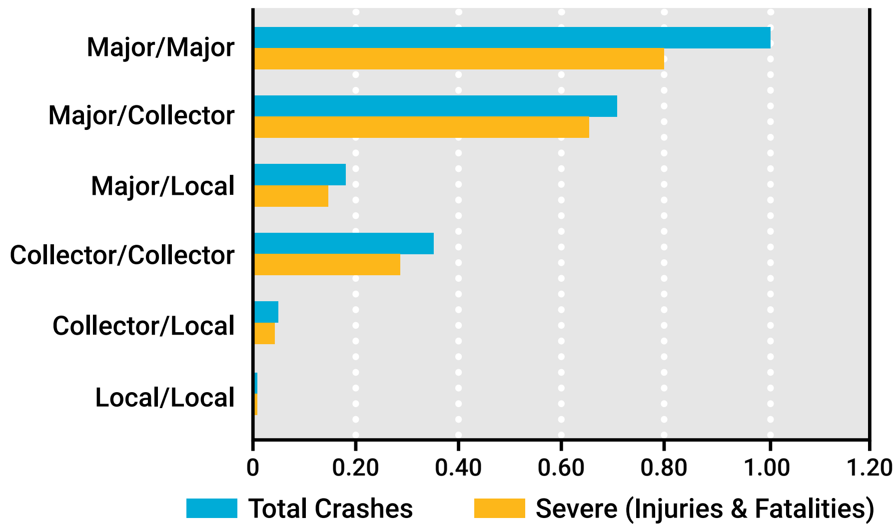
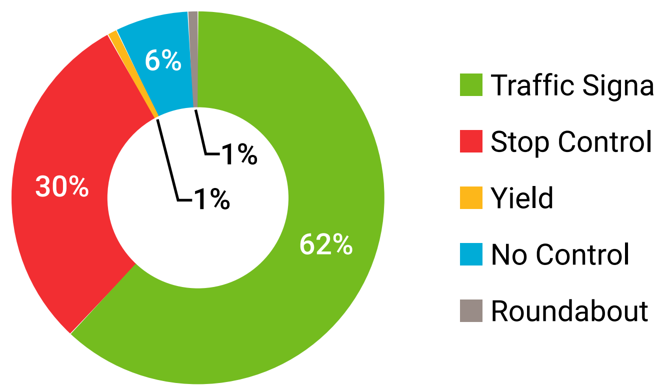


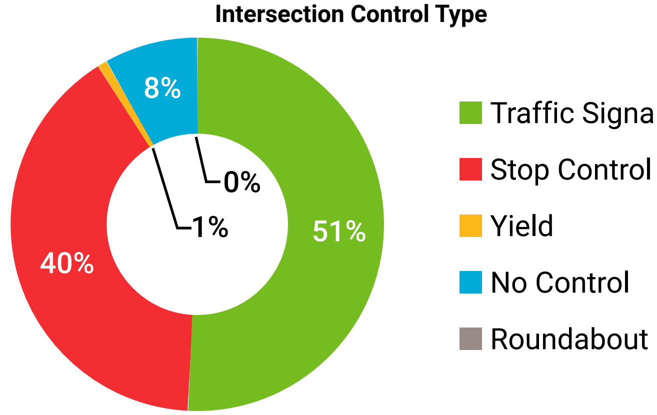
Figure 34 summarizes the average number of pedestrian and bicycle crashes at an intersection over a five year span. For example, an intersection of two major routes (i.e., Major/Major) averaged one crash involving a pedestrian or bicycle over the past 5 years. The data reveals that bike and pedestrian crashes at intersections were predominantly a major street problem. Targeted bike and pedestrian improvements can achieve the largest crash reduction when deployed at major intersections.

Figure 35: Average Annual Pedestrian Crashes by Intersection Control Type



The bike and pedestrian intersection crash data was then reviewed for crash patterns by control type. **Figure 35** reviews pedestrian crashes only while **Figure 36** shows bicycle crashes.

Figure 36: Average Annual Bicycle Crashes by Intersection Control Type



Over 90% of pedestrian and bicycle intersection crashes occurred at two control types. Most crashes were at a signalized intersection (62% pedestrian; 51% bicycle), followed by stop controlled intersections (30% pedestrian; 40% bicycle). Given the greater number of pedestrian and bicycle crashes at traffic signals and that there are fewer traffic signals than stop controlled intersections, signalized intersections provide the best opportunity to address pedestrian and bike safety needs.

A segment-related crash analysis was also conducted. The data captured in **Figure 37** (pedestrian crashes) and **Figure 38**

Figure 37: **Average Annual Pedestrian Crashes by Street Segment Cross Section Type**

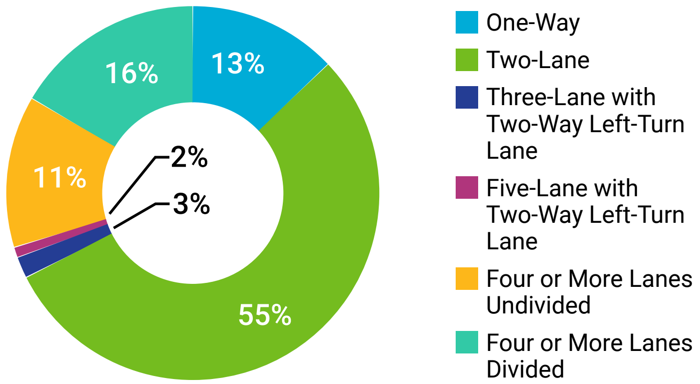
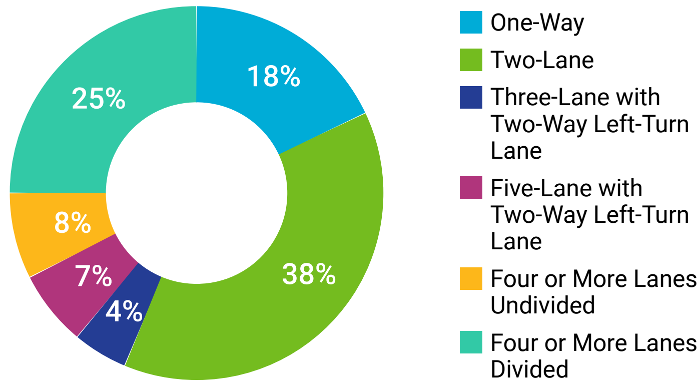


Figure 38: **Average Annual Bicycle Crashes by Street Segment Cross Section Type**



(bike crashes) identifies that a few segment cross sections account for a majority of crashes. Half of bicycle crashes occurred on two-lane (38%) and four or more lane divided (13%) streets. Over 70% of pedestrian crashes occurred on these two type of street cross sections. Two lane facilities may represent primarily local streets and a smaller number of collector or major streets in contrast with four lane facilities that exclusively serve major street traffic.

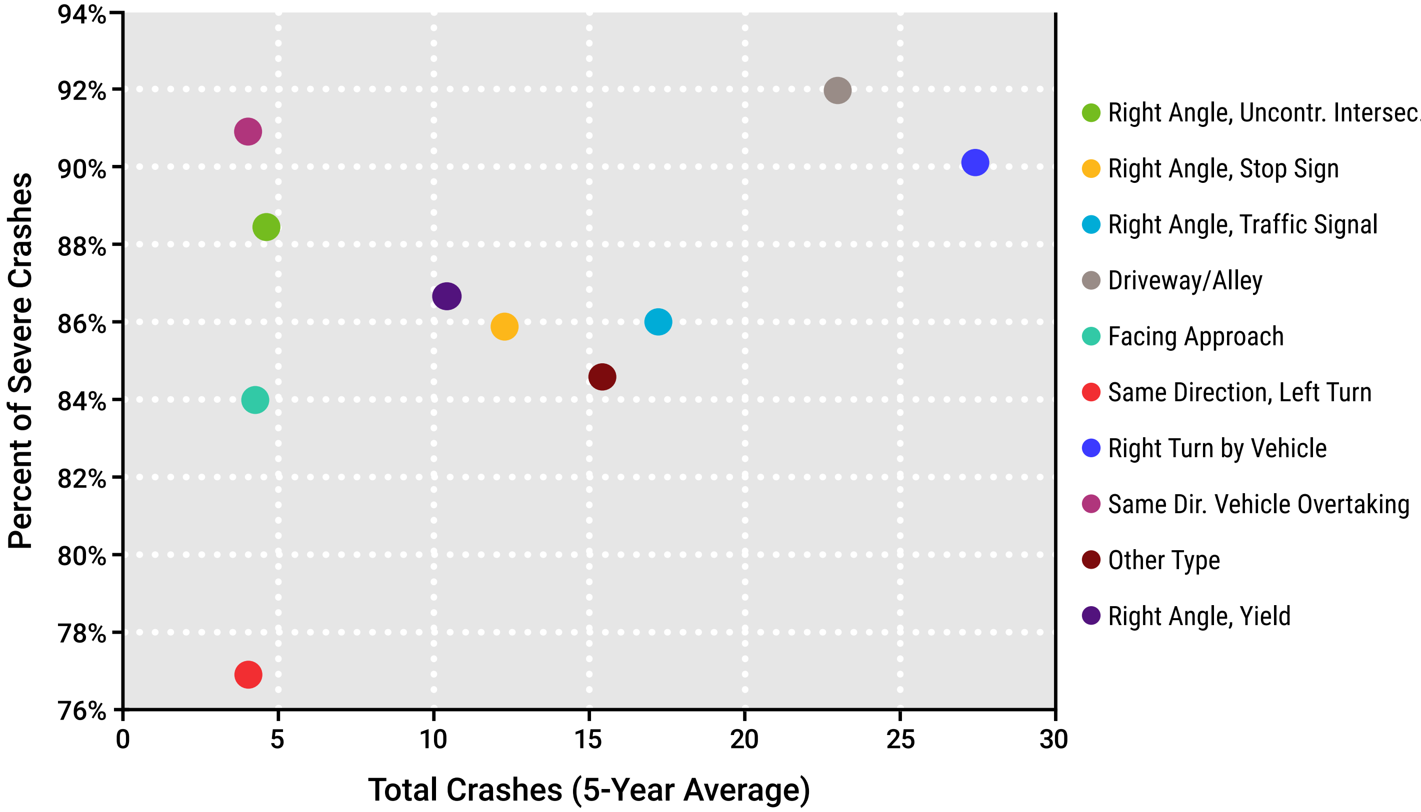
The third highest for pedestrian and bike crashes are one way streets. One way streets make up a smaller portion of the Lincoln transportation network, but are prominent in downtown Lincoln, which has high activity levels of active transportation.

What

The biggest difference in pedestrian and bicycle crashes versus all mode crashes is the crash type or the **what**. The patterns of crashes can change drastically between whether the focus of analysis is on the collision of an auto and a bike or an auto and a pedestrian. **Figure 39** shows the frequency and severity of bike crashes by type and **Figure 40** shows the frequency and severity of pedestrian crashes by type. For example, **Figure 39** shows that 27 bike crashes per year are of the crash type: right turn by vehicle. In this type of crash where a bike is struck by a right turning vehicle, **Figure 40** also shows that roughly 90% of crashes of that type are severe crashes.

The two figures show the variation of both crash frequency and crash severity for a number of crash types. Generally, the largest crash issues are toward the top right of the chart. Since pedestrian and bike crashes already exhibit high risk of severity, the crashes to the right of the chart are good crash types to target for countermeasures. For bike crashes, the four most frequent crash types are right turn by vehicle, driveway/alley, right angle at traffic signal, and same direction left turn. For pedestrian crashes, the three most frequent crash types are left turn at intersection, unauthorized crossing, and right turn at intersection.

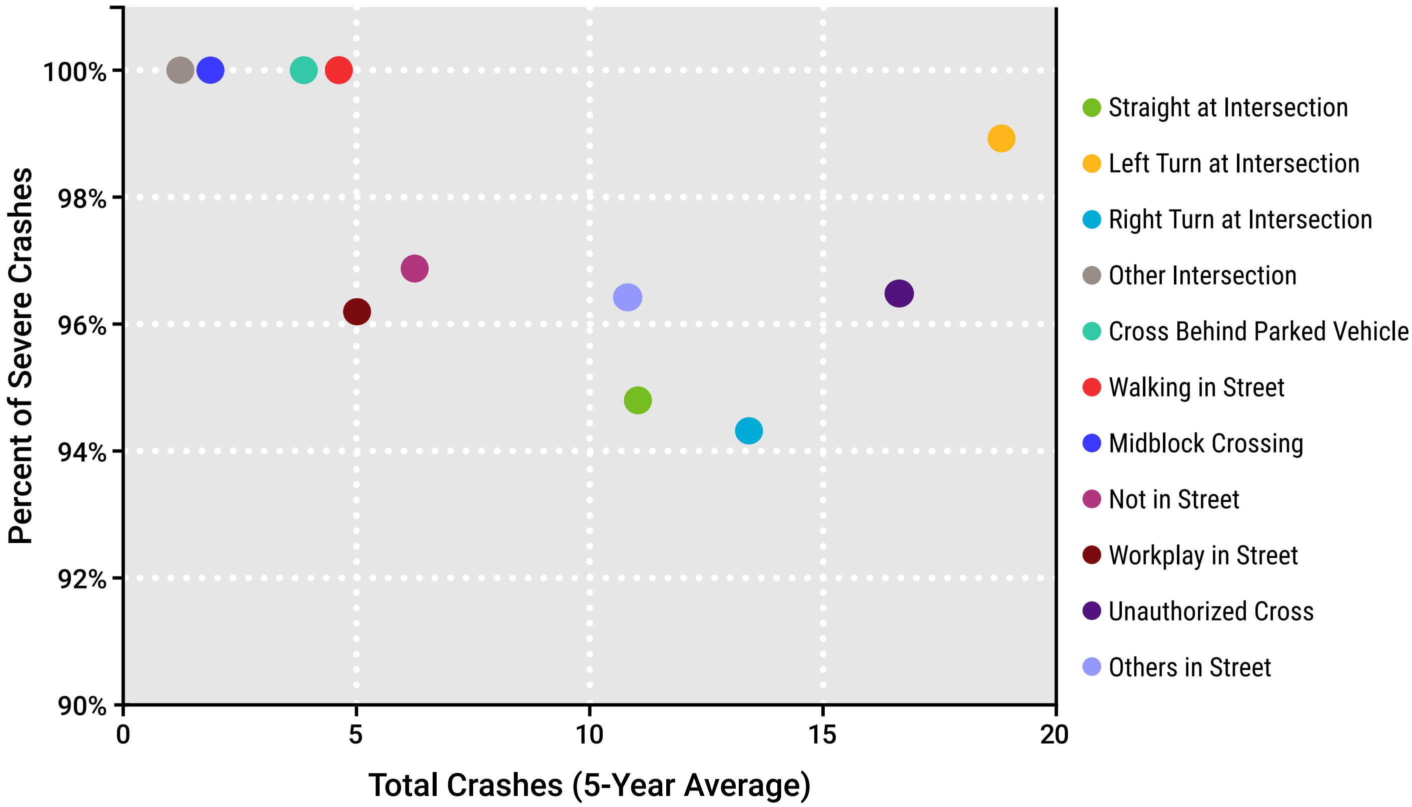
Figure 39: Annual Bike Crashes by Crash Type and Percent Severe



Summary

- There are fewer pedestrian and bicycle crashes than auto-only crashes in Lincoln, but pedestrian and bicycle crashes make up 12% of all severe crashes.
- The limited number of crashes makes diagnosing safety issues more challenging, which the project team addressed by reducing the number of factors analyzed compared to the all mode crash analysis and by performing fewer joint analyses of multiple factors.
- The isolated analysis of **where** pedestrian and bicycle crashes occurred highlighted crash concentrations on major streets, particularly at intersections.
- When focused just on segment crashes, the highest rate of severe pedestrian and bike crashes occurred on one way streets, like those in the downtown area.
- The **what** crash type analysis identified seven crash types that account for the highest frequency of pedestrian and bicycle crashes.
  - Of those crash types, five are the result of turning movements by vehicles through the path of the pedestrian or bicyclist.
  - Countermeasures to address these turning crashes can range from complete removal of the conflict (closing access points, prohibiting turning movements) to improved management of the conflict area (intersection leading pedestrian interval, improved striping / signing / visibility of the crosswalk).
  - Other countermeasures to address crossing violations may look at both design opportunities for more frequent crossings and increased enforcement of jaywalking on high volume streets.

Figure 40: Annual Pedestrian Crashes by Crash Type and Percent Severe



CHAPTER 4: TARGETED INTERSECTIONS

The City of Lincoln maintains an intersection identification database, which includes roughly 6,300 intersections. Each of these intersections represents a crossing point of multiple conflicting traffic flows. From the period 2012-2016 a total of nearly 2,650 intersections experienced at least one crash. This widespread crash dispersion underscores why the City of Lincoln focuses on city-wide crash activity. Locating crash activity is also connected to another agency focus: helping the City of Lincoln understand where the highest concentrations of crashes are located, locations where the City can make an improvement in order to best utilize limited resources for improvements. Based upon the data review, the study team selected 25 intersections to undergo further study and consideration for safety countermeasures.

Screening Methodology

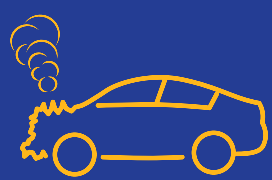
The project team calculated crash rates for each intersection within the City's system. The crash rate was a simple ratio of number of crashes to exposure to risk, which for intersections is taken as number of vehicles entering an intersection, in millions.

The City of Lincoln provided both the crash records to identify number of crashes and the estimated daily traffic volumes entering each intersection. The crash rates provided a measure for rating how well each intersection performed from a safety context, but to establish locations of need, a reference crash rate needed to be determined. In this study, the chosen threshold between intersections considered for further study and those eliminated was the critical crash rate.

Critical crash rate is based on the average crash rate for similar intersections in the City and results in a threshold from that average that takes into consideration the level of traffic volume at individual intersections. The critical crash rate method creates a more rigorous criterion for consideration of further study than just comparing intersections to an average value. It also controls for bias at low volume locations. The breakdown of what portion of the Lincoln system exceeds the critical crash rate is shown in **Table 2**.

As the table shows, 607 of 6,227 intersections exceed the threshold of critical crash rate and were considered further.

INTERSECTION CRASH RATE =
NUMBER OF CRASHES / EXPOSURE



Exposure = *5 year study period * 365 days per year * Average daily entering vehicles*

CRITICAL CRASH RATE =

$$\text{AVERAGE CRASH RATE}_i + K_{95} * \sqrt{\frac{\text{AVERAGE CRASH RATE}_i}{\text{EXPOSURE}}} + 0.5 / \text{EXPOSURE}$$

i = *Class of intersection based on the facility type of the crossing street and intersection control type*
K_{95} = *The 95th percentile confidence interval based on a standard normal distribution, 1.645*

Table 2: Intersections Above Critical Crash Rates by Functional Class and Control Type

Class	Control	Intersections Above Critical	Percent of Intersections Above Critical
Local/Local	STOP SIGN	15	10%
	YIELD SIGN	8	9%
	NO CONTROL	288	8%
	SUBTOTAL	**311**	**8%**
Collector/Local	STOP SIGN	18	11%
	YIELD SIGN	2	6%
	NO CONTROL	22	8%
	SUBTOTAL	**42**	**9%**
Collector/Collector	TRAFFIC SIGNAL	2	18%
	STOP SIGN	1	6%
	SUBTOTAL	**3**	**5%**
Major/Local	TRAFFIC SIGNAL	9	18%
	STOP SIGN	168	14%
	SUBTOTAL	**177**	**14%**
Major/Collector	TRAFFIC SIGNAL	12	14%
	STOP SIGN	14	19%
	SUBTOTAL	**26**	**16%**
Major/Major	TRAFFIC SIGNAL	35	18%
	STOP SIGN	12	30%
	ROUNDABOUT	1	11%
	SUBTOTAL	**48**	**20%**
All Intersections	TRAFFIC SIGNAL	58	17%
	STOP SIGN	228	13%
	YIELD SIGN	10	8%
	NO CONTROL	308	8%
	ROUNDABOUT	3	13%
	SUBTOTAL	**607**	**10%**

After calculating the critical crash rate to eliminate locations with lower levels of crash activity, the screening process required more stringent criteria to screen out additional intersections. The project team accomplished this task by developing a multi-criteria ranking system. Criteria ranked include:

- Crash frequency, all severity levels
- Crash rate, all severity levels
- Fatal and Injury crash frequency
- Fatal and injury crash rate
- Bicycle and pedestrian-involved crash frequency, all severity levels

As seen in **Table 3**, 104 fell within multi-criteria ranking. Further screening, review of individual intersections, and prior intersection countermeasures were utilized to develop the final list of locations.

The City of Lincoln is already undergoing a dramatic improvement program via Green Light Lincoln (GL2). The City's plan to improve corridor signal timings and the City's overall traffic management system may have many significant impacts to crash activity on improved corridors. Thus, when screening intersections, the project team focused on locations not part of the GL2 initiative at the time of study. In addition, the study team removed intersection locations with already programmed safety improvements in design/construction phases. Further, the project team and City staff identified three types of categories that were responsible for locations ranked high for crash activity: pedestrian and bike related crashes, unsignalized severe crashes, and overall high frequency crash locations. The pedestrian and bike and unsignalized locations typically represented a lower frequency of target crashes that could be reduced, so the project team identified a limited number of intersections in each category, with a goal to have at least 5 locations in the two categories. The remaining overall high frequency crash locations typically involved the crossing of two major streets at a traffic signal with very similar crash patterns. The process did not simply select the highest overall ranked locations. As earlier mentioned, consideration was given to pedestrian, bicycle, and severe unsignalized intersection crashes. Furthermore, crash frequency, percent of crashes that were severe, predominate crash types, and study team knowledge about locations were used to make the final determination.

Initially, 30 locations were selected because it was assumed several locations would not be suitable for the detailed site analysis (e.g., improvements made during the crash study period). The final 24 locations selected for study are shown on **Figure 41**, including four pedestrian and bike intersections, seven unsignalized severe crashes intersections, and 14 overall high frequency crash intersections. The final location selected (N 27th Street and King Lane) was discovered to have been improved after the detailed review began. A replacement location was not added; instead the final section of this chapter describes the improvement and the reduction in intersection crash frequency.

Table 3: Candidate Intersections by Crash Pattern Ranking

Green Light Lincoln Location | Selected Unsignalized Intersections | Removed from Consideration

Selected Pedestrian & Bike Intersections | Selected Signalized Intersections

"On Street"	"At/Between" Street	Class	Control	Number of Criteria Met	Crash Rate Rank	Severe Crash Rate Rank	Crash Total Rank	Severe Crash Total Rank	Ped & Bike Crash Total Rank	Average Rank
O ST	27TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	5	8	12	5	1	12	7.6
VINE ST	N 27TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	5	7	20	6	6	1	8.0
CORNHUSKER HWY	N 27TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	5	5	24	2	2	13	9.2
O ST	48TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	5	3	31	4	5	14	11.4
O ST	33RD ST	MAJOR/MAJOR	TRAFFIC SIGNAL	5	19	21	9	8	15	14.4
NEBR HWY	S 27TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	4	6	28	3	3	51	18.2
COTNER BLVD	O ST	MAJOR/MAJOR	TRAFFIC SIGNAL	4	17	15	8	4	51	19.0
KNOX ST	N 27TH ST	MAJOR/LOCAL	TRAFFIC SIGNAL	5	26	13	22	9	28	19.6
O ST	10TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	4	11	51	7	38	7	22.8
CAPITOL PKWY	S 27TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	5	38	44	14	15	5	23.2
NEBR HWY	S 40TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	4	25	23	10	7	51	23.2
VINE ST	N 48TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	5	29	30	17	13	29	23.6
A ST	S 48TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	4	12	7	33	17	51	24.0
O ST	17TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	5	24	27	21	19	30	24.2
OLD CHENEY RD	S 27TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	4	30	37	13	12	51	28.6
NEBR HWY	S 56TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	4	32	35	15	11	51	28.8
O ST	9TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	3	31	51	11	51	9	30.6
HOLDREGE ST	N 27TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	5	46	48	28	27	6	31.0
S 84TH ST	YANKEE WOODS DR	MAJOR/LOCAL	STOP SIGN	2	1	1	51	51	51	31.0
SUPERIOR ST	N 27TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	4	42	43	12	10	51	31.6
K ST	S 17TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	4	28	14	44	25	51	32.4
G ST	S 11TH ST	COLLECTOR/LOCAL	STOP SIGN	2	4	5	51	51	51	32.4
E ST	S 21ST ST	COLLECTOR/LOCAL	STOP SIGN	2	9	3	51	51	51	33.0
VAN DORN ST	S 37TH ST	MAJOR/COLLECTOR	STOP SIGN	2	13	4	51	51	51	34.0
FAULKNER DR	VILLAGE DR	COLLECTOR/LOCAL	NO CONTROL	2	16	2	51	51	51	34.2
S CODDINGTON AVE	W VAN DORN ST	MAJOR/MAJOR	STOP SIGN	2	10	11	51	51	51	34.8
Y ST	N 26TH ST	COLLECTOR/LOCAL	STOP SIGN	2	21	10	51	51	51	36.8
FAIRFIELD ST	N 27TH ST	MAJOR/COLLECTOR	TRAFFIC SIGNAL	4	51	39	40	24	31	37.0
HOLDREGE ST	N 70TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	4	18	34	39	43	51	37.0
O ST	70TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	3	49	51	16	18	51	37.0
CORNHUSKER HWY	STATE FAIR PARK RD	MAJOR/COLLECTOR	TRAFFIC SIGNAL	3	34	51	19	30	51	37.0
OLD CHENEY RD	S 40TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	2	51	51	26	14	51	38.6
A ST	S 70TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	2	51	51	20	20	51	38.6
NEBR HWY	S 14TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	2	51	51	18	23	51	38.8

"On Street"	"At/Between" Street	Class	Control	Number of Criteria Met	Crash Rate Rank	Severe Crash Rate Rank	Crash Total Rank	Severe Crash Total Rank	Ped & Bike Crash Total Rank	Average Rank
SOUTH ST	S 27TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	4	36	41	36	33	51	39.4
O ST	56TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	2	51	51	25	21	51	39.8
NORMAL BLVD	S 56TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	3	51	51	34	32	33	40.2
ADAMS ST	N 48TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	2	51	51	51	47	2	40.4
PIONEERS BLVD	S 70TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	2	51	51	23	26	51	40.4
NORMAL BLVD	S 48TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	3	45	51	24	31	51	40.4
NEBR HWY	OLD CHENEY RD	MAJOR/MAJOR	TRAFFIC SIGNAL	2	51	51	35	16	51	40.8
OLD CHENEY RD	S 14TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	3	40	51	27	36	51	41.0
P ST	N 16TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	2	23	29	51	51	51	41.0
E MANOR DR	SUMNER ST	COLLECTOR/LOCAL	NO CONTROL	2	27	25	51	51	51	41.0
N ST	S 10TH ST	MAJOR/COLLECTOR	TRAFFIC SIGNAL	2	22	51	31	51	51	41.2
Q ST	N 10TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	51	51	51	3	41.4
A ST	S 27TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	3	33	51	38	51	34	41.4
FREMONT ST	N 48TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	51	51	51	4	41.6
D ST	S 4TH ST	COLLECTOR/LOCAL	NO CONTROL	1	51	6	51	51	51	42.0
K ST	S 10TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	51	51	51	8	42.4
STATE FAIR PARK RD	THERESA ST	COLLECTOR/LOCAL	STOP SIGN	1	51	8	51	51	51	42.4
J ST	S 40TH ST	MAJOR/LOCAL	STOP SIGN	1	51	9	51	51	51	42.6
P ST	N 10TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	51	51	51	11	43.0
O ST	25TH ST	MAJOR/LOCAL	TRAFFIC SIGNAL	4	47	36	46	35	51	43.0
W VAN DORN ST	FOLSOM ST CONNECTOR	MAJOR/LOCAL	STOP SIGN	1	14	51	51	51	51	43.6
O ST	14TH ST	MAJOR/COLLECTOR	TRAFFIC SIGNAL	2	44	51	51	51	22	43.8
S 70TH ST	PINE LAKE RD	MAJOR/MAJOR	TRAFFIC SIGNAL	1	15	51	51	51	51	43.8
S WEDGEWOOD DR	S 70TH ST	MAJOR/COLLECTOR	TRAFFIC SIGNAL	1	51	51	51	51	16	44.0
W DAWES AVE	N 1ST ST	MAJOR/LOCAL	STOP SIGN	1	51	16	51	51	51	44.0
CORNHUSKER HWY	N 48TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	3	39	51	30	50	51	44.2
ADAMS ST	N 14TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	2	35	33	51	51	51	44.2
D ST	GOODHUE BLVD	COLLECTOR/LOCAL	STOP SIGN	1	51	17	51	51	51	44.2
Q ST	N 9TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	51	51	51	18	44.4
NEBR HWY	S 70TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	2	51	51	47	22	51	44.4
CORNHUSKER HWY	N 33RD ST	MAJOR/MAJOR	TRAFFIC SIGNAL	2	51	51	41	28	51	44.4
W A ST	SW 30TH ST	MAJOR/LOCAL	STOP SIGN	1	51	18	51	51	51	44.4
CORNHUSKER HWY	N 84TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	2	20	51	50	51	51	44.6
LEIGHTON AVE	N 63RD ST	MAJOR/LOCAL	STOP SIGN	1	51	19	51	51	51	44.6
N 27TH ST	KING LN	MAJOR/LOCAL	STOP SIGN	1	51	51	51	51	20	44.8
D ST	S 2ND ST	COLLECTOR/LOCAL	NO CONTROL	1	51	22	51	51	51	45.2
PINE LAKE RD	S 27TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	2	51	51	32	42	51	45.4
O ST	13TH ST	MAJOR/COLLECTOR	TRAFFIC SIGNAL	1	51	51	51	51	23	45.4

"On Street"	"At/Between" Street	Class	Control	Number of Criteria Met	Crash Rate Rank	Severe Crash Rate Rank	Crash Total Rank	Severe Crash Total Rank	Ped & Bike Crash Total Rank	Average Rank
Q ST	N 16TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	51	51	51	24	45.6
A ST	S 18TH ST	MAJOR/LOCAL	STOP SIGN	1	51	26	51	51	51	46.0
VAN DORN ST	S 38TH ST	MAJOR/LOCAL	STOP SIGN	1	51	51	51	51	27	46.2
O ST	84TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	2	51	51	29	49	51	46.2
VAN DORN ST	S 70TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	2	51	51	45	34	51	46.4
R ST	N 48TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	3	51	50	43	39	51	46.8
M ST	S 9TH ST	MAJOR/COLLECTOR	TRAFFIC SIGNAL	3	50	51	42	51	41	47.0
NW 56TH ST	W PARTRIDGE LN	MAJOR/LOCAL	STOP SIGN	1	51	32	51	51	51	47.2
Y ST	N 27TH ST	MAJOR/COLLECTOR	TRAFFIC SIGNAL	1	51	51	51	51	35	47.8
O ST	50TH ST	MAJOR/LOCAL	STOP SIGN	1	51	51	51	37	51	48.2
CORNHUSKER HWY	N 11TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	51	37	51	51	48.2
N COTNER RAMP	N 66TH ST	COLLECTOR/LOCAL	NO CONTROL	1	37	51	51	51	51	48.2
O ST	66TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	2	51	51	49	40	51	48.4
K ST	S 16TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	38	51	51	51	48.4
S 56TH ST	YANKEE HILL RD	MAJOR/MAJOR	STOP SIGN	1	51	40	51	51	51	48.8
SALT CREEK RDWY	N ANTELOPE VALLEY PKWY	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	51	51	41	51	49.0
S 87TH ST	NEBR HWY	MAJOR/LOCAL	TRAFFIC SIGNAL	1	41	51	51	51	51	49.0
NEBR HWY	S 91ST ST	MAJOR/LOCAL	STOP SIGN	1	51	42	51	51	51	49.2
RANDOLPH ST	S 27TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	51	51	51	43	49.4
G ST	S 18TH ST	COLLECTOR/LOCAL	STOP SIGN	1	43	51	51	51	51	49.4
O ST	44TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	51	51	44	51	49.6
ADAMS ST	N 84TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	51	51	45	51	49.8
WOODS BLVD	S 27TH ST	MAJOR/LOCAL	TRAFFIC SIGNAL	1	51	45	51	51	51	49.8
W O ST	SUN VALLEY BLVD	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	51	51	46	51	50.0
LINK 55-W	S 14TH ST	MAJOR/MAJOR	STOP SIGN	1	51	46	51	51	51	50.0
TETON DR	S 70TH ST	MAJOR/COLLECTOR	TRAFFIC SIGNAL	1	51	51	51	51	47	50.2
SAUNDERS AVE	N ANTELOPE VALLEY PKWY	MAJOR/LOCAL	STOP SIGN	1	51	47	51	51	51	50.2
A ST	S 56TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	51	51	48	51	50.4
O ST	1ST ST	MAJOR/COLLECTOR	TRAFFIC SIGNAL	1	51	51	51	51	48	50.4
HOLDREGE ST	N 48TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	51	48	51	51	50.4
S COTNER BLVD	S 48TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	1	48	51	51	51	51	50.4
NEBR HWY	S 84TH ST	MAJOR/MAJOR	TRAFFIC SIGNAL	1	51	49	51	51	51	50.6

Countermeasure Selection

PEDESTRIAN AND BIKE COUNTERMEASURES

Pedestrian and bike countermeasures focus on better separating crossing traffic by mode. Countermeasures serve objectives, such as:

- **A.** Improving pedestrian / bicycle safety awareness and behaviors
- **B.** Increasing enforcement of laws pertaining to pedestrians
- **C.** Expanding and improving pedestrian/ bicycle facilities
- **D.** Improving safety for children walking to school

LEADING PEDESTRIAN INTERVAL

A short walk indication for pedestrians while all vehicle traffic experiences a red before the movement parallel to the walk indication gets a green.

BICYCLE BOX

Pavement reserved ahead of the vehicle stop bar to allow bicyclists a safe, visible location ahead of queued motorized traffic.

Within these objectives a number of strategies exist that all attempt to reduce crashes involving non-motorize street users. Category C focuses on primarily intersection design/operational treatments that can make non-motorized users more visible. Some of these strategies include shortening crossing distances, installing pedestrian countdown timers, providing a leading pedestrian interval in the traffic signal timing, and installing bicycle boxes. A complete list of objectives and strategies considered in the development of this study are included as **Appendix A – Pedestrian and Bike Countermeasures**.

UNSIGNALIZED INTERSECTION COUNTERMEASURES

The study also looked at unsignalized intersection countermeasures to reduce severe crashes. Unsignalized intersection countermeasures serve objectives, such as:

- **A.** Reducing the frequency and severity of intersection conflicts through geometric design improvements
- **B.** Improving sight distance
- **C.** Improving driver awareness of intersections as viewed from the intersection approach
- **D.** Improving driver compliance with traffic control devices
- **E.** Identifying appropriate intersection traffic control to minimize crash frequency and severity

These objectives provide a range of potential improvement strategies allowing for intersection improvements to fit within the appropriate context and available space. One improvement strategy is the conversion of a stop-controlled intersection to a roundabout. When space is available, roundabouts introduce lower levels of delay than a stop-controlled intersection and transform angle crashes to sideswipe crashes that are less prone to injuries. In locations where a roundabout is not a good fit, measures can be taken to better separate streams of traffic, increase visibility of cross street traffic, and delineate the intersection area. A complete list of objectives and strategies considered in the development of this study are included as **Appendix B – Unsignalized Intersection Countermeasures**.

MINI ROUNDABOUT

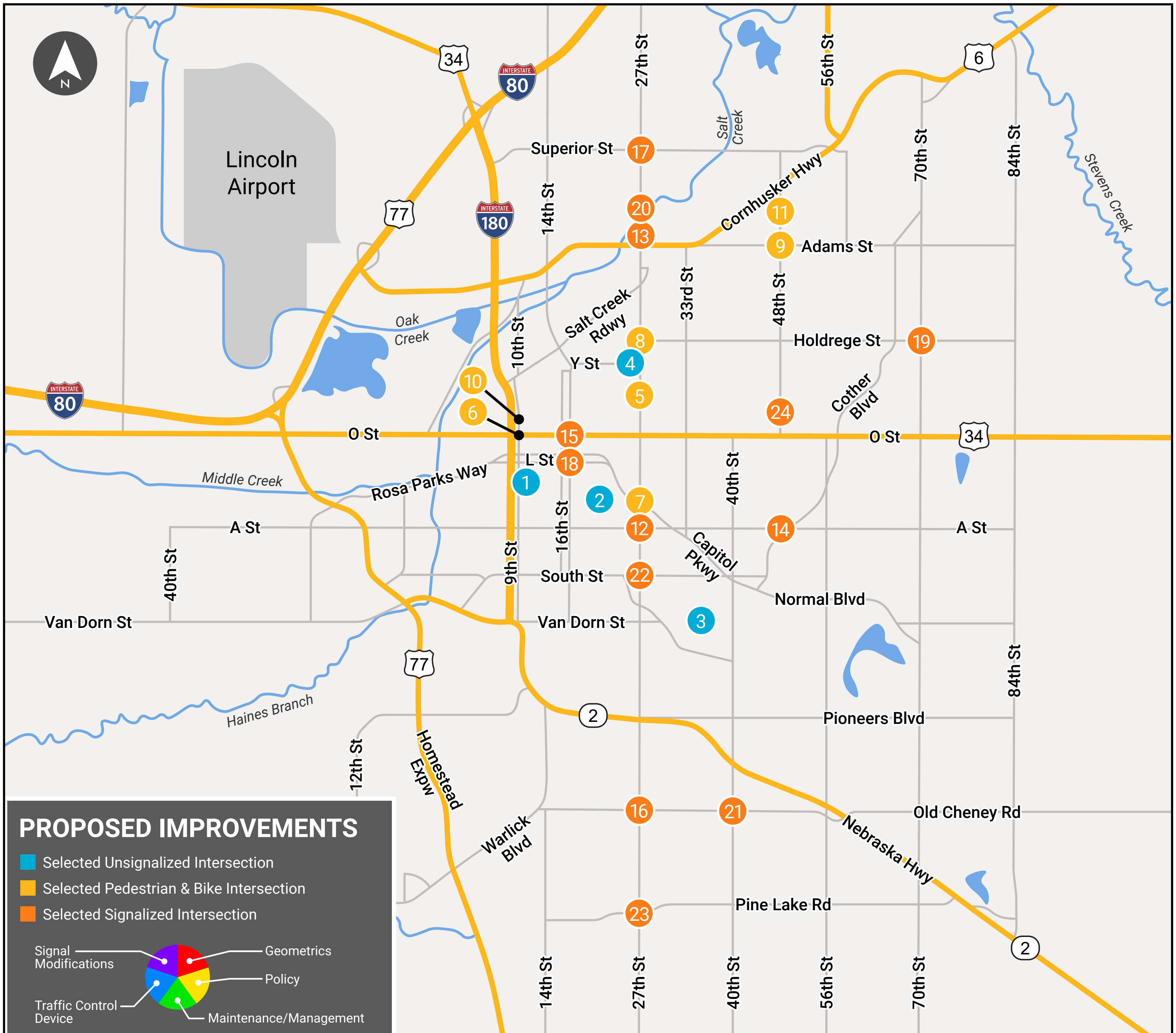
Unsignalized intersection with a small diameter circular path that changes all crossing movements to merge and diverge movements reducing right angle crashes.

SIGNALIZED INTERSECTION COUNTERMEASURES

Signalized intersection countermeasures serve objectives, such as:

- **A.** Reducing the frequency and severity of intersection conflicts through traffic control and operational improvements

Figure 41: **Countermeasures Recommended by Intersection**



1. G St & S 11th St
2. E St & S 21st St
3. Van Dorn St & S 37th St
4. Y St & N 26th St
5. Vine St & N 27th St
6. O St & 10th St
7. Capitol Pkwy & S 27th St
8. Holdrege St & N 27th St
9. Adams St & N 48th St
10. Q St & N 10th St
11. Fremont St & N 48th St
12. A St & S 27th St
13. Knox St & N 27th St
14. A St & S 48th St
15. O St & 17th St
16. Old Cheney Rd & S 27th St
17. Superior St & N 27th St
18. K St & S 17th St
19. Holdrege St & N 70th St
20. Fairfield St & N 27th St
21. Old Cheney Rd & S 40th St
22. South St & S 27th St
23. Pine Lake Rd & S 27th St
24. R St & N 48th St

B. Reducing intersection conflicts through geometrics

C. Improving driver awareness of intersections and signal control

D. Improving driver compliance with traffic control devices

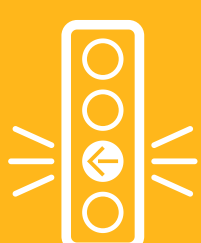
E. Improving safety through other infrastructure treatments

F. Selecting appropriate intersection traffic control

Signalized intersection countermeasures recognize that at traffic signals there are a number of factors, mixed between driver behavior/expectations, signal operation, geometric design and signing that influence intersection safety performance. When space is available, strategies can often consider better separation of conflicts and reduced queue lengths through additional through or turn lanes. On the other hand, queuing is also attributable to signal timing, so in certain cases a safety problem can suggest that the current signal timing is not well matched to traffic patterns. In still other cases, a contributing factor to intersection safety is clearing the intersection from other conflicting access by removing on-street parking or closing/restricting movements from adjacent driveways. A complete list of objectives and strategies considered in the development of this study area included as **Appendix C – Signalized Intersection Countermeasures**.

FLASHING YELLOW ARROW (FYA)

Left turn traffic signal treatment that replaces the green ball signal indication with a flashing yellow arrow. FYA better conveys clearance intervals to reduce left turners from unknowingly crossing opposing through vehicles that have a green indication.



Intersection Diagnostic and Countermeasure Selection

After stratifying these Top 25 intersections within the three categories, an assessment was made regarding the needs of each intersection. The assessment considered physical conditions of the intersection, operation of the intersection, recent crash history, traffic patterns and other factors. The primary information reviewed in assessing intersection needs was summarized for each intersection in a crash performance summary sheet, collision diagram, and collision diagram summary sheet, located in **Appendix D – Top 25 Intersection Data Sheets**.

Countermeasures were selected for each intersection to provide a menu of alternatives. Simply put, the recommended countermeasures for each intersection represent options that can be implemented, not a recommendation to install all countermeasures. For instance, some unsignalized intersections could realize a safety benefit from conversion from a two-way stop controlled intersection to either an all-way stop controlled intersection or a mini-roundabout, but both options cannot be chosen. Leaving the recommended countermeasures as a menu gives City staff flexibility to pursue improvements at these locations without being locked into one alternative. This can be important if future engineering design determines a certain countermeasure is not feasible. In many cases, the recommended countermeasures would work well if implemented in concert, like updating all intersection signal timings while also providing additional left turn displays on signal poles to improve driver visibility of the crosswalk. In all, 89 countermeasures were recommended to address safety issues, including:

- 52 countermeasures that address opportunities for signal timing setting modifications. These countermeasures can require additional engineering analysis, but can be deployed relatively quickly because they require limited procurement and minor impact to install. The operational strategies can provide large immediate benefits to safety, but represent a limited timeframe investment as engineering staff will need to invest in reassessing the sufficiency of traffic signal operating plans every 3 years.

- 16 countermeasures in the maintenance and management area. This group of countermeasures can serve multiple purposes, but include activities that may represent a one time engineering decision, but require general upkeep to remain effective. Countermeasures range from placement of signage to clearing trees that create a visual obstruction. A more major change in this category might include converting a two-way stop controlled intersection to a four-way stop controlled intersection involving placing new stop signs and pavement markings. The countermeasures in this category, if implemented, must be folded into the City's current maintenance plans to receive on-going observation and upkeep when necessary.
- 11 countermeasures in the geometric area. Modifying intersection geometry falls in the highest cost class of improvements. In many cases, these improvements cost the most because a major change must take place to correct safety or operational deficiencies. Geometric countermeasures can be identified at the planning stage, but often take greater shape through subsequent stages of the design process. If implemented, geometric improvements have significantly longer service lives than operational or maintenance / management countermeasures.
- 9 countermeasures in the policy area. The study identified one location where a potential for safety benefit exists just through coordinating traffic patterns with a local volunteer organization. Other policy recommendations looked at enforcement for red light running and prohibition of right turn on red movements with high crash activity.
- 1 recommendation for further study. The mix of bicycle and pedestrian safety issues identified in the network screening and countermeasure identification stages of the study suggested that further study could be beneficial. The study of city-wide bicycle and pedestrian safety should include robust stakeholder coordination to engage the non-motorized travel community. Targeted outreach related to the proposed study could be seen as a safety countermeasure to improve safety at many intersections throughout the city.

Figure 42 provides a map denoting countermeasure categories recommended for each location. In the figure, the color background for each location represents whether that location was primarily evaluated as a pedestrian and bike intersection, unsignalized intersection, or signalized intersection. A full countermeasure list for the target intersections is included as **Appendix E – Recommended Intersection Countermeasures**.

Predicted Countermeasure Effectiveness

Once the countermeasures were identified for each intersection, a benefit-cost analysis was conducted to determine whether each countermeasure provided enough benefit to warrant further consideration for implementation. The three parts to the question of how beneficial a countermeasure is are the predicted crash reduction, the anticipated service life, and the implementation cost. The predicted crash reduction can be identified through past study of the recommended countermeasure or similar treatment to review crash patterns before and after the application of the treatment. Industry resources like the FHWA Proven Safety Countermeasures program, the AASHTO Highway Safety Manual 1st Edition, and the FHWA CMF Clearinghouse were consulted to identify the best available estimate of countermeasure crash reduction. Any remaining countermeasures were evaluated through past City studies of safety effectiveness and recommendations based on engineering judgment. The crash reduction factors identified for each countermeasure were applied to the annual average crash frequency / severity at the intersection based on the previous five years of crash history. In this study, the best estimate of future long-term crash activity at an intersection is the average of the recent crash history, which is assumed to occur each year over the period of the benefit-cost analysis.

The second element developed was the treatment service life. The importance of this value is that after a certain duration, the countermeasures safety effectiveness will trail off without further investment. Service life is the amount of time the treatment should remain at its target effectiveness before major rehabilitation, complete replacement, or a plan update as opposed to the first need for minor maintenance or tweaks to the original plan. Service lives were taken from other studies, including FHWA publications. In the absence of an applicable publication, service lives were estimated using engineering judgment and vetted with past City experience.

The final element of the benefit-cost analysis was the estimation of countermeasure cost. In the development of costs, prior plans, studies, and estimates were consulted to determine a planning-level cost estimate for geometric construction, procurement of signal equipment, and pavement markings / treatments. Other countermeasures, like signal retiming were estimated based on hours of effort of engineers and technicians to develop and implement an updated plan multiplied by reasonable estimates of hourly compensation. All cost estimates were reviewed in comparison to past City safety projects and adjusted to match current levels of cost inflation.

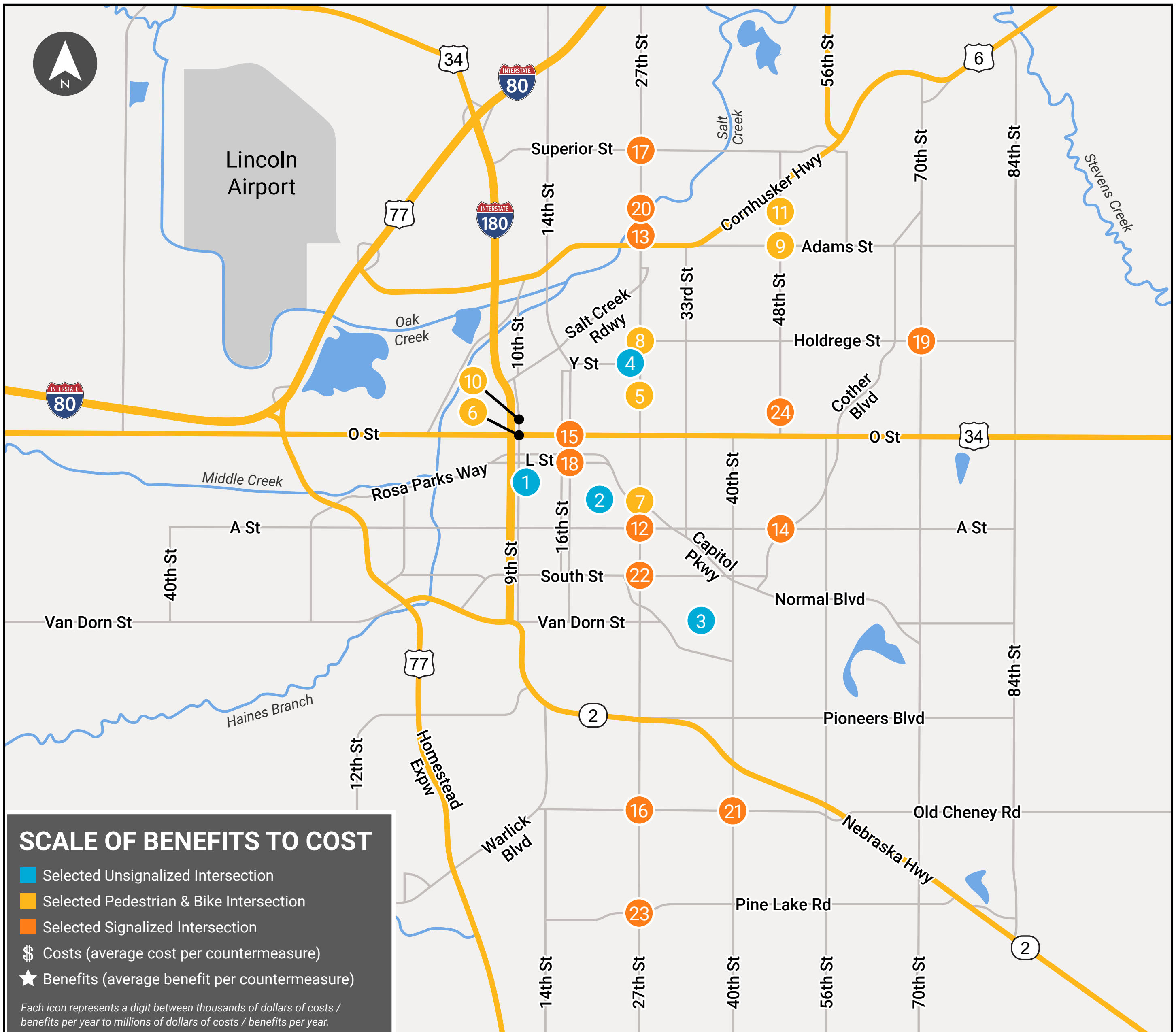
The benefits that were assumed to occur over each year of the service life were discounted to apply the time value of money back to a present value using a 4% discount rate. The benefits were then divided by the construction costs. The result is the benefit-cost metric of countermeasure effectiveness to show that for each agency dollar spent, "X" dollars of public safety benefit is predicted to be realized. The benefits of low cost countermeasures were capped at 50 times the cost of the countermeasure to present a conservative financial case for each treatment. This conservative adjustment is appropriate because it reduces the impact of certain biases leading to overestimation of benefits.

All 89 countermeasures were predicted to exceed a benefit-cost of 1.0, meaning that all countermeasures were retained due to financial viability. The benefit-cost ratios calculated are within the following ranges:

- 5 countermeasures that are between a B-C of 1.0 and 5.0. These are higher cost countermeasures, which limits how effective the countermeasures can be per dollar. The 6 treatments combined could still yield a benefit of nearly $11.5 million over their respective service lives.
- 6 countermeasures that are between a B-C of 5.0 and 50.0.
- 78 countermeasures that are above a B-C ratio of 50.0, but have been capped at the 50.0 level for this analysis.
- The cumulative cost for all countermeasures except two conversions from a signalized intersection to a modern roundabout was estimated at $1.4 million dollars. If each countermeasure could be implemented and undertaken as being fully effective even when combined with other treatments, that would mean the City could see a safety benefit as large as $70 million for a relatively small investment. However, that value would go down as multiple countermeasures at the same intersection have a joint effect that is smaller than each measure in isolation. The total cost and benefits would also decrease since some locations have a recommended menu of countermeasures where two or more countermeasures cannot both be implemented (e.g. recommended mini-roundabout and recommended conversion to all-way stop control).

Figure 42 provides a graphical representation of the scale of potential benefits to cost for countermeasures identified at each location. In **Figure 42** the dollar and star icons both range from one to four icons per location. Each icon

Figure 42: Countermeasure Benefits to Costs by Key Intersection



Intersection	Costs	Benefits
1. G St & S 11th St	$$$	★★★
2. E St & S 21st St	$	★★★
3. Van Dorn St & S 37th St	$$$	★★★
4. Y St & N 26th St	$$$	★★★
5. Vine St & N 27th St	$$	★★★★
6. O St & 10th St	$	★★★
7. Capitol Pkwy & S 27th St	$$	★★★★
8. Holdrege St & N 27th St	$	★★★
9. Adams St & N 48th St	$$	★★★
10. Q St & N 10th St	$	★★★
11. Fremont St & N 48th St	$	★★★
12. A St & S 27th St	$	★★★
13. Knox St & N 27th St	$	★★★
14. A St & S 48th St	$$$	★★★★
15. O St & 17th St	$	★★★
16. Old Cheney Rd & S 27th St	$	★★★
17. Superior St & N 27th St	$	★★★
18. K St & S 17th St	$	★★★
19. Holdrege & N 70th St	$$$	★★★★
20. Fairfield St & N 27th St	$	★★★
21. Old Cheney Rd & S 40th St	$	★★★
22. South St & S 27th St	$	★★★★
23. Pine Lake Rd & S 27th St	$	★★★★
24. R St & N 48th St	$	★★★★

Table 4: Key Information for N 27th Street and King Lane

N 27th Street and King Lane	Before (2012 & 2013)	After (2015 & 2016)
Total Crashes	15	7
Injury Crashes	5	2
Crashes involving Broadside from Minor Street Through/Left Movement	4	0 (Movement Prohibited)
Crashes involving Broadside from Major Street Left Movement	5	0

represents a digit between thousands of dollars of costs / benefits per year to millions of dollars of costs / benefits per year. Complete benefit cost calculations are documented in **Appendix F – Benefit-Cost Analysis**.

Observed Countermeasure Effectiveness

N 27TH STREET AND KING LANE

The intersection screening methodology described earlier in this chapter identified 25 target locations. For each of the 25 locations, crash patterns were reviewed along with aerial imagery and site photography. At the intersection of N 27th Street and King Lane, the project team identified a recent improvement project that significantly changed the crash patterns of the intersection. Prior to mid-2014, the N 27th Street and King Lane intersection operated as a two-way stop controlled intersection with full access from the side streets. In the mid-2014 period, a shaped median was introduced on N 27th Street through the King Lane intersection. The median allows for major street to minor street left turns, but does not allow for minor street to major street left turns, known as a ¾ intersection. City staff considered replacing the location for another unimproved intersection, but instead agreed to analyze the intersection based on limited observed before-after crash data as part of the safety plan.

The crash data depicted in **Table 4** shows a pattern of turning crashes related to minor street traffic finding an acceptable gap in N 27th Street traffic. That pattern was directly correctable for through and left movements via the ¾ median. During the same time period, a similar number of crashes occurred from major street to minor street lefts which was not prohibited through the new design. The major street to minor street appears to also have been improved through the updated configuration as the major street left turn lanes now have positive offset that was not present before. Both of these left turn patterns were not present in the crashes occurring in the after timeframe. The primary conclusion in this case being that crash frequency decreased at the intersection, but the limited number of crashes occurring during the before and after period (i.e., small sample size) reduces the confidence in the comparison between the two timeframes.

On related issue of safety effectiveness, independent sources of before-after study were consulted to estimate the long term average safety effectiveness of the ¾ design. No studies were identified from the primary crash prediction sources with an exact match for the ¾ design, but a similar treatment looking at the safety effectiveness of directional median openings estimated the crash reduction from the treatment at 51%. Given the limited crash history at this location, the before-after data is similar to the findings of this independent study.

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CHAPTER 5: TARGETED CORRIDORS

Corridor Selection Methodology

The project team also analyzed several corridors as part of the safety plan. The three corridors were selected based on an evaluation of the crash concentrations for midblock and unsignalized intersection related crashes. A critical crash rate analysis was conducted for midblock locations using techniques modified from those presented in the prior section. The primary difference in the two methods is that a midblock segment crash rate is calculated per vehicle mile traveled (VMT) rather than entering vehicle. Essentially, that means a short one-tenth mile segment would need to be traversed by 10 vehicles to equal one VMT. This difference in exposure relates to the change in risk between an intersection (many traffic streams crossing) versus a segment (most traffic continuing forward along street). The results of the crash rate analysis are presented in Table 5.

The crash rate analysis shows that the number of street segments above the critical crash rate is much higher than the number of intersections above the critical crash rate. The finding validates the need to develop safety countermeasures for corridors, but left the project team with many more potential locations to analyze. The project team again sought to rank safety characteristics of the segments exceeding critical crash rates. Unlike the intersection condition, segment rankings became quite complicated as adjacent segments rarely operated at similar safety levels

Table 5: Street Segments above Critical Crash Rates by Functional Class and Cross Section

Class	Cross Section	Street Segments Above Critical	Percent of Street Segments Above Critical
Local	ONE WAY	1	33%
	TWO LANE	464	14%
	TWO LANE W/ COMMON LEFT TURN	0	0%
	TWO LANE W/ LEFT TURN	3	27%
Collector	ONE WAY	30	75%
	TWO LANE	148	29%
	TWO LANE W/ COMMON LEFT TURN	2	25%
	TWO LANE W/ LEFT TURN	10	33%
	FOUR LANE	7	32%
	FOUR LANE W/ LEFT TURN (CONCRETE MEDIAN)	0	0%
Major	ONE WAY	132	59%
	TWO LANE	163	35%
	TWO LANE W/ COMMON LEFT TURN	118	53%
	TWO LANE W/ LEFT TURN	138	52%
	FOUR LANE	111	69%
	FOUR LANE W/ LEFT TURN (PAINTED MEDIAN)	52	71%
	FOUR LANE W/ LEFT TURN (CONCRETE MEDIAN)	328	65%
	FOUR OR MORE LANE (DIVIDED MEDIAN)	0	0%
	FOUR OR MORE LANE W/LT LANE (CONC MED)	12	52%
Expressway	ONE WAY	0	0%
	FOUR OR MORE LANE (DIVIDED MEDIAN)	14	47%

even though to build a corridor a number of adjacent segments would need to be analyzed as a unit. Thus, a combined corridor screening method was developed that looked at the spatial distribution of rankings and a specific improvement strategy. The mid-block segments exceeding critical crash rates were mapped using geographic information system (GIS) tools and displayed in five categories. The highest category looked at the 20% of locations with the highest ratio of mid-block crash rate to critical crash rate. The next category looked at the locations outside the top 20%, but within the top 40% and each subsequent category included the next 20% of locations. Through visual inspection, corridors with multiple locations in the top few categories drew greater consideration. The improvement typologies considered were:

- Road diet – The reduction of four-lane, undivided facility to a facility with fewer continuous lanes, but improved separation of conflicts and modes through turn lanes and/or bicycle lanes. This improvement typology is appropriate given data from **Table 5** that shows 69% of major street four-lane cross section segments were above critical crash rates.
- Access management – The redesign of the street, driveways, or parking circulation to balance the needs of through traveler mobility and adjacent land use access in a safe manner. Access to adjacent land uses focuses on movements both into and out of the development and must also consider whether a left turn or right turn is allowed to enter/exit. A business or residence adjacent to the street may be provided only some movements for access if the property is close to a major intersection.

  Access management particularly looks at agency planning, agreements, and construction that replaces an existing street design with abundant access with a design that improves safety by balancing between access and through mobility. Corridors considered for this strategy should have frequent driveways and likely include sections of streets without a median.
- Non-specific crash concentration – Beyond the two prior City priority strategies, certain corridors exhibit crash concentrations that don't have an obvious explanation. These corridors may represent a desirable, median divided cross section, but still experience a high number of crashes due to some combination of speed, access, and other factors.

Upon review of the crash segment rankings, consideration of the improvement strategies, and consultation with City plans, the project team elected to study the following corridors:

- Vine Street from 27th Street to 66th Street
- N 48th Street from O Street to Adams Street
- O Street from Antelope Valley Parkway to 48th Street

In addition to each corridor's primary improvement strategy, supplemental countermeasures for urban street segments were evaluated against a list of safety objectives and strategies, compiled as **Appendix G – Recommended Segment Countermeasures**.

Vine Street Improvements

Vine Street was selected as a candidate for a road diet. The road diet would fit this corridor as today Vine Street operates as a four lane undivided street throughout the corridor except in the vicinity of major intersection where medians exist. East of 66th Street Vine Street is a three-lane street with one lane in each direction and a center continuous left turn lane. West of 27th Street, Vine Street is a four-lane divided street approaching the University of Nebraska-Lincoln campus.

The investigation looked at the potential to reduce crashes by converting some or all of the street to a three-lane section with additional space to be repurposed, potentially for bike lanes. The crash patterns were reviewed for Vine Street, finding that the corridor experiences a number of rear end, sideswipe, left-turn leaving, and angle crashes that could be attributable to unexpected braking to make a left turn from the inside through lane.

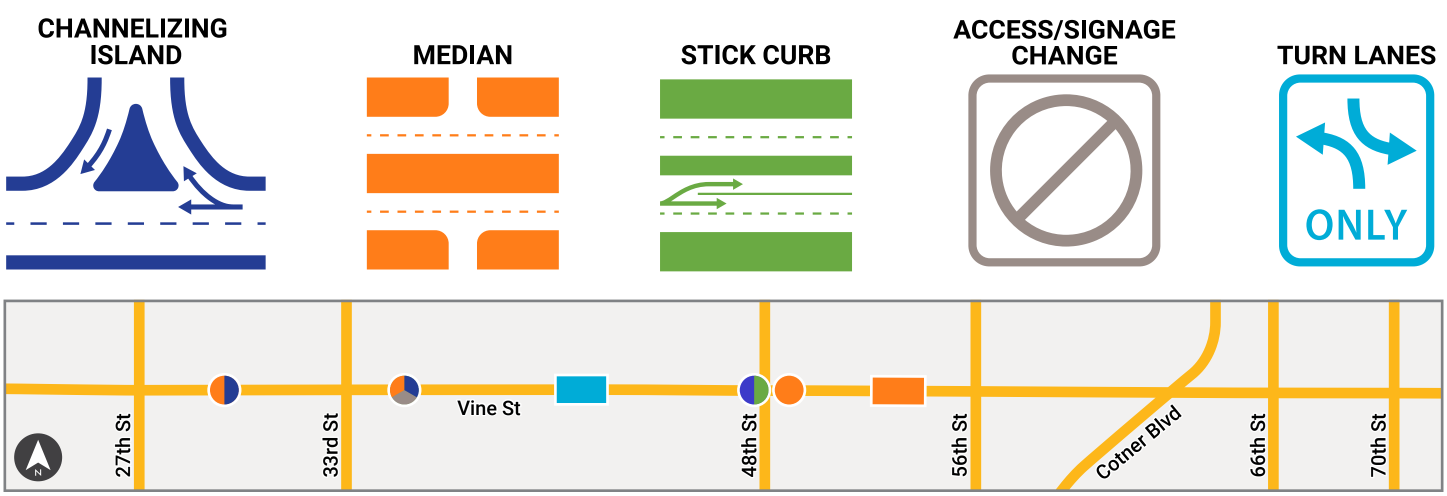
Concentration of this crash activity are most prevalent between 26th Street and 31st Street, at 35th Street, near 40th and 42nd Street, and near Culler Middle School (~52nd Street). The target crashes do occur with a lower frequency along most of the corridor (notable exception: very few segment crashes between Cotner Boulevard and 66th Street) although not necessarily indicating a large number of turning crashes. The corridor was also reviewed for traffic volume and patterns. Traffic volumes on the corridor in the peak hours of travel were found to be significant. More than 1,000 vehicles per hour are present along portion of Vine Street, leading to concern that a road diet would not serve the corridors safety and mobility needs.

Given that road diets reduce the number of through lanes, the remaining lanes are required to carry more traffic or the measure can be used to promote travelers taking an alternative route. For Vine Street, there is peak congestion on parallel routes, so traffic is not likely to find a good alternate route. Also, travelers on Vine Street are likely destined for one of the many residential areas along the street, also making it unlikely travelers will divert. With less capacity and limited diversion, the congestion on Vine Street under a road diet may grow to levels that create congestion-related safety issues. City staff still envisions the road diet as an opportunity to improve other streets throughout Lincoln, but the agency and project team elected not to recommend a road diet for this corridor due to a less than ideal fit between existing travel patterns and safety needs.

In replacement for the potential road diet improvements to Vine Street, the project team developed a targeted list of spot improvements to Vine Street shown in Figure 43.

- 27th Street to 31st Street
  - 30th Street (offset T-intersection) – Add median or channelizing islands to create Right-In/Right Out (RIRO) access at both locations
- 33rd Street to 45th Street
  - 35th Street – Add median or channelizing islands to create RIRO or sign time of day turn restrictions.
  - 40th Street & 42nd Street – short turn lanes on Vine Street
- 45th Street to 48th Street
  - At the commercial driveway, adjacent to the eastbound travel lane, 200 feet west of 48th Street – channelizing island or stick curb
- 48th Street to 56th Street
  - N49th Street – close median break
  - El Avado Ave to 54th Street – Median between intersections to prevent left turns

Figure 43: Countermeasures Recommended for Vine Street Corridor

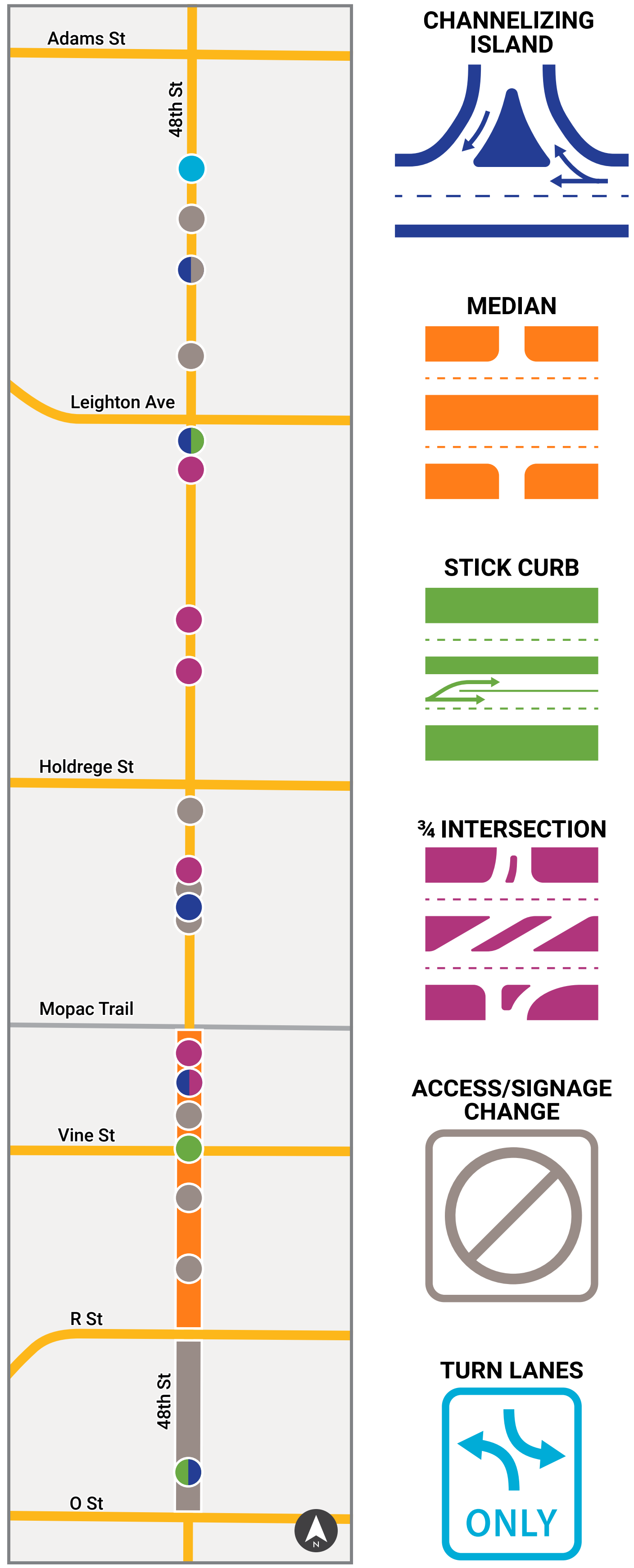


N 48th Street Improvements

The analysis of N 48th Street between O Street and Adams Street focused on access management. In this case the two types of data that exist are the number of access points along the corridor and the crash activity present at those access points. Since crashes during a certain time period are random there can be a bias for the crashes either toward a specific access point or not supporting an argument to consider restrictions on an access point. As the data is looked at as a whole considering more access points as a unit, the bias becomes less pronounced. Thus, the project team moved down section-by-section through the corridor looking at whether there was a general need to improve access management in that section. When recommending access management countermeasures it is important to coordinate access changes with stakeholders and property owners early in the design phase. In this planning stage, recommendations for access changes were made prior to stakeholder involvement, focusing on landowners with multiple access points and driveways nearer to major intersections. Consideration of these countermeasures would require further study into feasibility of driveway consolidation agreements or study of neighborhood and emergency vehicle traffic patterns to make sure a side street turn restriction is feasible. Countermeasures recommended for N 48th Street are shown in Figure 44.

- O Street to R Street
  - Consider converting right northbound lane to business access lane or add northbound right turn lane to commercial access closest to O Street
  - Southbound commercial access closest to O Street – restrict to nearest two lanes with either stick curb or channelizing island
- R Street to Mopac Trail
  - Convert 5-lane to 4-lane divided with turn lanes
  - Driveway consolidation
  - Potential right turn pockets if volumes / space permit

Figure 44: Countermeasures Recommended for N 48 Street Corridor



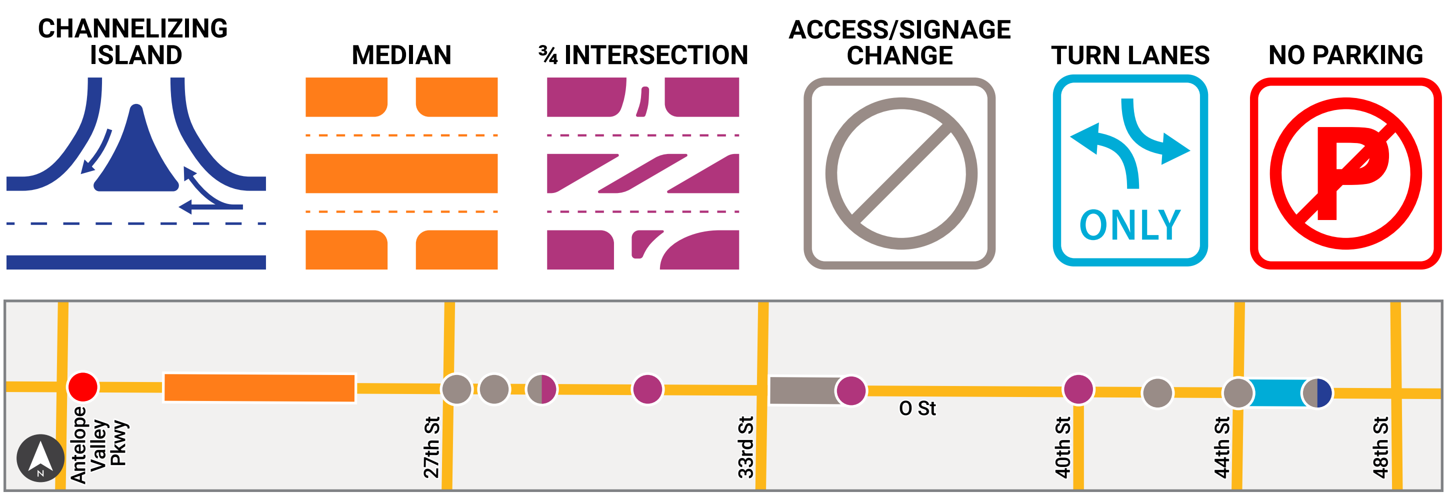
    - W Street – ¾ intersection or RIRO
    - Wilshire Blvd – ¾ intersection
    - Stick curb for southbound 48th Street at Vine Street
- Mopac Trail to Holdrege Street
    - East Orchard Street - channelizing island
    - Driveway closures north and south of Orchard Street
    - Dudley Street – ¾ intersection
    - Driveway consolidation/closures for commercial access adjacent to Holdrege Street intersection
- Holdrege Street to Leighton Avenue
    - Francis Street or Martin Street – ¾ intersection
    - Garland Street – ¾ intersection
    - Channelizing island at commercial driveway closest to Leighton Avenue or stick curb at northbound 48th Street and Leighton Avenue
- Leighton Avenue to Adams Street
    - One-way sign away from 48th Street at alley near auto dealer
    - Pedestrian plaza at St. Paul Avenue
    - Baldwin Avenue – RIRO or one-way away
    - Madison Avenue – add pedestrian crossing signs
    - Madison Avenue – convert southbound through lane to left turn lane

O Street Improvements

The final corridor analyzed was O Street between Antelope Valley Parkway and 48th Street. The corridor experienced a very high frequency of crashes, which is not surprising since it is one of Lincoln's high volume arterials. O Street is primarily a four-lane divided street within the project limits. Exceptions to that general cross section include the five-lane section with center turn lane between 21st Street and 25th Street and a short six-lane divided segment between 46th Street and 48th Street. Reviewing crashes along O Street, there are numerous crash concentrations, including: 20th Street to 21st Street, 22nd Street east to 25th Street, 28th Street to 30th Street, 31st Street to 33rd Street, driveways east of 33rd Street, and 40th Street to 46th Street.

Reviewing that list of crash concentrations, a couple of previously discussed strategies are pertinent to these crash patterns. The project team sees potential in the removal of on-street parking on O Street east of Antelope Valley Parkway. Just to the east of that location, the project team recommends the 5-lane section be converted to a four-lane divided street, moving some access off of O Street to the supporting street system. Treatments for other segments look at restricting access particularly for left turns onto the corridor. For example, 35th Street is a skewed intersection that could be improved

Figure 45: Countermeasures Recommended for O Street Corridor



with turn restrictions. On the far east side of the corridor, congestion increases significantly and adversely impacts safety. In the vicinity of 40th Street and 42nd Street there may be a visibility-restriction combined with unexpected queuing, that could benefit from improved geometrics, signage, or traffic control. Access to N 46th Street appears to pose some safety concerns with a westbound lane that drops as a right turn and a crest curve near 47th Street that restricts sight distance of fast approaching traffic. The following list of improvements were identified were identified and are depicted in **Figure 45**.

- Antelope Valley Pkwy to 27th Street
    - Median from 21st Street to 25th Street and driveway consolidation
    - Remove parking near Antelope Valley
- 27th Street to 33rd Street
    - 29th Street and/or 31st Street – ¾ intersection
    - Close parking lot exit west of 29th Street
    - Eastbound from 28th Street to 29th Street – close driveways and direct traffic to alley or 28th Street
    - Eastbound from 27th Street to 28th Street – convert alley to one-way away from O Street
- 33rd Street to 40th Street
    - 35th Street – ¾ intersection to prohibit side street lefts and also prohibit westbound left
    - Driveway consolidation between 33rd Street and 35th Street
- 40th Street to 48th Street
    - 46th Street – RIRO
    - 44th Street – Extend westbound lane drop (two blocks of curb reconstruction / business acquisitions possible)
    - 42nd Street eastbound – Bus stop relocation / improve queue visibility
    - 40th Street – Improved ¾ intersection design or signal with protected-permitted phasing

CHAPTER 6: CONCLUSIONS

The project team conducted a city-wide assessment of crash data patterns throughout Lincoln. The study uncovered a number of crash data patterns that affect the overall Lincoln transportation system, including:

City-Wide Trends

- While Lincoln experiences more crashes today than the previous analysis years, overall crash rates are lower, and travel demand has continued to increase. This trend shows that growth in the amount of travel in Lincoln is a more dominant trend than the subtly decreasing trend in crash rates.
- City-wide there are roughly 10 crashes involving a fatality each year and 1,850 crashes each year involving one or more injuries. That equates to roughly 22% of all crashes being a severe crash (a crash resulting in a fatality or injury), which is a slight decrease from the prior 2012 Lincoln study that identified 23.7% of crashes as severe crashes.
- The most common crash types in Lincoln are: rear end, right angle, hit parked vehicle, turning, and ran off-road, with each exceeding the average crash frequency by type.
- 71% of all injury crashes are rear end, right angle, and turning. Countermeasures that target those types of conflict are likely to bear the greatest improvements in safety across the city.
- Lincoln's severe crashes occur at a 70/30 split between intersections and midblock segments. Looking at the intersection crashes, 89% of crashes occur where at least one of the two cross streets is a major street. The City's safety plan can target the highest number of crashes by focusing on major intersection locations for deploying safety countermeasures.

Pedestrian and Bicycle Patterns

- Pedestrian and bicycle crashes made up 3% of all crashes, but accounted for 12% of all severe crashes. A detailed review of crash patterns specific to pedestrian and bicycle crashes is justified based on how vulnerable these users of the transportation system are in all crash situations (92% of all pedestrian and bicycle crashes result in one or more injuries).
- Patterns of pedestrian and bicycle crashes showed similar time of day patterns and location patterns to auto crash patterns, suggesting that reducing major street and intersection congestion during peak periods could yield crash reductions for all modes.
- The biggest difference in the dedicated pedestrian and bicycle crash analysis was in the type of crashes most frequently occurring. For bike crashes the four most frequent crash types are right turn by vehicle, driveway/ alley, right angle at traffic signal, and same direction left turn. For pedestrian crashes the three most frequent crash types are left turn at intersection, unauthorized crossing, and right turn at intersection.
- For pedestrian and bicyclists, countermeasures to address turning crashes can range from complete removal of the conflict (closing access points, prohibiting turning movements) to improved management of the conflict area (intersection leading pedestrian interval, improved striping / signing / visibility of the crosswalk).
- Other pedestrian and bicycle countermeasures may attempt to curb crossing violations by looking at both design opportunities for more convenient managed crossings and increased enforcement of jaywalking on high volume streets.

Targeted Intersections

- The 6,300 intersections within the City of Lincoln were screened using critical crash rate and targeted crash characteristics. Top locations for five safety characteristics were documented to construct a list of 104 candidate intersections. The five safety

characteristics ranked based on 2012-2016 crash data were:
  - Top 50 Annual Crash Frequency, All Crash Severities
  - Top 50 Crash Rate (Exceeding critical crash rate), All Crash Severities
  - Top 50 Annual Crash Frequency, Severe Crashes
  - Top 50 Severe Crash Rate (Exceeding critical crash rate)
  - Top 50 Pedestrian and Bike Crash Frequency, All Crash Severities
- The project team recommended countermeasures for 25 target intersections that fell within one of three classes: pedestrian and bike crash patterns, unsignalized intersection crash patterns, or signalized intersection crash patterns. Intersections were evaluated within their class as to safety objectives and strategies that could mitigate the existing crash pattern. A complete list of objectives and strategies can be found in **Appendices A-C** and countermeasures recommended for each intersection are listed in **Appendix E**.
- The study process included a benefit-cost analysis (BCA) for recommended countermeasures at the targeted 25 intersections with an estimated cost in the $5 - $7 million range yielding potentially $70 million in user benefits. Complete BCA results are included in **Appendix F – Benefit-Cost Analysis**.

Targeted Corridors

- Three corridors were reviewed for crash patterns that could potentially be addressed through targeted safety countermeasures.
  - Road diet – Vine Street between 27th Street and 66th Street
  - Access Management – North 48th Street between O Street and Adams Street
  - Unknown crash concentration – O Street between Antelope Valley Parkway and 48th Street
- Though screened as a potential road diet, further study identified that Vine Street traffic is not conducive to repurposing traffic lanes nor was the corridor's crash pattern suggestive of corridor-wide turning issues. A series of spot safety improvements were recommended for the corridor.
- The N 48th Street corridor was reviewed for crash history and the relationship of those crashes to minor intersections and driveways. A list of safety countermeasures were developed for the corridor focusing on reducing the number of turning conflicts at crash concentrations through implementation of a median, side street and driveway channelization, and driveway consolidation.
- The O Street corridor was reviewed for crash clusters implying segment safety issues. Countermeasures focused on heavy crash concentrations just east of Antelope Valley, between 27th Street and 33rd Street, and from 40th Street east to 48th Street. On the west side of the corridor, recommendations focused on removing on-street parking and converting access points from full to partial access. On the east side of the corridor, slightly more extensive recommendations were developed that consider additional signalization at 40th Street, converting 46th Street to Right-In/Right-Out access, and extending the 6-lane section of O Street westbound to 44th Street.

Summary

This crash data analysis focused on identifying Lincoln's city-wide crash trends and selecting targeted intersections and corridors for further analysis; resulting in safety countermeasure recommendations for the target locations. At the target intersections, this crash data analysis resulted in $1.4 million in recommended projects plus two potential roundabouts. If implemented, the projects could net a safety benefit to the City and residents of $70 million over the service life of the improvements.

The City of Lincoln should continue to utilize a data driven approach when addressing crash analyses and development of engineering solutions to improve safety. In addition, it is recommended that the City develop a comprehensive City-Wide Transportation Safety Plan could help City staff reduce crashes associated with driver behavior and programmatic issues. For example, nearly 15.5% of all crashes in Lincoln (including 15.5% of severe crashes) were reported as involving a distracted driver. Combining distracted driving with crashes involving a driver under the influence (4% of crashes, 6% of severe crashes), nearly 20% of crashes involve just those two human behaviors. A multi-agency effort to develop an integrated approach involving engineering, enforcement, education and emergency medical services and engage the public could yield further crash reductions.

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