EVALUATION OF ROADSIDE COLLISIONS WITH UTILITY POLES AND TREES AT INTERSECTION LOCATIONS

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EVALUATION OF ROADSIDE COLLISIONS WITH UTILITY POLES AND TREES AT INTERSECTION LOCATIONS

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SUMMARY

The United States averages 40,000 traffic fatalities annually. The American Association of State Highway and Transportation Officials (AASHTO) *Roadside Design Guide* cites run-off-the-road crashes as contributing greatly to this statistic, with about one-third of all traffic deaths [1]. This number has remained relatively constant over the past four decades, and despite a major increase in vehicle miles traveled (VMT), the rate of fatalities per 100 million vehicle miles traveled has declined. However, this relatively large number of run-off-the-road crashes should remain a major concern in all roadway design.

The Highway Safety Act of 1966 marks a defining moment in the history of roadside safety [1]. Before this point, roadways were only designed for motorists who remained on the roadway, with no regard for driver error. As there was no legislation or guidelines concerning roadside design, roadways constructed prior to 1966 are littered with fixed objects directly off of the edge of pavement. Fortunately, many of these roads have reached their thirty year design lives and have become candidates for improvement.

The following report examines roadside crashes on nine Atlanta urban arterial roadways. Accident type, severity, and location for all crashes on these were evaluated. It is found roadside collisions with utility poles and trees were more prone to occur at intersection locations than midblock locations. Also for the studied roadway corridors, on average, roadside collisions were more likely to result in serious injury or fatality. Based on these findings initial recommendations are offer for improving clear zone requirements.

CHAPTER 1

INTRODUCTION

The "forgiving roadside concept", emanating from the Highway Safety Act of 1966, promotes safety for errant motorists. In short, the forgiving road concept results in roadside designs that allow motorists leaving the roadway ample opportunity to regain control and maneuver back to the roadway. There are many reasons for vehicles leaving a roadway including [1]:

- Driver fatigue or inattention
- Excessive speed
- Driving under the influence of drugs or alcohol
- Crash avoidance
- Roadway conditions such as ice, snow, or rain
- Vehicle component failure
- Poor visibility

As motor vehicle driving continues to increase in the United States, forgiving roadsides remain an important element of effective road design. This is especially true with driver inattention becoming more of a problem with the advent of cellular telephones and other devices that shift motorists' attention [2]. Today's more active lifestyles inspire people to multi-task to save time and money. Though there may be some benefit in utilizing what is otherwise considered lost time while driving, such activities are dangerous and potentially deadly.

This issue has received the attention of transportation agencies. For example, in an effort to combat run-off-the-road crashes, many transportation planning agencies are adding rumble strips at the edge of pavement to alert drivers that they are no longer traveling in the roadway. A reduction in single vehicle crashes has been reported by several agencies that have begun using this treatment method [1]. Some states are considering outlawing the use of cell phones while driving. Many states have already passed legislation limiting the number of teenagers that can be in a car when there is a teenage driver, an effort reduce distractions.

1.1 Study Overview

The National Cooperative Highway Research Program (NCHRP) Project 16-04, "Design Guidelines for Safe and Aesthetic Roadside Treatments in Urban Areas" focused on promoting safer roads by encouraging more context sensitive roadside environments. Context sensitive solutions (CSS) refers to a process of considering community and environmental considerations in the early design process. Essentially, context sensitivity is a balancing of the needs and desires of multiple stakeholders, including motorists, cyclists, pedestrians, business owners, and residents. The three main aspects of a context sensitive solution are safety, community, and operational performance [3]. This relationship can be seen in Figure 1.1 with the intersecting center section representing the best context-sensitive solution. Arriving at this balance might be challenging in that the safest road for motorists may not be pedestrian or bicycle friendly. Conversely, a roadside lined with trees and decorative lighting may be a wonderful pedestrian environment, but a crash risk for motorists.

In an ideal design for motorist safety, all roadsides would be completely traversable and clear for errant motorists. Unfortunately, this is not always feasible or even possible. The placement of utilities and landscaping can present a dangerous obstacle for errant vehicles. These same features that provide desirable and livable communities may also be detrimental to the roadway's safety. All the while, the operational performance of the roadway must be considered. Clearly, if the road does not operate well from a traffic flow standpoint, it is of little benefit to the transportation network of which it belongs. An effort must be made to attain a balance among safety, community, and operational performance.

Figure 1.1 The three dimensions of context-sensitive solutions.

NCHRP Project 16-04 was developed to address the relationship between a transportation network and its surrounding environment. The project's working plan states that "A major challenge for the transportation profession is to enhance the current practices and guidelines to simultaneously increase the mobility, accessibility, and safety of the transportation while simultaneously preserving the scenic, aesthetic and community values of the area in which they are located" [4]. The project examined several urban arterial corridors in four states –Georgia, California, Illinois, and Oregon– to determine the effect of the placement of off-road fixed objects on safety. Nine urban arterials representing three counties within the Atlanta Metropolitan Area were selected for study corridors. While these corridors share the same highway functional classification, each has unique roadside characteristics that contribute to the number of run-off-the-road (ROR) crashes. Although the number of off-road collisions can largely be determined by the geometric alignment of the roadway, NCHRP 16-04 focuses primarily on roadside features and their contribution to ROR crashes.

From the data gathered for the NCHRP project, it was noticed that a large percentage of ROR crashes on the study corridors were near intersections. Starting from this observation, this thesis focuses on the congregation of fixed object crashes, particularly those involving trees and utility poles, and their relative proximity to intersection locations. The following sections of this chapter provide an overview of the remainder of the report.

1.2 Literature Review

The literature review found in Chapter 2 of this report is divided into four sections. The first section discusses existing guidelines from the American Association of State Highway and Transportation Officials (AASHTO) and other agencies. The second section examines the danger of utility pole collisions and their contributions to traffic fatalities. Next, past research and literature on tree collisions is examined. Finally, countermeasures for preventing, minimizing, and reducing the danger of roadside collisions are presented.

1.3 Field Data Collection and Processing

Chapter 3 focuses on the methodology used in collecting and processing the data used in the study. It provides step by step instructions on video and GPS data collection processes. Additionally, it discusses data reduction techniques used to format the field data into a usable form. Data was collected from several corridors from several states in different parts of the country including Atlanta, Georgia; Orange County, California; San Diego, California; Chicago, Illinois; and Portland, Oregon. For the purpose of this report, only Atlanta data was analyzed.

1.4 Analysis and Findings

Chapter 4 of the report focuses on the analysis and conclusions drawn from the Atlanta crash data and corridor analysis. The chapter analyzes the severity and frequency of roadside collisions on the study corridors, as well as the information concerning the location of roadside incidents and their proximity to intersection locations. In addition, Chapter 4 also examines crash scenarios that are prevalent at intersection locations involving single and multiple vehicles.

1.5 Conclusions

Chapter 5 of this thesis presents conclusions from the data collection, as well as recommendations for decreasing the number of roadside collisions with utility poles and trees. These recommendations come from both field observation, crash data analysis, and the review of incident reports.

1.6 Appendices

Additional tables and figures that are not included in the body of this report can be found in the appendices. Appendix A includes geographic information system (GIS) maps of the study corridors examined in the report. Appendix B contains tables and graphs with data specific to each of the study corridors.

CHAPTER 2

LITERATURE REVIEW

The following chapter contains information gathered from the existing literature concerning roadside crashes, in particular those crashes involving utility poles and trees. The chapter will discuss not only several existing roadside design standards, but also countermeasures for addressing roadside collisions.

2.1 Existing Roadside Design Guidelines

In 2004, the Transportation Research Board (TRB) published *Utilities and Roadside Safety*. This report notes 1967 Yellow Book, *Design and Operational Practice Related to Highway Safety,* as being the first to mention the concept of *forgiving roadsides* [5]. The *Yellow Book* had been a significant influence on roadside design in the four decades since its publication, sparking the development of breakaway signage, collision-worthy guardrails and other roadside devices [1]. Without question, many lives have been saved over the years from these contributions. Unfortunately, nontraversable roadsides are far too common on American roadways and contribute many injuries and fatalities annually.

Since the publication of the *Yellow Book* many additional resources have built upon the concepts outlined within its pages. Discussed in the following sections are some of the current resources utilized by today's designers and planners to aid in the creation of safer designs.

2.1.1 National Cooperative Highway Research Program *Report 500 Series*

The National Cooperative Highway Research Program published the *Report 500 Series* [6] containing several volumes, each addressing a different type of highway crash. Volume 6 of this report is entitled "A Guide for Addressing Run-Off-Road Collisions. This volume evaluates countermeasures for the treatment of roadside crashes using ratings of effectiveness: tried, experimental, or proven [6]. A tried measure is one that has been implemented in many locations and may even be accepted as common practice, but has not yet been fully evaluated in terms of performance [6]. An experimental strategy may only have been suggested by one agency and does not have wide scale use [6]. Like tried measures, experimental measures should be applied with caution. A proven measure is one that has been widely used and evaluations have shown to be effective [6].

2.1.2 AASHTO A Policy on the Geometric Design of Highways and Streets

AASHTO's *A Policy on the Geometric Design of Highways and Streets* [7], more commonly known as the *Green Book*, is the primary reference used by transportation design engineers in the United States. Chapter 7 of the publication "Rural and Urban Arterials", focuses on "information needed to establish the basis of design for these roadways" [7]. Urban arterials can range from controlled access freeways to two-lane streets with closely spaced traffic signals, making their regulation difficult for governing agencies.

The *Green Book* defines a clear zone as the designation for "the unobstructed, relatively flat area provided beyond the edge of the traveled way for the recovery of errant vehicles" and recommends a minimum of 10 feet clear zone on rural collectors and local roads. However, it also states that a "minimum offset distance of 500 mm (18 in) should be provided beyond the face of the curb, with wider offset provided where practical [7]. It should be recognized, however, that curbs are usually not placed on high speed roadways. The *Green Book* [7] recognizes that 18 inches is not necessarily optimal and agrees that greater offsets should be used when possible. The book also addresses the clearance of roadside objects from curbed roadways near intersections and driveways. In these cases, a minimum setback distance of 3 feet is recommended beyond curb lines.

The *Green Book* [7] also discusses traversable roadsides, stating that anything located within the clear zone should be of a breakaway variety or shielded by some barrier or attenuator. It states that a nontraversable object should be shielded "by an appropriate barrier as long as the barrier represents a lower potential for severe crashes [7]." This regulation could be strengthened by placing specific requirements on the performance of the shielding devices. Finally, the *Green Book* [7] refers to the *Roadside Design Guide* [1] as a further reference to clear zone width regulations.

2.1.3 AASHTO Roadside Design Guide

The AASHTO *Roadside Design Guide* is the major source of federal roadside design guidelines. Fundamentally, the *Roadside Design Guide's* [1] stance on utility pole placement is to avoid their use in roadside area or at least move them as far away as possible from the roadway. The book highlights the dangers of utilities and other rigid objects in the right-of-way. Future revisions, however, could benefit from providing more information specific to the placement of these objects.

The Guide focuses on the severity of utility pole collisions, noting that they are responsible for 10 percent of all fixed-object fatality crashes [1]. Utility poles are most commonly owned by private corporations and installed on publicly owned land; they are not under the direct responsibility of highway agencies [1]. "This dual responsibility sometimes complicates the implementation of effective countermeasures [1]."

The viewpoint of the *Roadside Design Guide* is that no utility pole should be placed in a location where it can be struck, but if necessary, it should use a breakaway or some other design that reduces the danger of the collision. Primarily, the guide addresses countermeasures that should be used to prevent the use of utilities within the roadway right-of-way. As this document takes a stance firmly against utility pole placement in vulnerable areas, it provides no specific standards for locations on the roadside. Understandably, AASHTO does not advocate the construction of dangerous environments. However, it could be beneficial for the organization to provide greater standards on utility pole placement as they are and will continue to be placed in roadside environments.

2.1.4 AASHTO A Policy on the Accommodation of Utilities within Freeway Right of Way

The *Roadside Design Guide* cites other sources as providing more detailed information regarding the installation of utilities within highway rights-of-way such as AASHTO's *A Policy on the Accommodation of Utilities within Freeway Right of Way (UAPSM)* [8]. However, this document provides no specific guidelines to utility placement in terms of setbacks from the roadway. This publication focuses specifically on the placement of utilities within a freeway right-of-way and is, therefore, not necessarily applicable for facilities with lower functional classification, such as those in the study effort.

A section of the document entitled "Existing Utilities Along Proposed Freeways" explains that a utility may remain "as long as it does not adversely affect the safety, design, construction, traffic operations, maintenance, or stability of the freeway [8]." However, the document offers no detailed guidance on determining whether a utility meets the standard. Similarly, in the "New Utility Installations Along a Freeway" section of the document states that in cases were longitudinal installations are requested along roadways that "the accommodation will not adversely affect safety…" [8]. Future revisions of the document will have adequate areas for improvement in terms of placing clearly defined limits and regulations. Again, minimal guidance is offered for determining if an installation meets this standard. Providing planners and designers with additional guidance on implementation of the outlined safety goals would likely result in overall improvements in highway safety.

2.1.5 GDOT Transportation Design Manual

Chapter 5 of the Georgia Department of Transportation Design Manual [9], Roadside Safety and Horizontal Clearance, provides standards for roadside design. Table 2.1 from the GDOT Design Manual provides general guidelines for the placement of trees along roadways. The table groups trees into two categories, less than or equal to 4 inches in diameter and those greater than 4 inches in diameter. The minimum clearance on urban shoulders with less than 35 miles per hour design speed is 4 feet from the curb face. For design speeds greater than 35 miles per hour and not exceeding 45 miles per hour, trees less than 4 inches in diameter should be a minimum of 8 feet from the curb. Additionally, there are several categories defining the recommended placement of trees exceeding 4 inches in diameter. For design speeds of less than 35 miles per hour, between 35 and 45 miles per hour, and equal to 45 miles per hour, tree setbacks should have horizontal clearances of 8, 10, and 14 feet, respectively.

Table 2.2 from the GDOT Design Manual displays information concerning utility installation on GDOT's right-of-way. The table provides minimum horizontal clearances for utility poles of 6, 8, and 12 feet for urban shoulders of design speeds of less than 35, between 35 and 45, and greater than 45 miles per hour, respectively [9]. From these standards, utility poles are given slightly less rigid restrictions when compared to trees with a greater than 4 inch diameter. Additionally, the table refers to the Georgia Department of Transportation's *Utility Accommodation Policy and Standards Manual (UAPSM)* [10] as the source for general guidance for utility installation.

Table 2.1 Horizontal Clearance to Trees and Shrubs from GDOT Design Manual [9].

General guidance	Guidance provided from the Office of Maintenance regarding landscaping requirements (MOG 6655-9), which includes approvals through the Office of Traffic Safety and Design; Guidance provided by the Office of Planning through the Pedestrian and Streetscape Guide. The Design Speed shall be used to determine Horizontal Clearance criteria.
Rural Shoulders	Locate outside the clear zone.
Urban Shoulders, Posted/Design Speed less than or equal to 35 mph, tree size at maturity **less than or equal to 4 inches in diameter** measured at 2 feet up from the ground.	Minimum Horizontal Clearance from center of tree to face of curb is 4 feet
Urban Shoulders, Posted/Design Speed less than or equal to 35 mph, tree size at maturity **greater than 4 inches in diameter** measured at 2 feet up from the ground.	Minimum Horizontal Clearance from center of tree to face of curb is 8 feet
Urban Shoulders, Posted/Design Speed greater than 35 mph, but less than or equal to 45 mph, tree size at maturity less than or equal to 4 inches measured at 2 feet up from the ground.	Minimum Horizontal Clearance from center of tree to face of curb is 8 feet.
Urban Shoulders, Posted/Design Speed greater than 35 mph, but less than 45 mph, tree size at maturity **greater than 4 inches in diameter** measured at 2 feet up from the ground.	Minimum Horizontal Clearance from center of tree to face of curb is 10 feet. Minimum Horizontal Clearance in median is 16 feet, from the inside edge of travel to the center of the tree.
Urban Shoulders, Posted/Design Speed equal to 45 mph, tree size at maturity less **than 4 inches in diameter** measured at 2 feet up from the ground.	Minimum Horizontal Clearance from center of tree to face of curb is 8 feet (by PSG).
Urban Shoulders, Posted/Design Speed equal to 45 mph, tree size at maturity **greater than 4 inches in diameter** measured at 2 feet up from the ground.	Minimum Horizontal Clearance on outside shoulders from center of tree to face of curb is 14 feet.

Table 2.2 GDOT Design Manual Horizontal Clearances for Utility Installations [9].

General Guidance	Utility Installations are generally governed by GDOT's *Utility Accommodation Policy and Standards Manual(UAPSM).* Reader is encouraged to read and understand the referenced policy, in conjunction with this guidance.
Rural Shoulders, Posted Speeds less than 60 mph, fill section with slopes 4:1 or flatter.	Utility obstacles shall be located at least 30 feet from the edge of pavement (traveled way) to the face of the obstacle.
Rural Shoulders, Posted Speeds less than 60 mph, fill section with slopes steeper than 4:1.	Utility obstacles shall be located at an offset that provides for at least 30 feet of net traversable and recoverable slope from the edge of traveled way to the face of the obstacle. The horizontal distance in which slopes steeper than 4:1 are encountered are not to be considered as 'traversable and recoverable'. Consult the RDG and the UAPSM for full understanding.
Rural Shoulders, Posted Speed greater than or equal to 60 mph, all slope conditions.	Utility obstacle shall be located outside the accepted Clear Zone for the prevailing conditions, or 30 feet, whichever is greater.
Urban Shoulders, general.	Utility obstacles shall be positioned as near as possible to the right of way or utility easement line. Utility obstacles should be placed in keeping with the nature and extent of roadside development. Horizontal clearance for utility objects is measured from the Face of Curb to the Face of Pole or object. For Utility Relocation on Urban Highway projects, the Utility offset should be governed by the Design Speed. No Utility object shall encroach on current sidewalk clearances required by ADA.
Urban Shoulders, Posted Speed or Design Speed less than or equal to 35 mph	Minimum horizontal clearance is 6 feet.
Urban Shoulders, Posted Speed or Design Speed greater than 35 mph and less than 45 mph	Minimum horizontal clearance is 8 feet.
Urban Shoulders, Posted Speed or Design Speed equal to 45 mph	Minimum horizontal clearance is 12 feet.

2.1.6 GDOT Utility Accommodation Policy and Standards Manual

The preface of the Georgia Department of Transportation *Utility Accommodation Policy and Standards Manual* (UAPSM) asserts that the "Department of Transportation is charged with constructing, maintaining, and operating the State's highways safely and efficiently for the benefit of the motorists who use them" and that the use of public right-of-way "by water, sewer, gas, power, and communications and other public utilities is a privilege afforded utility companies by the Department in the general public interest [10]." Therefore, it is the responsibility of the DOT to regulate the placement of utilities in the best interests of citizens while maintaining motorist safety standards.

The UAPSM states that "longitudinal installations are to be located on uniform alignment as near as practical to the right-of-way line so as to provide a safe environment for traffic operation and preserve space for future highway improvements or other utility installations [10]." The current standards, however, allow the design engineer to interpret a distance that is as "near as practical" to the edge of the right of way.

Additionally, GDOT's UAPSM affirms that "full consideration shall be given to the measures, reflecting sound engineering principles and economic factors, necessary to preserve and protect the integrity and visual quality of the highway, its maintenance efficiency, and the safety of highway traffic." Moreover, this section of the book promotes context sensitive design through the examination of not only efficiency and safety of traffic, but also economic factors and visual quality of the highway.

2.2 Utility Pole Collisions

Approximately 10 percent of all fixed-object crashes are collisions with utility poles [1]. As expected, most fixed object crashes are with trees as they greatly outnumber utilities, mailboxes, and guardrails on American roadways. Utility poles crashes are more common in urban than rural areas, due to the higher density. These crashes can be particularly dangerous as utility poles are not typically designed to be "forgiving" when hit in a ROR incident.

In 1980, utility pole collisions were responsible for more than 1,900 fatalities on U.S. roadways [5]. Fortunately, this number has decreased steadily and was nearly cut in half by the year 2000 to approximately 1,100 fatalities, as shown in Figure 2.1. In addition to 1,100 deaths, 60,000 traffic injuries are associated with utility pole collisions. However, historically, utility poles have not received significant attention from regulatory agencies. Likely due to the rankings of utility poles behind trees, embankments, and guardrails in the number of fixed object fatalities as seen in Table 2.3.

The installation of utility poles directly off roadways has long been practiced in the United States. A TRB utility safety publication cites a certain utility pole in a northern U.S. state that had been struck by a vehicle at least once in each of 50 consecutive years [11]. The pole in question had been damaged on several occasions sufficient to warrant replacement, and in each case a new pole was installed in the same location. Clearly, steps should be taken by governing agencies, utility companies, and other stakeholders to eliminate these events.

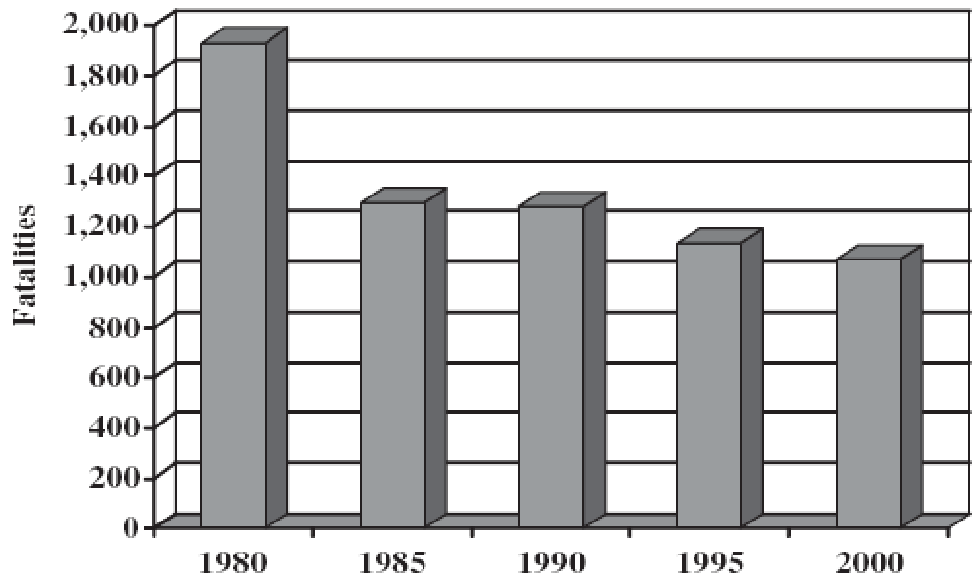


Figure 2.1 Utility pole fatalities by year [5].

Table 2.3 Fixed Object Fatalities in 2000 [5].

Fixed Object (F.O.)	Fatalities	% Total (41,821)	% F. O. (12,175)
Tree/Shrubbery	3,379	8.1	27.8
Embankment	1,283	3.1	10.5
Guardrail	1,171	2.8	9.6
Utility Pole	**1,103**	**2.6**	**9.1**
Ditch	944	2.3	7.8
Other F. O.	4,295	10.2	35.2
TOTAL	12,175	29.1	100.0

2.3 Tree Collisions

As seen in Table 2.3, trees account for the largest percentage of fixed object fatality crashes on U.S. roadways. Due to the sheer number of trees, they are often difficult to manage. Volume 3 of NCHRP *Report 500* focuses specifically on these crashes and is entitled "A Guide for Addressing Collisions with Trees in Hazardous Locations" [12].

The document cites statistics from the Fatal Accident Reporting System data in which 10,967 fatal crashes were the result of fixed object collisions in 1999. Of these fatalities, 3,010 were the result of fixed object collisions with trees [12]. Additionally, *Report 500* states that 90 percent of these fatalities occurred on two-lane roads [12]. From this statistic it can be concluded that the majority of fixed object collisions occur in rural areas. For this reason, rural two-lane roads receive most of the attention in *Report 500*. There are two primary strategies identified in the report to address tree collisions; to "prevent trees from growing in hazardous locations" and "to eliminate the hazardous condition and/or reduce the severity of the crash [12]." Nicholas Bratton, of the University of Washington, writes that from a dataset of 1,830 tree collisions, 39 percent were found to have occurred in urban areas while the remaining 61 percent were in a rural setting [13]. Additionally, he points out the severity of these collisions with only 29 percent of crashes resulting in no injury [13].

2.4 Run-off Road Collision Treatment Options

There are two classic approaches for reducing ROR crashes on the nation's roadways: keeping vehicles on the roadway and minimizing the consequences of leaving the roadway. In AASHTO's *Strategic Highway Safety Plan* [14], both are listed as safety plan goal areas. As 40 percent of traffic fatalities in 2003 can be credited to ROR crashes, their prevention should be given priority in roadway designs. The next two sections outline methods used for keeping vehicles on the roadway and for minimizing the consequences when a vehicle leaves the roadway.

2.4.1 Keeping Vehicles on the Roadway

The primary line of reasoning behind keeping vehicles on the roadway is quite simple. If a vehicles remains on the roadway, it cannot experience a ROR crash. In many cases, however, this could be the most expensive method for reducing roadside collisions. For example, reducing ROR crashes on a particular roadway segment may require a change in the roadway alignment, a potentially costly mitigation strategy. Aside from geometric alignment, several techniques for keeping vehicles on the roadway include: rumble strips, sharp curve delineation, and skid resistant pavements. In Chapter 3 of *Utilities and Roadside Safety*, Don Ivey and Paul Scott explain that these measures to keep vehicles on the road are not the total answer as they will be never be completely effective. These countermeasures should be coupled with the reduction, removal, relocation, or shielding of the utility poles [5]. A brief discussion of these countermeasures follows.

2.4.1.1 Rumble Strips

One of the simplest and most effective means for keeping vehicles on the roadway is the use of rumble strips. The Federal Highway Administration has conducted several studies and estimate that roadside crashes can be reduced approximately 20 to 50 percent with the use of rumble strips [6]. Rumble strips are grooves, often placed on roadway shoulders, that are “0.5 inches deep, spaced about 7 inches apart, and cut in groups of four or five [6].” The result of a vehicle driving over the rumble strips is a vibrating or rumbling that will alert the driver that he or she has left the lane and is encroaching on the edge of the roadway. These devices can also be used to alert drivers of approaching intersections or other important features ahead.

2.4.1.2 Sharp Curve Delineation

A large percentage of ROR crashes occur on roadways with sharp curves. Considering the high cost of realignment, increased warning through pavement markings and signage can be an effective means for reducing crashes. Increasing the visibility of signage with larger signs and flashing lights is a popular choice for delineating the effects of sharp curves [6]. Another technique involves creating a greater sense of danger, using human perception to encourage traveling through the curves in a more careful manner. One such method uses pavement markings that give the impression that lanes are narrowing when negotiating a curve. The goal is that if the driver has the impression that they are traveling in an especially narrow lane, he or she will likely be more focused on maintaining the vehicle's position on the roadway. Another measure that has been practiced as a delineator on a sharp curve is the use of rumble strips prior to the curve to alert the driver of the upcoming curve.

2.4.1.3 Skid Resistant Pavements

Many ROR crashes can be credited to motorists losing control of their vehicles. Wet pavement is a major contributor to these crash types, with 11 percent of single vehicle ROR fatal crashes occurring on these surfaces [6]. The decrease in friction from wet pavement surfaces makes it especially difficult for motorists to negotiate curvatures. It is interesting to note that with a water film thickness of 0.002 inches the friction between a tire and the pavement decreases by 20 to 30 percent [6]. There are several available countermeasures for improving the skid resistance of pavements. Specific pavement mixtures, overlays, or the addition of texture is often used in an effort increase resistance [6]. This is a difficult problem to design against, however, as pavement surfaces change drastically over time due to wear from vehicles and weather. Additionally, pavement texturing such as asphalt grooving can, at times, decrease skid resistance by providing an area for water to puddle.

2.4.2 Minimizing the Consequences of Leaving the Roadway

It is the intent of the roadway design to keep vehicles on the highway. However, at present it is not reasonable to guarantee that vehicles will never leave the roadway. It is the responsibility of agencies and roadway designers to minimize, as much as possible, the consequences of leaving the roadway. This is stated clearly in Goal 16 of the AASHTO's Strategic Highway Safety Plan [14].

Furthermore, the AASHTO *Roadside Design Guide* [1] makes several recommendations to the placement of trees, utilities poles, and other objects on roadsides, by identifying six options. In order of preference, these are:

1. Remove the obstacle.
2. Redesign the obstacle so it can be traversed.
3. Relocate the obstacle to a point where it is less likely to be struck.
4. Reduce impact severity by using an appropriate breakaway device.
5. Shield the obstacle with a longitudinal traffic barrier or crash cushion or both if it cannot be eliminated, relocated, or redesigned.
6. Delineate the obstacle if the above alternatives are not appropriate.

Clearly, the best option for reducing utility pole collisions is eliminating the poles themselves. Other options are identified in the *Roadside Design Guide* specifically for the reduction of utility pole crashes. These solutions include [1]:

- Increase lateral pole offset.
- Increase pole spacing.
- Combine pole usage with multiple utilities.
- Bury electric and telephone lines underground.

The use of these techniques minimizes the consequences of leaving the road, and particularly reduces the frequency of roadside crashes with fixed objects when a vehicle does leave the roadway. The following sections will address, specifically, the techniques of removing or changing obstacle position, traversable roadside devices, increasing the visibility of objects, and traffic calming as methods for minimizing the consequences of leaving the travelway.

2.4.2.1 Removal or Change Position of Obstacle

Cost is a major issue when considering complete removal of roadside fixed objects. Unfortunately, if utilities are buried, there is a significant increase in installation and repair costs, as well as routine maintenance costs that would be suffered by utility providers [1]. Moreover, the right-of-way required to place utilities underground can be more than twice that of overhead installations [1]. Again this represents additional costs that would have to be suffered by the utility companies and passed on to the consumer. Also, Zegeer [15] notes that reducing the number of utility poles will provide fewer locations for street lamps to be placed. Additionally, it should be considered that utility pole removal may not completely eliminate utility crashes. For example, additional transformers that may be needed in the case of underground utilities due to the limitations of current capacity [1].

When option 1 [1], the complete removal of the obstacle, is not feasible it would still be beneficial to decrease their frequency on roadside environments. However, in the case of utility poles this may not be possible, at least with not without significant additional costs. Increasing pole spacing may require larger and more costly poles [15]. An engineering study would be necessary to determine if this type of improvement was cost-effective or even possible [1].

Option 1, from the *Roadside Design Guide's* suggestions to reduce utility pole crashes, is to increase the lateral pole offset from the roadway. This is due to an overrepresentation of pole accidents being found within 10 feet of the roadway [15]. In a 1978 study by William Hunter, it is suggested that the frequency of off-road fixed object collisions will not be reduced through this technique as errant vehicles will strike other objects [16]. Following this study, Rinde assumed no decrease in fixed object accident frequency by increasing the lateral clearance from the roadway and found that there was a decrease in fatal accidents [17]. The decrease in fatal accidents may be credited to the generally more rigid nature of utility poles as compared to other roadside objects [17]. Additionally, if an errant vehicle collides with a pole 30 feet after leaving the roadway as opposed to 10 feet, it will have a had a longer time period to avoid an object or at least reduce the speed at the point of impact.

In a more recent publication, Charles Zegeer provides recommendations for reducing utility pole crashes. The first step is to examine crash history and identify high incidence locations [18]. He contends that if each year utility companies and local highway agencies work together to improve problem locations, then utility pole crashes can be reduced in a relatively short time [18]. Zegeer's second step is for utility companies to place greater emphasis on the replacement of damaged poles. If the pole is in a location where additional ROR incidents are likely, a new pole location may be an effective countermeasure. The third step is to identify high risk utility poles, such as those at horizontal curves, busy intersections, or roadway medians [18].

Zegeer points out that allowing high risk poles to remain is not being proactive and simply waiting for crashes, possibility fatalities, to occur [18]. He further recommends agencies adoption of clear zone policies as seen in the AASHTO Roadside Design Guide [1]. Zegeer's final step is to establish a funding source for utility pole improvements. Certain monies should be set aside specifically for the reduction of these preventable crashes. The Washington and Pennsylvania Departments of Transportation have enacted programs for identifying and improving problem locations [18].

2.4.2.2 Traversable Roadside Features and Safety Devices

In 1993, The National Cooperative Highway Research Program (NCHRP) published Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features* [19]. The report tested several roadside safety apparatuses including barriers, terminals and crash cushions, and breakaway utility poles. It is considered the standard for the testing of highway safety devices in this country.

A breakaway support "refers to all types of sign, luminaire, and traffic signal supports that are designed to yield when impacted by a vehicle [1]." These devices were tested extensively for velocity criterion and other performance measures in NCHRP 350 [19]. Design considerations for the breakaway support design include structural stability to serve its purpose. Most of these devices are designed to function properly when impacted at bumper height. For this reason, breakaway supports should not be used near ditches or steep slopes which may lead to airborne impact [1]. Additionally, these devices are not effective when placed on top of concrete pedestals, which is fairly common in commercial parking lots. The design should not be so forgiving that it is unable to support its load with typical ice or wind loading. The *Roadside Design Guide* states that "as a general rule, breakaway supports should be used unless an engineering study indicates otherwise [1]."

Barrier end treatments and crash cushions are devices that are designed to decelerate vehicles before impact with a fixed object or redirect the vehicle away from the object. In locations where guardrails or other barriers are used, it is vital to place utility poles behind these devices [18]. Barrier end treatments should be crashworthy and should used at any location where a barrier terminates in a clear zone or any location where it is likely to be struck [1]. Crashworthy describes an object that does "not spear, vault or roll from head-on or angled impacts [1]." End treatments can be placed into two major categories; gating or non-gating. A gating end treatment is designed to allow an impacting vehicle to "pass through the device" where non-gating end treatments redirect vehicles [1].

An example of an end treatment, the Wyoming Box Beam End Terminal (WYBET-350) consists of a nosepiece which telescopes into a tube upon impact, dissipating kinetic energy [1]. NCHRP Report 350 [19] outlines the standards by which these treatments are tested. If barriers do not have crash worth end treatments, then they should be anchored into a backslope. This option "provides full shielding for the identified hazard, eliminates the possibility of an end-on impact with the barrier terminal, and minimizes the likelihood of the vehicle passing behind the rail [1]".

Crash cushions or impact attenuators are also used when fixed objects cannot be removed from roadside areas and when barrier end treatments may present other dangers. For instance, these devices are favorable when it is not necessarily safer for a vehicle to be redirected. On interstate off-ramps for example, a barrier end treatment may just redirect an errant vehicle into another obstacle, such as another lane, where an impact attenuator is designed to stop a vehicle upon impact. The *Roadside Design Guide* states that "crash cushions generally employ one of two concepts to accomplish this task-absorption of kinetic energy or transfer of momentum."

2.4.2.3 Increase Visibility of Obstacles

If other measures are not possible due to financial or other constraints, increasing the visibility of obstacles can be beneficial. Increased lighting on the roadways will increase driver visibility and should therefore reduce roadside crashes [5]. A less expensive option that may produce similar results is practiced by the Pennsylvania Department of Transportation. PennDOT has begun placing reflective tape on utility poles to increase their visibility at night. The theory behind this method is obviously not to reduce the severity of a collision, but to permit the driver a greater chance of performing an evasive maneuver away from the fixed object. However, if a motorist has no control over his vehicle, the increased visibility afforded will be of no benefit [20].

Report 500 [20] points out the cost benefit of this countermeasure and states that "if a reduction of crashes is assumed" this device will provide a good return in terms of cost-benefit. Again, this assumption may be ambitious in that most errant motorists do not have control to maneuver their vehicle away from impacting a fixed object, albeit illuminated or reflective. The report [20] also points out that if a motorist does strike a utility pole equipped with reflective markings the governing agency may be liable in a lawsuit due to its recognition of the obstacle as a potential danger, yet failure to use a more effective and tested countermeasure.

2.4.2.4 Traffic Calming

Traffic calming measures have also been implemented in some cases with the intent of reducing the severity of crashes with roadside objects. This technique is common in urban residential areas where utilities must be provided in a limited right of way. Primarily, traffic claming is implemented with the intention of reducing the speeds of motorists. By reducing speeds, it stands to reason that the severity of roadside crashes would also be reduced due to a lesser amount of energy upon impact [20]. Also, slower traveling vehicles would be less likely to strike roadside objects as well, given the likelihood of greater vehicle control and an increased available reaction time. Additionally, traffic calming has been proven to be an effective deterrent for motorists simply using the roadway as a shortcut, therefore reducing the average daily traffic (ADT) on the roadway. Consequently, a lower ADT would, other things being equal, result in fewer crashes along the corridor. However, the possibility exists that these trips are moved to an alternate corridor which may experience and increase in incidents with the associated ADT increase.

2.5 Literature Review Summary

The primary focus of the literature review was existing was existing regulations and design recommendations by transportation agencies. Specifically, AASHTO's *A Policy on Geometric Design of Highways and Streets* [7], *Roadside Design Guide* [1], the Policy on the

Accommodation of Utilities within Free Right of Way [8], GDOT's *Transportation Design Manual* [9], and the Utility Accommodation Policy and Standards Manual [10].

In addition to citing existing regulations, the chapter also notes areas in which additional guidance in the manuals could be useful. Also, the chapter examines literature on utility pole and tree collisions. Specifically, statistics describing the number of these roadside crashes are discussed. Finally, treatment options for reducing roadside fixed object crashes were examined.

CHAPTER 3

FIELD DATA COLLECTION AND PROCESSING

The data collection portion of NCHRP 16-04 took place in several locations throughout the country, including: Atlanta, Georgia; Chicago, Illinois; Orange County, California; San Diego, California; and Portland, Oregon. Different regions were chosen as study corridors in order to provide a more diverse sample set. For this thesis, only data collected in the Atlanta metropolitan area was analyzed.

This chapter will focus on the processes and methodology used for collecting data for this project. It is divided into scions covering Study Corridors, Field Data Collection, Field Data Processing, and Accident Data Processing. The Field Data Collection section is divided into Video and GPS data collection.

3.1 Study Corridors

Geographic Information System (GIS) images of each of the Atlanta study corridors analyzed in this report are included in Appendix A. An example of one such image can be seen in Figure 3.1. The focus of this study is on urban arterials, however, even given the similar functional classification of the corridors, a wide range of roadside characteristics is found. All study corridors can be seen along with Atlanta expressways in Figure 3.2. The study corridors examined in the report are:

- 14th Street from Northside Avenue to West Peachtree Street, West Peachtree Street from 14th Street to Peachtree Road, Peachtree Road from West Peachtree Street to Peachtree Valley Road
- Roswell Road from Sandy Springs Place to The Valley Road
- Roswell Road from Greenbriar Parkway to Taliwa Trial
- Roswell Road from Red Fox Trial to Fields Pond Drive
- Alpharetta Highway from Liberty Lane to Mansell Place
- Franklin Road from Cobb Parkway to South Marietta Parkway
- Moreland Avenue from Eden Avenue to Briarcliff Road, Briarcliff Road from Moreland Avenue to Chalmette Drive
- Briarcliff Road from Zonolite Road to North Druid Hills Road, North Druid Hills Road from Briarcliff Road to Buford Highway
- Candler Road from Ellen Way to Flat Shoals Parkway, Flat Shoals Parkway from Candler Road to Waldrop Road

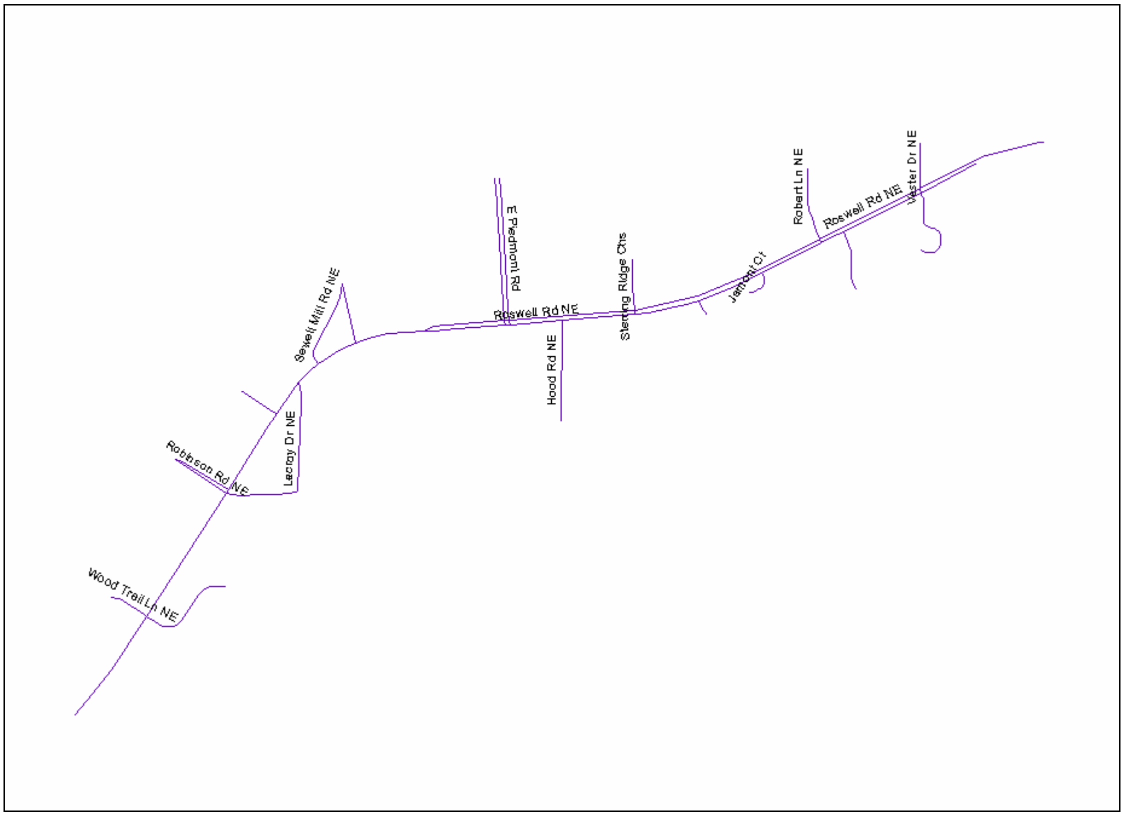


Figure 3.1 GIS Image of Roswell Road Corridor (Length of 2.03 miles).

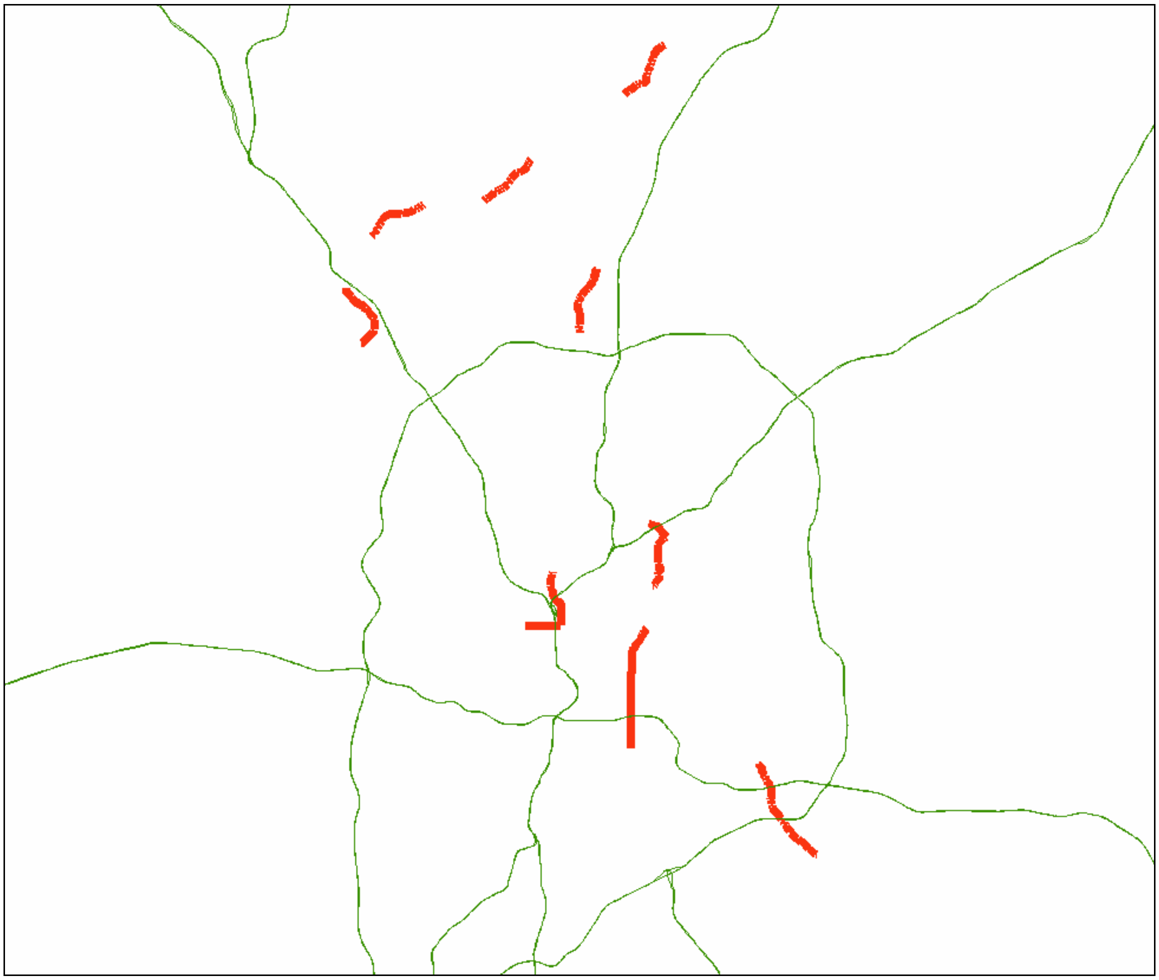


Figure 3.2 GIS Image of all study corridors with Atlanta expressways.

3.2 Field Data Collection

The following section discusses the methods and equipment used to collect the field data used in this report. Primarily, there were two portions of field data collection: video and GPS. The data for each were collected simultaneously from April 2007 to June 2007.

3.2.1 Video Collection

In order to have a visual image of each study corridor, the corridor roadsides were video recorded. To accomplish this task, a camera was mounted to the windshield inside of the vehicle on the front passenger side as shown in Figure 3.3. A Canon Optura Xi Digital Video Camcorder was focused to capture the edge of pavement and the right-of-way and any obstructions or features that were present. A DC power cable was used to ensure sufficient battery life during the collection period.

While driving on the study corridors, the driver of the vehicle would remain in the far right travel lane so as to capture the clearest image of the corridor's roadside. In some cases, it was impossible to remain in the far right line due to on-street parking and right turn lanes. To increase the video quality, the investigators attempted not to exceed 35 miles per hour, but often found this impossible for safety reasons. While driving the corridors, street names and other roadside information was reported verbally to aid with the video analysis.

Figure 3.3 Photograph of video camera with windshield mount.

3.2.2 GPS Data Collection

The GPS data and video data were collected simultaneously. A Hewlett-Packard iPaq 2210 PDA was used along with Haicom 303E GPS Receiver with a magnet antenna placed on the roof of the investigator's vehicle. A DC cable was used with the PDA to ensure the data would be collected properly.

A run is defined as a single trip in one direction of a corridor. Therefore, each study corridor required a minimum of two runs. At the beginning of each run, the PDA's screen with the PDA clock time displayed was video recorded to provide a synching point for the later analysis. GPS data was recorded throughout the entire travel run. The GPS data included second-by-second latitude, longitude, and speed, as well as other information.

3.3 Field Data Processing

After recording, the video was digitized to allow viewing and storage on a computer. The videos were divided into separate video files for each run on each study corridor. A timestamp superimposed on the video image by using Sony Vegas 5 video editing software (Figure 3.5).

To sync the GPS data with the video stream, a new field, "Video Time", corresponding to the video timestamp was added to each GPS data point. Using the starting point established by recording the PDA clock time at the beginning of each video, it was possible to determine the GPS location related to the video timestamp. Next, the GPS points were plotted in ArcGIS using the latitude and longitude as x and y coordinates and labeling each point with its "Video Time". The image in Figure 3.4 represents an example GIS image on 14th Street in Midtown Atlanta. Figure 3.5 shows the corresponding video image for one of the points in Figure 3.4. This method of coordinating the video and GPS data made it possible to watch the video while easily locating the point in the GIS.

After the video and GPS data were synced as described above, the videos were reviewed concurrently with the ArcGIS file. Notes were taken describing the roadside conditions in terms of frequency of utility poles, trees, raised curb and gutter, decorative lighting, turning lanes, and other features. Corridors were examined in segments with each segment beginning and ending at crossing streets. Roadside conditions were noted for each segment without cross referencing crash data for the corridor. This procedure was used in order to prevent bias by the video reviewer.

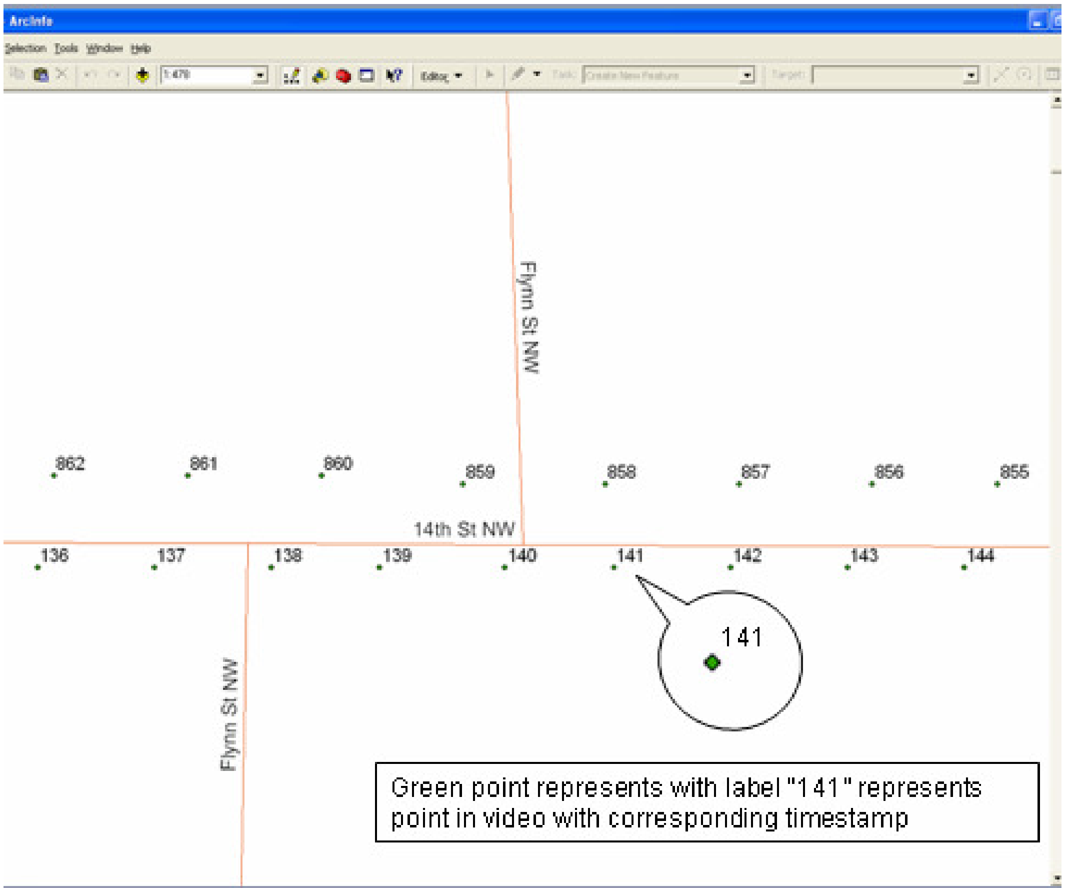


Figure 3.4 ArcGIS image of 14^{th} Street

Figure 3.5 Image from video of 14th Street

3.4 Accident Data Processing

Critical Analysis Reporting Environment (CARE) software developed at the University of Alabama was used in the reduction of the Georgia crash data for the purpose of the project. The software provides an easy-to-use interface that allows users to sort crashes by a variety of fields. Six years of accident data from 2001 to 2005 were analyzed in order to have a large sample size. CARE uses latitude and longitude as well as corridor mileposts to plot crashes in ArcGIS.

Initially, all Georgia collisions during the specified time period were plotted in ArcGIS. Next, all crashes within 100 feet of the study corridors were selected. From the selected crashes, tables were generated displaying the number of crashes by accident type, severity, and year. The resulting tables can be seen in Appendix B for each of the nine Atlanta corridors. An example of one such table is shown in Table 3.1. For the NCHRP 16-04 Report, specific focus was given to off-road fixed object crashes. In order to segregate these accidents, CARE was used to select accidents occurring on roadsides or shoulders with the manner of collision defined as "not a collision with a motor vehicle". The resulting crashes were examined manually, eliminating crashes that did not meet criteria, specifically location. Examples of eliminated incidents include those on neighboring streets that fell within the buffer, but did not occur on the roadside of one the study corridors.

Table 3.1 Table displaying the severity of accidents on Roswell Road (1) corridor.

Roswell Road (1), Fulton County, Georgia								
Crash Type		2000	2001	2002	2003	2004	2005	Total
Angle/Broadside		253	211	211	204	176	163	1218
Head-On		9	12	12	8	12	5	58
Hit Object (Total)								
	Fixed Object	13	11	20	21	15	6	86
Pedestrian		8	9	4	7	8	10	46
Rear End		215	197	206	234	202	173	1227
Sideswipe (Total)								
	Sideswipe Opposite Direction	5	6	4	11	5	7	38
	Sideswipe Same Direction	54	52	55	43	47	44	295
Total Crashes		557	498	512	528	465	408	2968

The resulting crashes were grouped by corridor and exported into nine separate spreadsheets. In order to quantify the locations of crashes along the corridors, histograms were created using a macro written using Visual Basic. An example of the resulting histograms can be seen in Figure 3.6. This histogram illustrates the number of crashes in 0.5 mile increments along a corridor. Additionally, line graphs were used to display the same information with a 0.1 mile interval. An example is pictured in Figure 3.7. The histograms for each of the study corridors can been found in Appendix B. This information was beneficial when comparing general roadside conditions found from the video analysis with off-road fixed object crash histories.

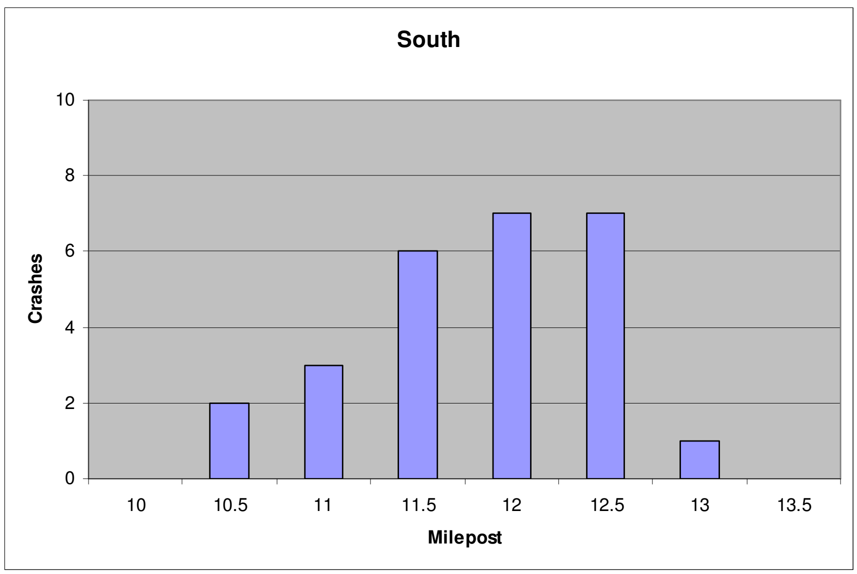


Figure 3.6 Histogram of off-road fixed object collisions for the southbound portion of Roswell Road (1) corridor.

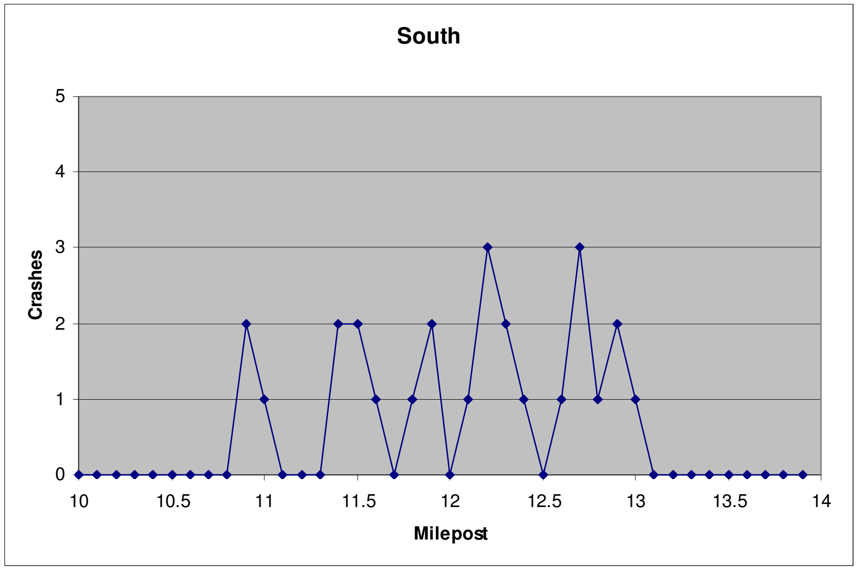


Figure 3.7 Graph displaying off-road fixed object collisions for the southbound portion of Roswell Road (1) corridor.

3.4.1 Locating Incidents

In order to determine the number of incidents located near intersection locations, buffers were used in ArcGIS. Figure 3.8 shows a portion of the 14th Street study corridor in which intersections with the intersecting roadways' centerlines are identified. From these points, buffers were placed as seen in Figure 3.9. The image displays a buffer of 100 feet, although buffers of 25 and 50 feet were also used. After the buffers were developed, it was possible to determine which crashes were within a specified distance from an intersection by plotting all roadside collisions with utility poles and trees along the study corridors and selecting which crashes fell within the buffer.

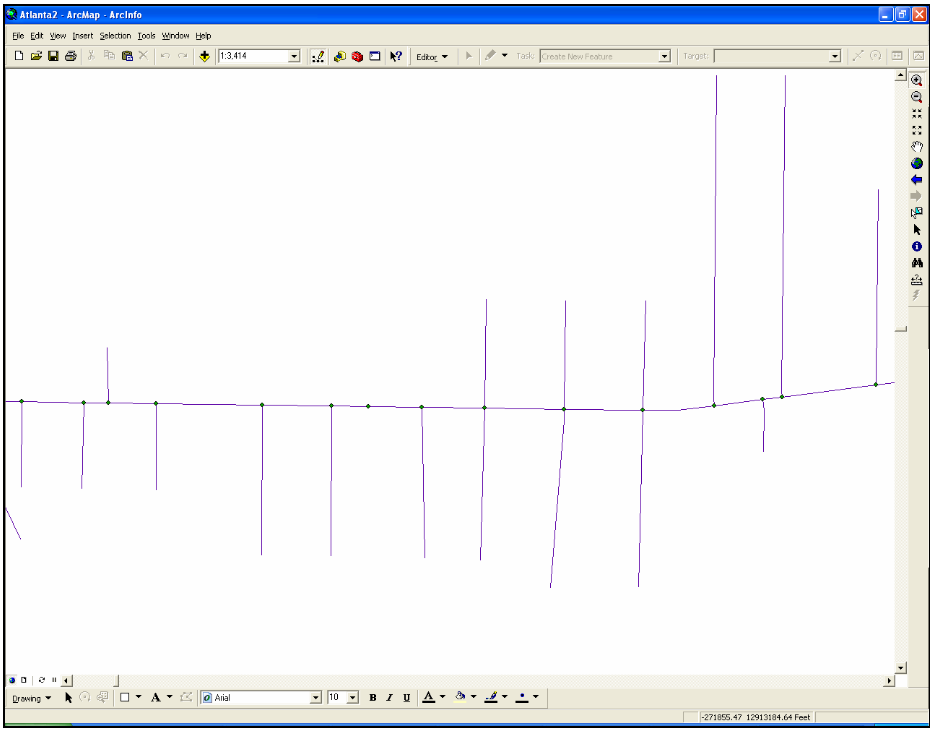


Figure 3.8 ArcGIS image of 14th Street with intersecting side streets and points at intersections.

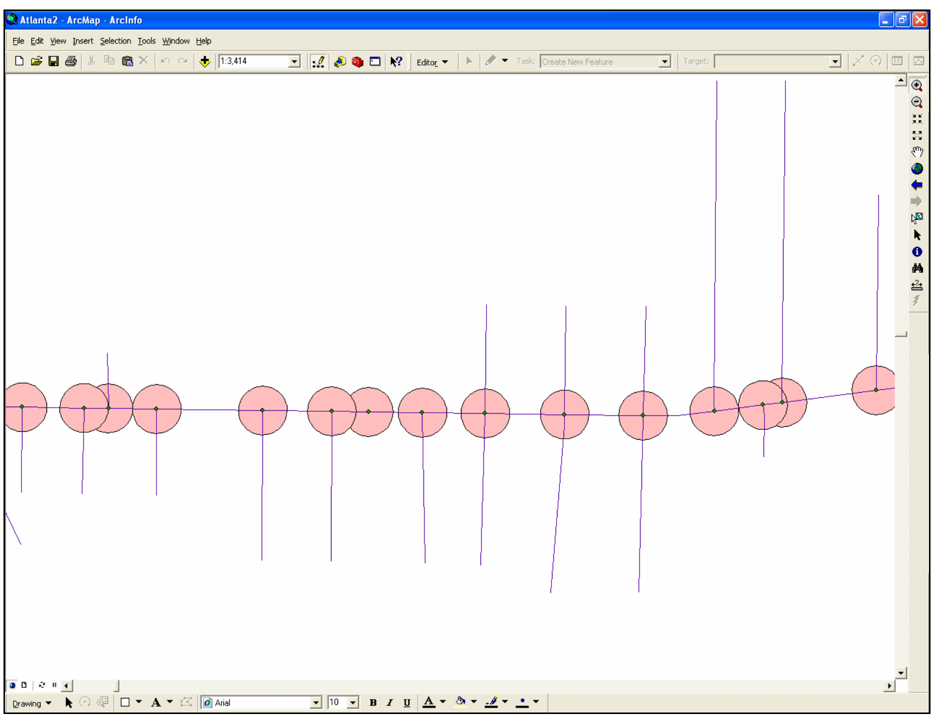


Figure 3.9 ArcGIS image of 14th Street with intersecting side streets and points at intersections and buffers.

3.5 Summary of Field Data Collection and Processing

Chapter 3 of this report focused on the methodology used for collecting and processing the field and accident data. Specifically, instructions were provided on the procedure used in driving, recording, and gathering of GPS data on the study corridors. All video and GPS data was collected between April and June 2007. Only information pertaining to the preparation of the data for analysis was included in this section. Chapter 4 provides a discussion of the data analysis.

CHAPTER 4

ANALYSIS AND FINDINGS

This chapter discusses the analysis of the collected field data as well as the accident records for the study corridors. The data were analyzed to determine if crashes that occur off of the roadway are more likely to result in injury or death than when considering all crashes. Additionally, this chapter will explore if a collision with a tree or utility pole is more dangerous than the "all off-road crashes". Finally, this chapter will investigate the propensity of these ROR collisions with trees and utility poles to occur at locations close to intersections rather than mid-block locations.

4.1 Roadside Incidents

The crash frequency on the Atlanta study corridors can be seen in Table 4.1. The table contains six years of crash data from 2000-2005 redacted from the CARE database. On the nine Atlanta corridors there were 25,841 reported incidents from 2000-2005. This value includes all crashes reported along the study corridors to have occurred within a buffer of 100 feet centered on the roadway. This value includes crashes that occurred on neighboring streets that fell within this buffer. This method was used for the initial screening of the incident data due to issues identified when attempting to screen corridor crashes by the street number and milepost. For example, some corridors were found to have had multiple mile markers. Also, mileposts were not specific enough to locate the crashes within the specified buffers. For example, a milepost of 21.25 does not provide the precision to locate this crash within 100 feet of an intersection, a requirement of later analysis. Additionally, this method provided a means for including crashes that could have been vehicles turning on or off the study corridor.

4.1.1 Study Corridors' Crash Frequency and Severity

The accident severity statistics demonstrates fairly similar likelihoods for each incident type across corridors. The combined results show that 78 percent of crashes on the study corridors resulted in property damage only (PDO). These numbers ranged between 72.76 percent on Franklin Road and 81.46 percent on the Briarcliff Road and North Druid Hills Road corridor. Additionally, the incidents resulted in one or more non-fatal injuries in approximately 22 percent of cases. The range of this statistic on the study corridors is 18.48 percent on the Briarcliff corridor to 27.07 percent on the Franklin Road Corridor. Lastly, the nine Atlanta study corridors were found to have been the site of 25 fatality crashes over the six years of accident data. These 25 crashes represent 0.10 percent of all crashes on the corridors.

Table 4.1 Table of frequency and severity of all crashes on the Atlanta study corridors from 2000-2005.

	All Crashes	PDO Crashes		Non-Fatal Injury		Fatal	
		Number	% of Total	Number	% of Total	Number	% of Total
14th St / Peachtree St	5767	4626	80.22%	1137	19.72%	4	0.07%
Roswell Road (1)	2968	2391	80.56%	573	19.31%	4	0.13%
Roswell Road (2)	660	517	78.33%	142	21.52%	1	0.15%
Roswell Road (3)	885	647	73.11%	237	26.78%	1	0.11%
Alpharetta Highway	3845	3056	79.48%	787	20.47%	2	0.05%
Franklin Road	1193	868	72.76%	323	27.07%	2	0.17%
Moreland Avenue / Briarcliff Road	3688	2783	75.46%	901	24.43%	4	0.11%
Briarcliff Road / North Druid Hills Road	3392	2763	81.46%	627	18.48%	2	0.06%
Candler Road / Flat Shoals Parkway	3443	2604	75.63%	834	24.22%	5	0.15%
Totals	**25841**	**20255**	**78.38%**	**5561**	**21.52%**	**25**	**0.10%**

4.1.2 Off-Road Crash Frequency of Study Corridors

Table 4.2 illustrates the number of off-road crashes and percentage of total crashes that occurred on the study corridors. All crashes with “off-road” or “on-shoulder” as their location of incident in the attribute table was taken to generate these statistics. Both locations of incidents were selected as each could be considered examples of run-off-the-road crashes. These numbers were generated simply to show the frequency of these crashes in comparison to the total number of crashes over the duration of the study period. The percentages ranged from less than one percent on Alpharetta Highway to greater than eleven percent on the second Roswell Road corridor. The other corridors had similar off-road crash percentages ranging from 2.15 percent on the Briarcliff Road corridor to 5.26 percent on the Moreland Avenue corridor. The highest percentage of roadside crashes was found on the Roswell Road (2) corridor. One possible reason for the unusually high percentage could be the speed limit of 45 miles per hour on a large portion of the roadway; however, a detailed analysis would need to be conducted to confirm this hypothesis. Most of the other corridors had speed limits of 35 miles per hour. Overall, 768 of the 25,841 or 2.97 percent of reported incidents on the study corridors were found to have occurred either off-road on on-shoulder.

Table 4.2 Table of the number of off-road and shoulder crashes on study corridors.

	All Crashes	Off-Road / On Shoulder Crashes	
		Number	% of Total
14th St / Peachtree St	5767	137	2.38%
Roswell Road (1)	2968	98	3.30%
Roswell Road (2)	660	74	11.21%
Roswell Road (3)	885	23	2.60%
Alpharetta Highway	3845	33	0.86%
Franklin Road	1193	41	3.44%
Moreland Avenue / Briarcliff Road	3688	194	5.26%
Briarcliff Road / North Druid Hills Road	3392	73	2.15%
Candler Road / Flat Shoals Parkway	3443	95	2.76%
Totals	**25841**	**768**	**2.97%**

4.1.3 Crash Severity of Off-Road Incidents on Study Corridors

Table 4.3 illustrates the severity of all off-road and on-shoulder collisions on the study corridors. When comparing to Table 4.1, it is easy to identify the relative severity of these type crashes as compared to the severity of all crashes. For example, all incidents on the study corridors were found to have resulted in property damage only in 78.38 percent of cases. Conversely, off-road and on-shoulder crashes resulted in PDO in approximately 70 percent of cases. Similarly, non-fatal injury was the result in all incidents in 21.52 percent of cases and 29.43 percent of cases in off-road and on-shoulder incidents. Moreover, as displayed in Table 4.4 run-off-the-road crashes resulted in fatality 0.52 percent as compared to 0.10 percent in all cases. Along the Atlanta study corridors, run-off-the-road crashes were five times more likely to be deadly as all crashes along the corridors. However, the given sample sizes are relatively small with 25 overall fatalities and 4 off-road / on-shoulder fatalities. Future analysis is needed to confirm this observation by significantly increasing the sample size through the inclusion of data from additional corridors.

Table 4.3 Table of the severity of off-road and shoulder crashes on study corridors.

	Off-Road / On Shoulder	PDO Crashes		Non-Fatal Injury		Fatal	
		Number	% of Total	Number	% of Total	Number	% of Total
14th St / Peachtree St	137	91	66.42%	45	32.85%	1	0.73%
Roswell Road (1)	98	72	73.47%	26	26.53%	0	0.00%
Roswell Road (2)	74	51	68.92%	22	29.73%	1	1.35%
Roswell Road (3)	23	18	78.26%	5	21.74%	0	0.00%
Alpharetta Highway	33	22	66.67%	11	33.33%	0	0.00%
Franklin Road	41	29	70.73%	11	26.83%	1	2.44%
Moreland Avenue / Briarcliff Road	194	134	69.07%	60	30.93%	0	0.00%
Briarcliff Road / North Druid Hills Road	73	54	73.97%	19	26.03%	0	0.00%
Candler Road / Flat Shoals Parkway	95	67	70.53%	27	28.42%	1	1.05%
Totals	**768**	**538**	**70.05%**	**226**	**29.43%**	**4**	**0.52%**

Table 4.4 Table of percentage of fatalities from all crashes and all off-road and shoulder crashes.

	All Crashes	Fatal		Off Road / On Shoulder	Fatal	
		Number	% of Total		Number	% of Total
14th St / Peachtree St	5767	4	0.07%	137	1	0.73%
Roswell Road (1)	2968	4	0.13%	98	0	0.00%
Roswell Road (2)	660	2	0.30%	74	1	1.35%
Roswell Road (3)	885	1	0.11%	23	0	0.00%
Alpharetta Highway	3845	1	0.03%	33	0	0.00%
Franklin Road	1193	2	0.17%	41	1	2.44%
Moreland Avenue / Briarcliff Road	3688	4	0.11%	194	0	0.00%
Briarcliff Road / North Druid Hills Road	3392	2	0.06%	73	0	0.00%
Candler Road / Flat Shoals Parkway	3443	5	0.15%	95	1	1.05%
Totals	**25841**	**25**	**0.10%**	**768**	**4**	**0.52%**

4.2 Roadside Collisions with Utility Poles and Trees

Trees and utility poles are rigid objects that can contribute to an incident resulting in severe injury or death. Clearly, as seen in Table 4.5, utility poles and trees are responsible for 23.44 percent of all reported off-road incidents. This is a significant percentage, especially considering the number of objects that can be found on roadsides. Other commonly hit objects included pedestrians, fences, curb faces, guardrails, and fire hydrants. The greatest percentage of utility pole and tree collisions occur on the 14th Street and Moreland Avenue corridors with 35.77 and 35.05 percent of all off-road collisions, respectively. These sites also have the greatest number of off-road incidents. A reasonable hypothesis is that the tree and utility pole placement, likely in combination with other roadway design characteristic, is contributing to an increase likely of an errant vehicle being involved in an off-road crash.

Table 4.5 Table of the number of utility pole and tree collisions in comparison to all off-road and shoulder crashes.

	Off-Road / On Shoulder Crashes	Utility Pole + Trees	
		Number	% of Total
14th St / Peachtree St	137	49	35.77%
Roswell Road (1)	98	20	20.41%
Roswell Road (2)	74	4	5.41%
Roswell Road (3)	23	3	13.04%
Alpharetta Highway	33	6	18.18%
Franklin Road	41	6	14.63%
Moreland Avenue / Briarcliff Road	194	68	35.05%
Briarcliff Road / North Druid Hills Road	73	13	17.81%
Candler Road / Flat Shoals Parkway	95	11	11.58%
Totals	**768**	**180**	**23.44%**

As shown in Table 4.6, utility poles are the off-road object hit in a significant percentage of the off-road crashes. The greatest percentage of utility pole collisions occur on the 14th Street and Moreland Avenue corridors contributing 32.12 and 29.38 percent of all off-road collisions, respectively. As previously stated, of the nine study corridors, these two contribute the greatest number and percentage of off-road crashes of the nine study corridors.

Tree collisions were also analyzed as they can share similar features with utility poles. It is possible that a tree collision would go unreported in an urban setting as many of the trees located within the right of way were found to have had a small diameter and may have resulted in little damage in a collision. The greatest percentages of tree collisions were found to have occurred on the Alpharetta Highway and Franklin Road corridors. Overall, trees were associated with 5.34 percent of off-road collisions on the Atlanta study corridors.

Table 4.6 Table of the number of utility pole collisions in comparison to the total number.

	Off-Road / On Shoulder Crashes	Utility Pole Collisions		Tree Collisions	
		Number	% of Total	Number	% of Total
14th St / Peachtree St	137	44	32.12%	5	3.65%
Roswell Road (1)	98	17	17.35%	3	3.06%
Roswell Road (2)	74	1	1.35%	3	4.05%
Roswell Road (3)	23	2	8.70%	1	4.35%
Alpharetta Highway	33	2	6.06%	4	12.12%
Franklin Road	41	1	2.44%	5	12.20%
Moreland Avenue / Briarcliff Road	194	57	29.38%	11	5.67%
Briarcliff Road / North Druid Hills Road	73	6	8.22%	7	9.59%
Candler Road / Flat Shoals Parkway	95	9	9.47%	2	2.11%
Totals	**768**	**139**	**18.10%**	**41**	**5.34%**

4.2.1 Severity of Utility Pole and Tree Collisions

Trees and utility poles are particularly unforgiving in collisions. This is evident in Table 4.7, which breaks down utility pole and tree collisions by corridor and severity. Overall, only 60 percent of crashes were PDO, while 38.33 percent and 1.67 percent were non-fatal injury and fatality crashes, respectively. These rates are skewed higher in severity than "all crashes" results and the "all off-road and on-shoulder crash results". For example, 38.33 percent of tree and utility collisions resulted in non-fatal injury, whereas 21.52 of all crashes and 29.43 percent of all off-road crashes have the same result. Similar results were found for fatal crashes, with trees and utility pole related crashes at 1.67, all off-road and on shoulder crashes at 0.10, and all crashes 0.52 percentages, respectively. Therefore, for the nine Atlanta study corridors, fatality was greater than three times more likely to result for an off-road collision with a tree or utility pole than for all off-road crashes. Moreover, fatality was sixteen times more likely to occur in an off-road collision with a tree or utility pole than all crashes on the study corridors.

Table 4.7 Table of the severity of utility pole and tree collisions.

	Utility Pole + Trees	PDO Crashes		Non-Fatal Injury		Fatal	
		Number	% of Total	Number	% of Total	Number	% of Total
14th St / Peachtree St	49	28	57.14%	20	40.82%	1	2.04%
Roswell Road (1)	20	12	60.00%	8	40.00%	0	0.00%
Roswell Road (2)	4	2	50.00%	2	50.00%	0	0.00%
Roswell Road (3)	3	1	33.33%	2	66.67%	0	0.00%
Alpharetta Highway	6	4	66.67%	1	16.67%	1	16.67%
Franklin Road	6	3	50.00%	2	33.33%	1	16.67%
Moreland Avenue / Briarcliff Road	68	46	67.65%	22	32.35%	0	0.00%
Briarcliff Road / North Druid Hills Road	13	6	46.15%	7	53.85%	0	0.00%
Candler Road / Flat Shoals Parkway	11	6	54.55%	5	45.45%	0	0.00%
Totals	**180**	**108**	**60.00%**	**69**	**38.33%**	**3**	**1.67%**

4.3 Roadside Crashes at Intersections

It has been identified that roadside fixed object crashes, particularly with utility poles and trees, are dangerous. This section of the report will provide data supporting the hypothesis that this type of crash is more prone to occur at intersection locations. This concept was born from the data analysis of the Georgia accident data for NCHRP 16-04. Through visual inspection, it was noticed that there was a disproportionally high percentage of off-road fixed object collisions clustered around intersection locations. It was then assumed that this was due, at least in part, to errant maneuvers of turning vehicles.

ArcGIS was used to determine the percentage of crashes that occurred near intersection locations. First, a point was generated at locations where study corridors intersected with other streets. From the resulting points, buffers were generated at different radii to visualize the number of crashes that occurred within the ranges. With the buffers, it was easy to determine how many and what percentage of roadside collisions occurred near intersection locations. However, it was decided that this information was of little significance if it could not be compared to the rest of the roadway.

To combat this problem, the length of roadway that fell into the various buffers was also calculated. This would allow for roads with fewer or greater number of cross streets to be more equally compared. For example, if 50 percent of crashes were found to have occurred within 100 feet of intersections while 50 percent of the roadway length also fell in the same range, then intersection locations are not overrepresented in crash rates.

4.3.1 Roadside Collisions with Utility Poles at Intersections

The number of utility pole crashes in relation to intersections for all study corridors can be seen in Table 4.8. As seen in the chart, there were 139 roadside fixed object collisions with utility pole crashes on the nine Atlanta corridors.

The sum of all of the study corridors' lengths was found to be 125,717 feet or 23.81 miles. Of this length, 9,485 feet lay within 25 feet of an intersection with another roadway. This length represents less than 8 percent of the entire roadway length. However, within this relatively small portion of roadway, nearly 22 percent of utility pole crashes occurred. Clearly, this section of roadway houses a proportionally larger amount of these types of crashes than the rest of the roadway. Similarly, less than 14 percent of the study corridor length is within 50 feet of intersection locations. Yet, greater than 30 percent of roadside utility pole collisions were found to have occurred in this space. Again, the same statistics prove true within 100 feet of intersection locations. Less than 25 percent of the corridors were within this distance, while housing nearly 62 percent of utility pole crashes.

In addition to percentage, off-road crash rates were also calculated. For the entire length of all corridors, there was an average of 5.84 off-road incidents with utility poles per mile as seen in Table 4.8. This number rises to 14.49 crashes per mile for sections of roadway within 100 feet of intersection. There is a slight drop off for roadway within 50 feet of intersections. As expected, sections of the study corridors within 25 feet of intersections had the highest crash rate at 16.70 per mile and nearly three times the average rate of all corridors. Individual tables for each of the nine study corridors can be seen in Appendix B.

Table 4.8 Table of the amount of utility crashes and their nearness to intersections.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes	Crashes Per Mile
Corridor	125716.80	100.00%	139	100.00%	5.84
Within 25'	9484.54	7.54%	30	21.58%	16.70
Within 50'	17412.51	13.85%	42	30.22%	12.74
Within 100'	31339.96	24.93%	86	61.87%	14.49

4.3.2 Roadside Collisions with Trees at Intersections

Utility pole collisions outnumber tree collisions rather significantly, due to the urban environment from which the data was collected. However, when hit, trees still represent a formidable object. For this reason, the same analysis that was performed on utility poles will be conducted on trees.

Though there were only 41 roadside collisions with trees on the Atlanta study corridors, they followed a similar pattern in location of occurrence with utility pole collisions. As seen in Table 4.9, 19.51 percent of tree collisions occurred within 25 feet of an intersection, or 7.54 percent of study corridors' length. Additionally, 29.27 percent of these collisions happened on 13.85 percent of the roadways, the portion within 50 feet of intersections. Finally, 51.22 percent of tree collisions occurred within 100 feet of an intersection, on less than 25 percent of the roadways. The crash rates increase significantly nearer to intersections with only 1.72 crashes per mile on average for the entire length and 3.54, 3.64, and 4.45 crashes per mile from 100 feet, 50 feet, and 25 feet, respectively.

Not only are utility pole crashes more prevalent on the study areas, they are also statistically more prone to occur at intersections than crashes with trees. This can be concluded from comparing the percentage of each type of crash that occurs within the given distances from intersections. Utility pole crashes and tree crashes were found to have occurred within 25 feet of an intersection in 21.58 and 19.51 percent of cases, respectively. Additionally, the same holds true for buffers of 50 and 100 feet, with utility poles showing higher percentages within these ranges. However, caution must be excised in the use of this result as a relative presence of utility poles and trees is not considered, potentially biasing the results. The issue will be further explored in Chapter 5.

Table 4.9 Table of the amount of tree crashes and their nearness to intersections.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes	Crashes Per Mile
Corridor	125716.80	100.00%	41	100.00%	1.72
Within 25'	9484.54	7.54%	8	19.51%	4.45
Within 50'	17412.51	13.85%	12	29.27%	3.64
Within 100'	31339.96	24.93%	21	51.22%	3.54

4.3.3 Roadside Collisions with both Utilities and Trees at Intersections

The combination of utility pole and tree collisions for the nine Atlanta study corridors can be seen in Table 4.10. This table simply is the sum of the two previous tables, utility pole crashes and tree crashes. Therefore, the percentage of crashes will be a weighted average of both types, while the crash rates will be the sum of both crash rates.

Overall, of the 180 roadside fixed object collisions with trees and utility poles 21.11 percent occurred within 25 feet of an intersection. Furthermore, 30 percent of these crashes took place within 50 feet of an intersection, an area representative of 13.85 percent of the roadways. Finally, 59.44 percent of incidents were within 100 feet of an intersection or 24.93 percent of the corridors.

The combined crash rates were 7.56 crashes per mile for the entire corridors. The crash rates within 100 feet and 50 feet of intersections were 18.03 and 16.37 crashes per mile, respectively. Lastly, the crash rate for sections of roadway within 25 feet of intersections was found to be the highest at 21.15 crashes per mile. Statistically, if the entire length of every corridor had the same crash rate as that within 25 feet of an intersection there would be greater than 500 off-road fixed object collisions with utility poles and trees rather than the 180.

Table 4.10 Table of the amount of utility and tree crashes and their nearness to intersections.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes	Crashes Per Mile
Corridor	125716.80	100.00%	180	100.00%	7.56
Within 25'	9484.54	7.54%	38	21.11%	21.15
Within 50'	17412.51	13.85%	54	30.00%	16.37
Within 100'	31339.96	24.93%	107	59.44%	18.03

4.4 Statistical Analysis

In order to determine the statistical significance of location on the severity of crashes and the proximity to intersections on the likelihood of the occurrence of roadside collisions with trees and utility poles, two Pearson's Chi-Square tests was conducted. In the tests, the observed number of crashes by was compared to the expected number of crashes by along the study corridors.

4.4.1 Statistical Analysis of Location on Crash Severity

The observed number of all crashes and roadside crashes by severity are in Table 4.11. The expected values in Table 4.12 represent the expected number of roadside crashes by severity provided there is no relationship between crash location and severity. Restated, the expected values are generated by using the percentage of crashes by severity for all crashes and applying the same rate to the smaller sample size of only off-road crashes. The null hypothesis used for the test is the severity of crashes is independent of the crash location. The critical value for the test uses the inverse of the one-tailed probability for the chi-squared distribution. For two degrees of freedom with 95 percent level of confidence, 5.99 is the critical value. In the test, this value is compared to the sum of residuals in Table 4.13. As the sum of 43.39 is greater than 5.99, the null hypothesis can be rejected. Therefore, with a 95 percent confidence level, crash severity is dependent upon crash location. In addition, the standardized residuals for crash severity were found to be significant with 95 percent confidence as per Table 4.14. For this statistical testing off-road crashes include both incidents with coded event locations of off-road and on-shoulder.

Table 4.11 Table of observed results used in Chi-Square test.

	PDO Crashes	Non-Fatal Injury	Fatal	Total	Percentage of Total
Off-Road Crashes	538.00	226.00	4.00	768	2.97%
All Crashes	20255	5561	25	25841	100.00%
Percentage of Total by Severity	78.38%	21.52%	0.10%		

Table 4.12 Table of expected results from Chi-Square test.

	PDO Crashes	Non-Fatal Injury	Fatal	Total	Percentage of Total
Off-Road Crashes	601.98	165.27	0.74	768	2.97%
All Crashes	20255	5561	25	25841	100.00%
Percentage of Total by Severity	78.38%	21.52%	0.10%		

Table 4.13 Table of residuals for Chi-square test.

	PDO Crashes	Non-Fatal Injury	Fatal
All Crashes	6.80	22.31	14.28
Off-Road Crashes	0.00	0.00	0.00
Σ =	43.39		

Table 4.14 Table of standardized residuals for Chi-square test.

	PDO Crashes	Non-Fatal Injury	Fatal
Off-Road Crashes	2.61	4.72	3.78

4.4.2 Statistical Analysis of Proximity to Intersections on the Occurrence of Roadside Crashes with Trees and Utility Poles

The observed number of all roadside crashes and roadside crashes within buffers of 25, 50, and 100 feet are in Table 4.15. The expected values in Table 4.17 were generating using the percentages of length of roadway within the various buffers from Table 4.16. These represent the expected number of roadside crashes within the buffers provided there is no relationship between proximity to intersection and crash frequency. The null hypothesis used for the test is that the occurrence of roadside crashes with trees and utility poles is independent of the proximity to intersections. The critical value for the test uses the inverse of the one-tailed probability for the chi-squared distribution. For two degrees of freedom with 95 percent level of confidence, 5.99 is the critical value. In the test, this value is compared to the sum of residuals in Table 4.18. As the sum of 163.88 is greater than 5.99, the null hypothesis can be rejected. Therefore, with a 95 percent confidence level, the frequency of roadside collisions with trees and utility poles is dependent upon proximity to intersections.

Table 4.15 Table of observed results used in Chi-Square test.

	25' Buffer	50' Buffer	100' Buffer
Off-Road Crashes within Specified Buffers	38.00	54.00	107.00
All Off-Road Crashes	180	180	180
Percentage of Total	21.11%	30.00%	59.44%

Table 4.16 Table of length of roadway within buffers used in Chi-Square test.

	25' Buffer	50' Buffer	100' Buffer
Length of Roadway within Specified Buffers	9484.54	17412.51	31339.96
Total Roadway Length (ft)	125716.8	125716.8	125716.8
Percentage of Total	7.54%	13.85%	24.93%

Table 4.17 Table of expected results used in Chi-Square test.

	25' Buffer	50' Buffer	100' Buffer
Off-Road Crashes within Specified Buffers	13.57	24.93	44.87
All Off-Road Crashes	180	180	180
Percentage of Total	7.54%	13.85%	24.93%

Table 4.18 Table of residuals for Chi-Square test.

	25' Buffer	50' Buffer	100' Buffer
Off-Road Crashes within Specified Buffers	43.97	33.90	86.01
All Off-Road Crashes	0	0	0
Σ **=**	163.88		

4.5 Contributing Scenarios

There were several factors that arose quite often when reviewing the crash records for the roadside collisions with utility pole and trees along the Atlanta study corridors. First, driver inattention and falling asleep were reported as the most common causes for these types of crashes. Additionally, these incidents were often the result of motorists losing control of their vehicles due to reasons such as car trouble, alcohol, driver inexperience, and others. These contributing factors, however, are not necessarily specific to intersection locations and could just as well occur at midblock locations.

As previously stated, it was easy to recognize from a glance that a large proportion of off-road fixed object collisions take place at or near intersections with cross streets. This section of the report will examine Georgia Department of Transportation accident reports in order to detect any trends that may have contributed to the number of crashes present at these intersections. There are features specific to intersection locations which generate the greater number of off-road collisions.

4.5.1 Single Contributing Vehicles

Before delving into GDOT accident reports, it was assumed an errant turning movement was the primary reason for the off-road crashes at intersections. This situation refers to a turning vehicle that either overshoots or undershoots its projected lane. These crashes commonly occur when a vehicle is trying to perform a turning movement while traveling too fast. Additionally, several accidents of this nature were found to have occurred during inclement weather that contributed to reduced available pavement friction. Also, there were several crashes of this variety that were a result of blown tires, lost steering, and other mechanical problems with the automobile.

An example of one such crash can be seen in Figure 4.1. In the example, the motorist took the turn too sharply from 14th Street to West Peachtree Street and collided with a light pole at the corner of the intersection. Similarly, an example of a vehicle "overshooting" his desired lane and colliding with a utility can be seen in Figure 4.2. This report shows a left turning vehicle that departed the roadway. In each of these cases, the driver may have misjudged the necessary turn radii.

Another scenario that was responsible for roadside collisions near intersections was the overcorrection of motorists. In this type of crash, while making a turning maneuver, the errant motorist was found to have lost control of a vehicle near the end of a turning movement. An accident report for this type of crash can be seen in Figure 4.3. In this incident, the vehicle lost control of his vehicle after turning out of a convenience store on Misty Waters Drive onto Candler Road.

4.5.2 Multiple Contributing Vehicles

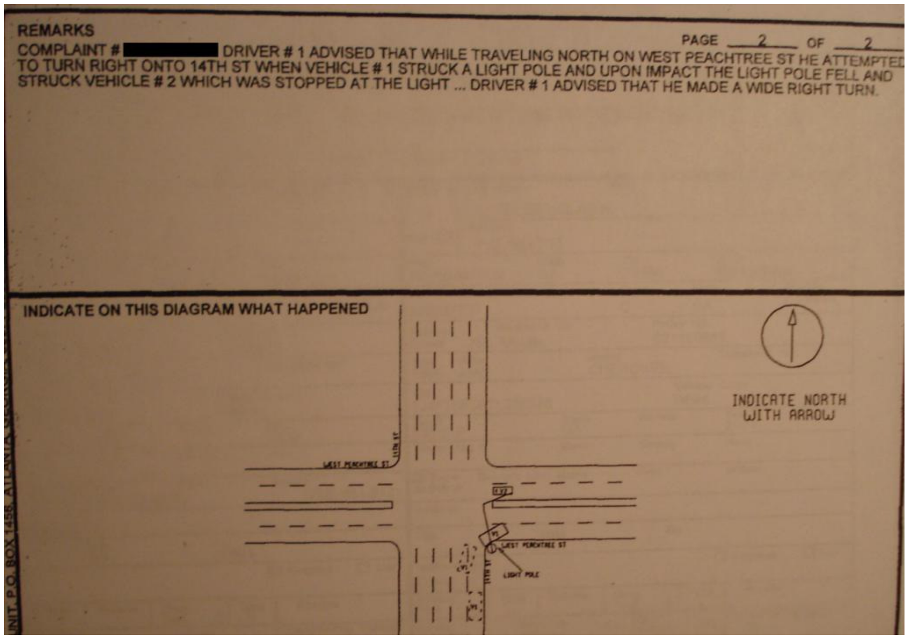
There were several prevalent scenarios that reappeared when reviewing accident records for the study corridors. These accidents largely stem from vehicles making unexpected maneuvers causing other motorists to swerve to avoid the crash, thus leaving the roadway. It would stand to reason that a large number of these crashes would occur at intersection locations due to a relatively large volume of turning vehicles.

Figure 4.4 contains a GDOT accident report for a roadside collision with multiple contributing vehicles. In the accident description the driver stated that a vehicle was stopped in the inside lane, perhaps because the vehicle was waiting to turn left. The approaching vehicle was forced to veer off at the last moment to avoid the stopped vehicle, propelling it into the roadside where it collided with a utility pole. A similar situation can been in Figure 4.5, where a vehicle was forced to turn into the roadside to avoid a collision with a stopped Metropolitan Atlanta Rapid Transit Authority (MARTA) transit bus on the far side of an intersection on Candler Road. There are many examples of this scenario that were simply reported as a vehicle being “cut off” by another vehicle who changed lanes prior to intersections and being forced into the right-of-way. It would make sense for this situation to occur more commonly at intersections as vehicles may be changing lanes to make a turning maneuver.

Several other crashes stemmed from stopped vehicles awaiting sufficient gaps to make a left turn. In these cases, a vehicle would change lanes to avoid the stopped car, thus forcing other vehicles to swerve away from the vehicle that is changing lanes. These cases show that there can be a ripple effect in these events as it not necessarily the first approaching vehicle that experiences the collision.

Another roadside crash type with multiple contributing vehicles can be seen in the accident report in Figure 4.6. The remarks on the accident report point out that vehicle 2 was attempting to travel southbound on Moreland Avenue through North Avenue while another vehicle was making a northbound left onto North Avenue. Vehicle 1 forced vehicle 2 to steer off of the roadway into a utility pole at the corner of the intersection.

The accident reported in Figure 4.7 describes an accident on West Peachtree Street, a one-way street in Midtown Atlanta. In this case, a vehicle attempted to make a left turn from a lane to the right of another vehicle. The turning vehicle essentially trapped the inside vehicle and forced it off of the roadway into a utility pole at the intersection with 16th Street.



REMARKS

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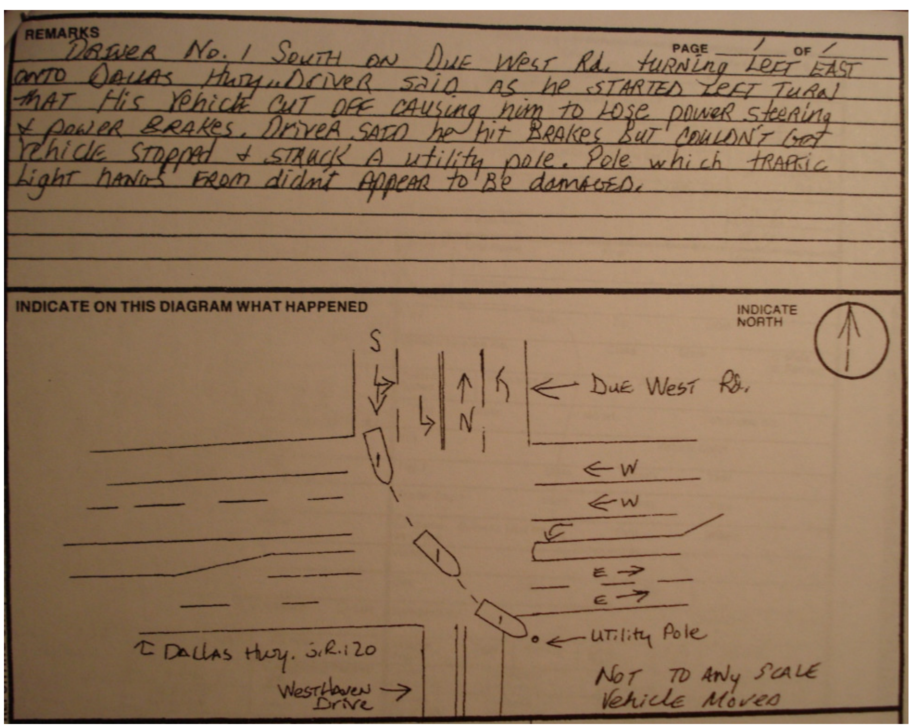
COMPLAINT # [redacted] DRIVER # 1 ADVISED THAT WHILE TRAVELING NORTH ON WEST PEACHTREE ST HE ATTEMPTED TO TURN RIGHT ONTO 14TH ST WHEN VEHICLE # 1 STRUCK A LIGHT POLE AND UPON IMPACT THE LIGHT POLE FELL AND STRUCK VEHICLE # 2 WHICH WAS STOPPED AT THE LIGHT ... DRIVER # 1 ADVISED THAT HE MADE A WIDE RIGHT TURN.

INDICATE ON THIS DIAGRAM WHAT HAPPENED

INDICATE NORTH WITH ARROW

Figure 4.1 Image of GDOT accident report for collision with utility pole at the intersection of 14th Street and West Peachtree Street.



REMARKS

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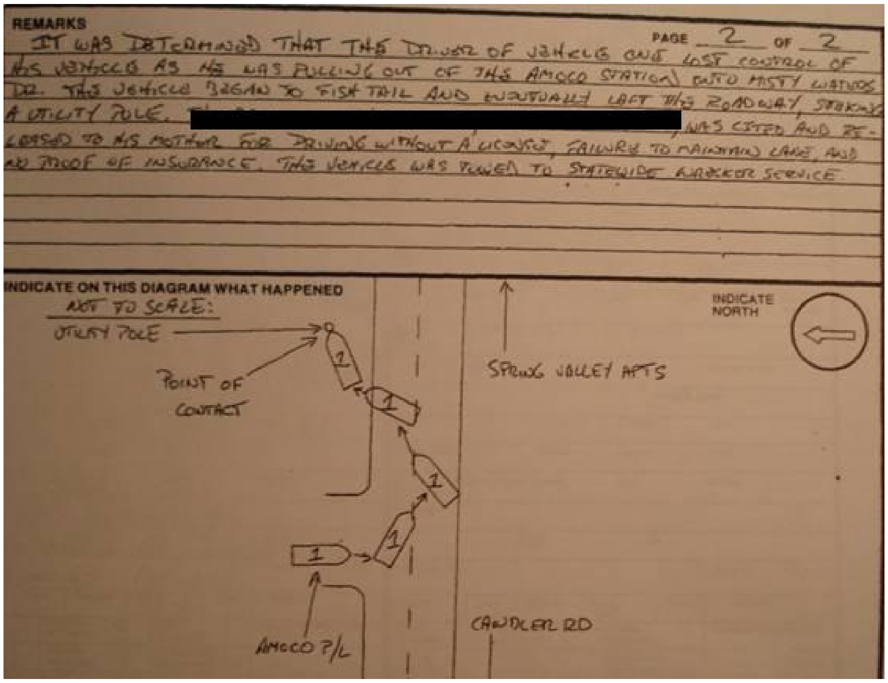
DRIVER No. 1 SOUTH ON DUE WEST Rd. turning LEFT EAST ONTO DALLAS HWY.. DRIVER SAID AS he STARTED LEFT TURN THAT His Vehicle CUT OFF CAUSING him to LOSE POWER steering & POWER BRAKES. DRIVER SAID he hit BRAKES BUT COULDN'T GET Vehicle STOPPED & STRUCK A utility pole. Pole which TRAFFIC Light HANGS FROM didn't APPEAR to BE DAMAGED.

INDICATE ON THIS DIAGRAM WHAT HAPPENED

INDICATE NORTH

Figure 4.2 Image of GDOT accident report for collision with utility pole at the intersection.

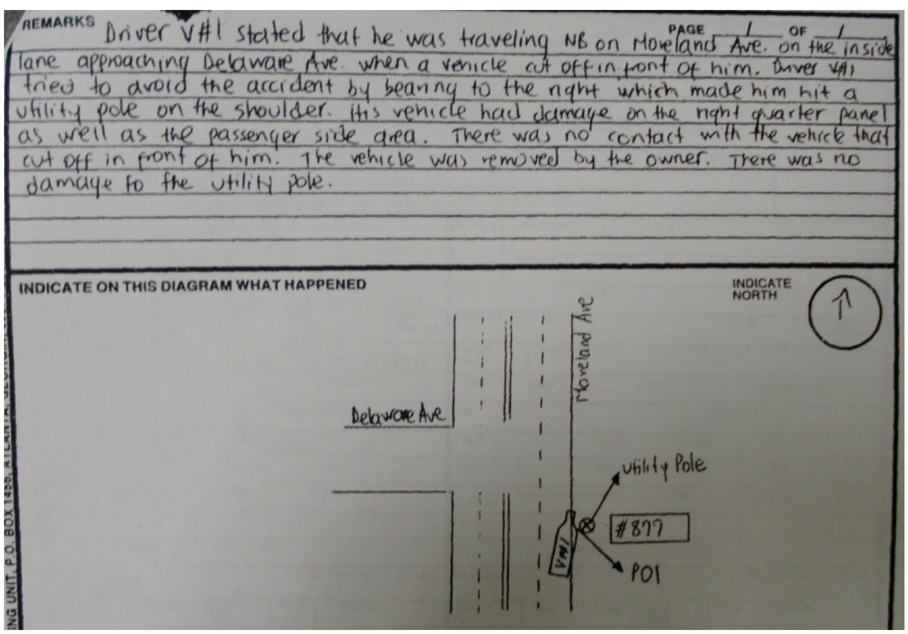


REMARKS PAGE 2 OF 2

IT WAS DETERMINED THAT THE DRIVER OF VEHICLE ONE LOST CONTROL OF HIS VEHICLE AS HE WAS PULLING OUT OF THE AMOCO STATION ONTO MISTY WATERS DR. THE VEHICLE BEGAN TO FISH TAIL AND EVENTUALLY LEFT THE ROADWAY, STRIKING A UTILITY POLE. [redacted] WAS CITED AND RELEASED TO HIS MOTHER FOR DRIVING WITHOUT A LICENSE, FAILURE TO MAINTAIN LANE, AND NO PROOF OF INSURANCE. THE VEHICLE WAS TOWED TO STATEWIDE WRECKER SERVICE.

INDICATE ON THIS DIAGRAM WHAT HAPPENED

Figure 4.3 Image of GDOT accident report for collision with utility pole at the intersection of Candler Road and Misty Waters Drive.

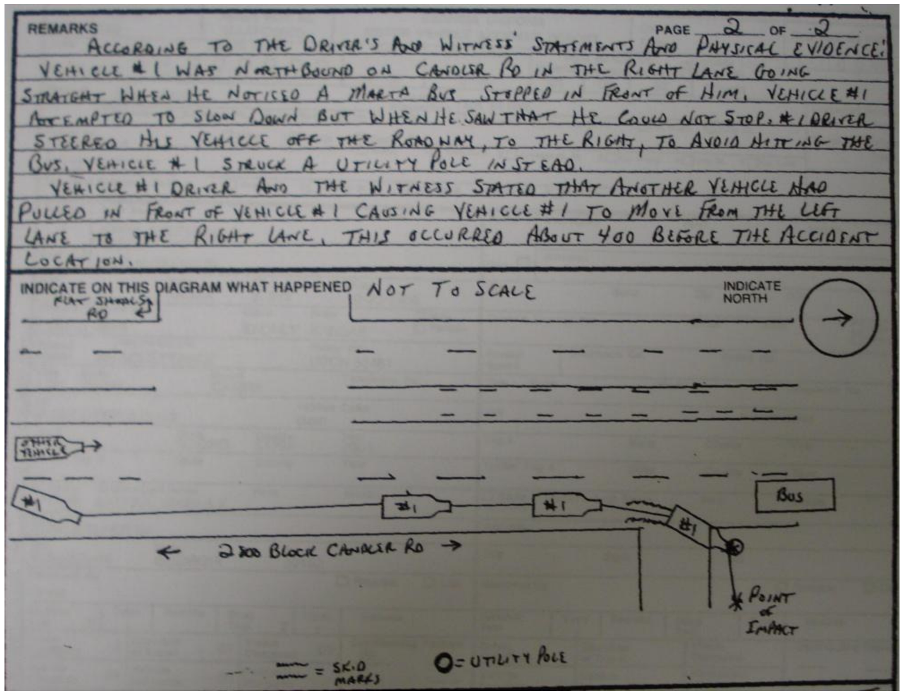


REMARKS PAGE 1 OF 1

Driver V#1 stated that he was traveling NB on Moreland Ave. on the inside lane approaching Delaware Ave. when a vehicle cut off in front of him. Driver V#1 tried to avoid the accident by bearing to the right which made him hit a utility pole on the shoulder. His vehicle had damage on the right quarter panel as well as the passenger side area. There was no contact with the vehicle that cut off in front of him. The vehicle was removed by the owner. There was no damage to the utility pole.

INDICATE ON THIS DIAGRAM WHAT HAPPENED

Figure 4.4 Image of GDOT accident report for collision with utility pole at intersection of Moreland Avenue and Delaware Avenue.



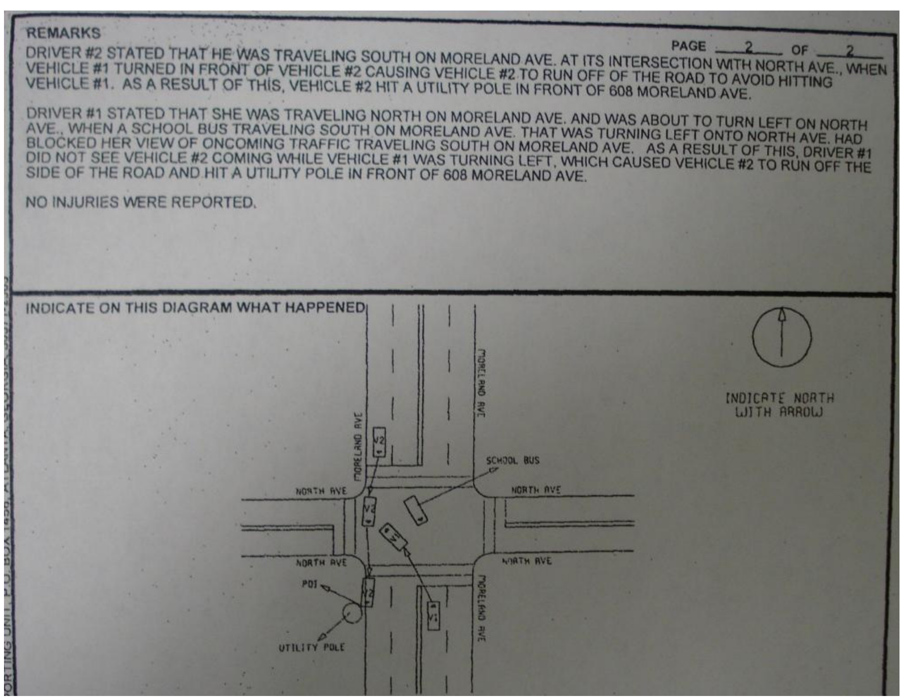
REMARKS PAGE 2 OF 2

ACCORDING TO THE DRIVER'S AND WITNESS' STATEMENTS AND PHYSICAL EVIDENCE: VEHICLE #1 WAS NORTHBOUND ON CANDLER RD IN THE RIGHT LANE GOING STRAIGHT WHEN HE NOTICED A MARTA BUS STEPPED IN FRONT OF HIM. VEHICLE #1 ATTEMPTED TO SLOW DOWN BUT WHEN HE SAW THAT HE COULD NOT STOP, #1 DRIVER STEERED HIS VEHICLE OFF THE ROADWAY, TO THE RIGHT, TO AVOID HITTING THE BUS. VEHICLE #1 STRUCK A UTILITY POLE INSTEAD.

VEHICLE #1 DRIVER AND THE WITNESS STATED THAT ANOTHER VEHICLE HAD PULLED IN FRONT OF VEHICLE #1 CAUSING VEHICLE #1 TO MOVE FROM THE LEFT LANE TO THE RIGHT LANE. THIS OCCURRED ABOUT 400 BEFORE THE ACCIDENT LOCATION.

INDICATE ON THIS DIAGRAM WHAT HAPPENED NOT TO SCALE INDICATE NORTH

Figure 4.5 Image of GDOT accident report for collision with utility pole on Candler Road.



REMARKS PAGE 2 OF 2

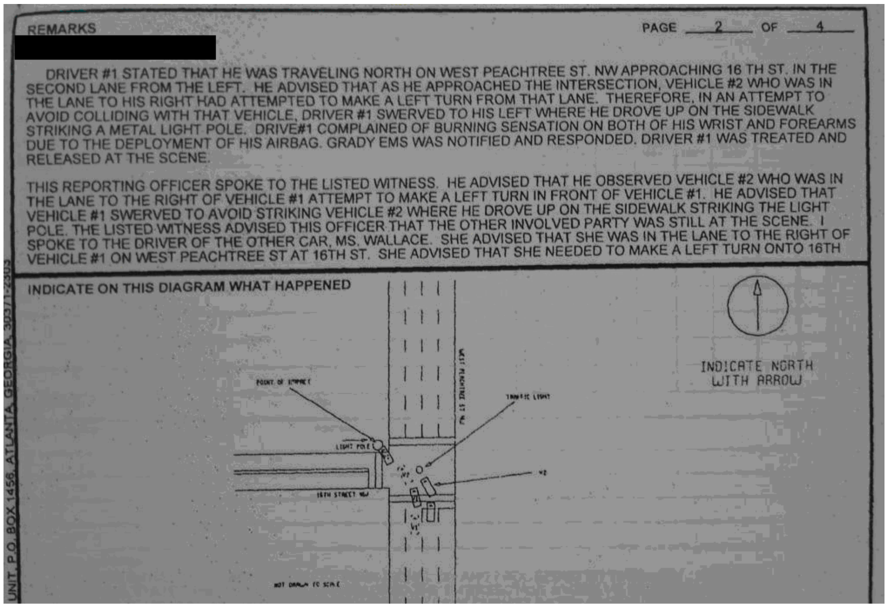
DRIVER #2 STATED THAT HE WAS TRAVELING SOUTH ON MORELAND AVE. AT ITS INTERSECTION WITH NORTH AVE., WHEN VEHICLE #1 TURNED IN FRONT OF VEHICLE #2 CAUSING VEHICLE #2 TO RUN OFF OF THE ROAD TO AVOID HITTING VEHICLE #1. AS A RESULT OF THIS, VEHICLE #2 HIT A UTILITY POLE IN FRONT OF 608 MORELAND AVE.

DRIVER #1 STATED THAT SHE WAS TRAVELING NORTH ON MORELAND AVE. AND WAS ABOUT TO TURN LEFT ON NORTH AVE., WHEN A SCHOOL BUS TRAVELING SOUTH ON MORELAND AVE. THAT WAS TURNING LEFT ONTO NORTH AVE. HAD BLOCKED HER VIEW OF ONCOMING TRAFFIC TRAVELING SOUTH ON MORELAND AVE. AS A RESULT OF THIS, DRIVER #1 DID NOT SEE VEHICLE #2 COMING WHILE VEHICLE #1 WAS TURNING LEFT, WHICH CAUSED VEHICLE #2 TO RUN OFF THE SIDE OF THE ROAD AND HIT A UTILITY POLE IN FRONT OF 608 MORELAND AVE.

NO INJURIES WERE REPORTED.

INDICATE ON THIS DIAGRAM WHAT HAPPENED

Figure 4.6 Image of GDOT accident report for collision with utility pole at intersection of Moreland Avenue and Delaware Avenue.



REMARKS PAGE 2 OF 4

[redacted]

DRIVER #1 STATED THAT HE WAS TRAVELING NORTH ON WEST PEACHTREE ST. NW APPROACHING 16 TH ST. IN THE SECOND LANE FROM THE LEFT. HE ADVISED THAT AS HE APPROACHED THE INTERSECTION, VEHICLE #2 WHO WAS IN THE LANE TO HIS RIGHT HAD ATTEMPTED TO MAKE A LEFT TURN FROM THAT LANE. THEREFORE, IN AN ATTEMPT TO AVOID COLLIDING WITH THAT VEHICLE, DRIVER #1 SWERVED TO HIS LEFT WHERE HE DROVE UP ON THE SIDEWALK STRIKING A METAL LIGHT POLE. DRIVE#1 COMPLAINED OF BURNING SENSATION ON BOTH OF HIS WRIST AND FOREARMS DUE TO THE DEPLOYMENT OF HIS AIRBAG. GRADY EMS WAS NOTIFIED AND RESPONDED. DRIVER #1 WAS TREATED AND RELEASED AT THE SCENE.

THIS REPORTING OFFICER SPOKE TO THE LISTED WITNESS. HE ADVISED THAT HE OBSERVED VEHICLE #2 WHO WAS IN THE LANE TO THE RIGHT OF VEHICLE #1 ATTEMPT TO MAKE A LEFT TURN IN FRONT OF VEHICLE #1. HE ADVISED THAT VEHICLE #1 SWERVED TO AVOID STRIKING VEHICLE #2 WHERE HE DROVE UP ON THE SIDEWALK STRIKING THE LIGHT POLE. THE LISTED WITNESS ADVISED THIS OFFICER THAT THE OTHER INVOLVED PARTY WAS STILL AT THE SCENE. I SPOKE TO THE DRIVER OF THE OTHER CAR, MS. WALLACE. SHE ADVISED THAT SHE WAS IN THE LANE TO THE RIGHT OF VEHICLE #1 ON WEST PEACHTREE ST AT 16TH ST. SHE ADVISED THAT SHE NEEDED TO MAKE A LEFT TURN ONTO 16TH

INDICATE ON THIS DIAGRAM WHAT HAPPENED

INDICATE NORTH WITH ARROW

UNIT, P.O. BOX 1456, ATLANTA, GEORGIA 30371-2303

Figure 4.7 Image of GDOT accident report for collision with utility pole at intersection of West Peachtree Street and 16th Street.

4.6 Summary of Analysis and Findings

Chapter 4 of this report focused on the analysis and findings of the data collection of this report. It was found that roadside crashes were more likely to result in injury or death than the sum of all corridor crashes. Also, roadside crashes with trees and utility poles were more likely to result in injury or death than the sum of all roadside crashes. Additionally, it was found that roadside crashes with trees and utility poles were more likely to occur in close proximity to intersections. Furthermore, statistical testing was conducted and verified that there is a relationship between, not only crash severity and location, but also proximity to intersections and the likelihood of roadside collisions with trees and utility poles.

CHAPTER 5

CONCLUSIONS

As previously stated, it was the Highway Safety Act of 1966 that first mentioned the concept of roadside safety [1]. Though strides have clearly been made over the years subsequent to its publication, there is still room for improvement. Roadside safety clearly has the attention of transportation professionals as is evident through the continued publication and revision of the AASHTO Roadside Design Guide [1] and the Highway Safety Manual currently in development. Chapter 5 of this report, however, will focus specifically on conclusions drawn from the analysis of roadside crashes and their frequency of occurrence near intersections. .

5.1 Data Analysis Results

Clearly, as shown in Chapter 4, any crash is dangerous and has the potential to result in serious injury or death. Moreover, roadside crashes have higher likelihood of resulting in injury or death. It can be concluded, further, that of all roadside incidents, those including collisions with utility poles and trees, resulted in injury or death more often than the "all off-road crashes". Finally, it is evident through the data analysis that roadside collisions, particularly those with trees and utility poles, are prone to occur near intersection locations.

Chapter 4 further delves into utility pole and tree collisions near intersection locations by examining the percentages that occur within 25, 50, and 100 feet of an intersection. Table 4.10 indicates that, proportionally, the area within 25 feet of an intersection has the highest rate of collisions with utility poles and trees. Additionally, scenarios which contributed to this large number of crashes were examined in Chapter 4. Therefore, it stands to reason that removal and relocation of obstacles at these locations could significantly reduce the total number and severity of off-road collisions.

5.2 Recommended Guidelines

The AASHTO *Green Book* [7] is discussed in Chapter 2 and states that no utility pole should be placed in a location where it can be struck, however, it does not provide much guidance on identifying these locations. Furthermore, AASHTO's *UAPSM* [8] states that a utility pole may be placed in a roadside environment "as long as it does not adversely affect the safety design, construction, traffic operations, maintenance, or stability". This document could be enhanced with future revisions by placing specific parameters defining what adversely impacts the safety of motorists.

As seen in Chapter 4, the area within 25 feet of intersections houses a disproportionate number of roadside collisions and should, therefore, receive a greater amount of attention when regulating the placement of utility poles and trees within the right-of-way. Hence, the findings of this report suggest that no utility be placed within 25 feet of an intersection. Furthermore, if this is violated, a minimum setback of 10 feet from the edge of the travelway should be applied. Clearly, exceptions may have to be made to allow for the placement of traffic signals, luminaries, or other objects that must be placed within this area.

In the cases where the 25 feet buffer must be violated, only breakaway devices should be used. Although these devices may not reduce the frequency of roadside collisions near intersections, it would certainly be an effective means for reducing the severity of the incidents. Only devices tested that have been tested to standards specified in NCHRP Report 350 [19] should be used in these cases.

5.3 Limitations of the Research

There were certain limitations with this research. Most evident, this report relies heavily on the accuracy of the accident reports and the CARE software. The accidnet reports, in particular, are an area of concern in that the data used by the CARE software is taken from these reports. As all of the information in the database has been extracted from an accident record that was completed by a reporting officer, there is a potential for error. Miscoding of accident type and location on roadway are two particular areas of potential error. Additionally, the location, in terms of milepost, is a great concern for the accuracy of the data as the results are completely dependent upon the accuracy of the location.

Another potential shortcoming of this research is the breadth of corridors examined. As all corridors were classified as urban arterials, it would be beneficial to further explore roadways of other classifications. Currently, it can only be concluded from this research that for urban arterials, roadside collisions are more prone to occur near intersection locations than midblock locations. Additional data could confirm or disprove the conclusions drawn from the data collection and determine if the results can be translated to a larger scale.

A potential bias that was considered was the possibility that a large percentage of utility poles are found near intersections along corridors. Hypothetically, if 80 percent of utility poles were located within 25 feet of an intersection and 80 percent of utility pole crashes being located within this same area, then the distribution of crashes is not necessarily greater due to the intersection location. To address this potential bias, the utility poles along

14th Street were counted. The results of this count are displayed in Table 5.1. On this corridor, the percentage of utility poles within 100 feet of an intersection did not exceed the percentage of the length of corridor within the same buffer. Future efforts should consider this potential bias on all corridors in the study.

Table 5.1 Table of utility poles along 14th Street Corridor.

	Length (ft)	Percentage of Length	Utility Poles	Percentage of Total
Length	6019	100.00%	121	100.00%
Within 100'	3835	63.71%	55	45.45%

5.4 Future Research Recommendations

Future research that should be considered to build upon this report would, most importantly, include a greater sample size of different classifications of roadways. Further research in this capacity could determine if the location of roadside collisions at close proximity to intersections is standard among all road types.

Additionally, research that focuses particularly upon the length of setbacks could also be extremely beneficial. This report only examines utility poles and trees and their proximity to intersections and does not include analysis of the lateral placement of these obstacles. Such research could be used in design manual revisions as it could provide more detailed lateral placement information.

APPENDIX A

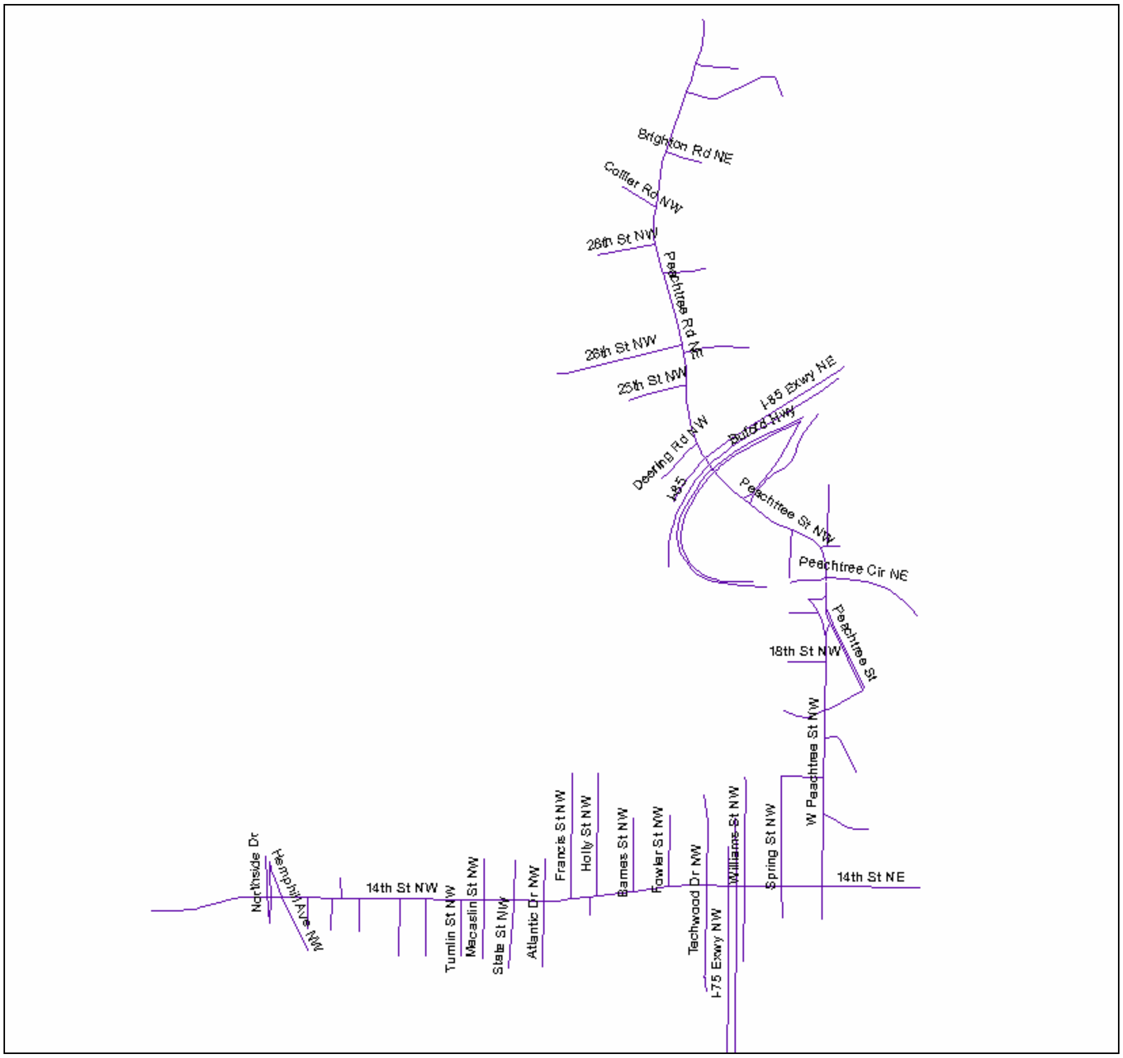


Figure A.1 GIS Image of 14th Street / Peachtree Street Corridor (Length of 3.0 Miles).

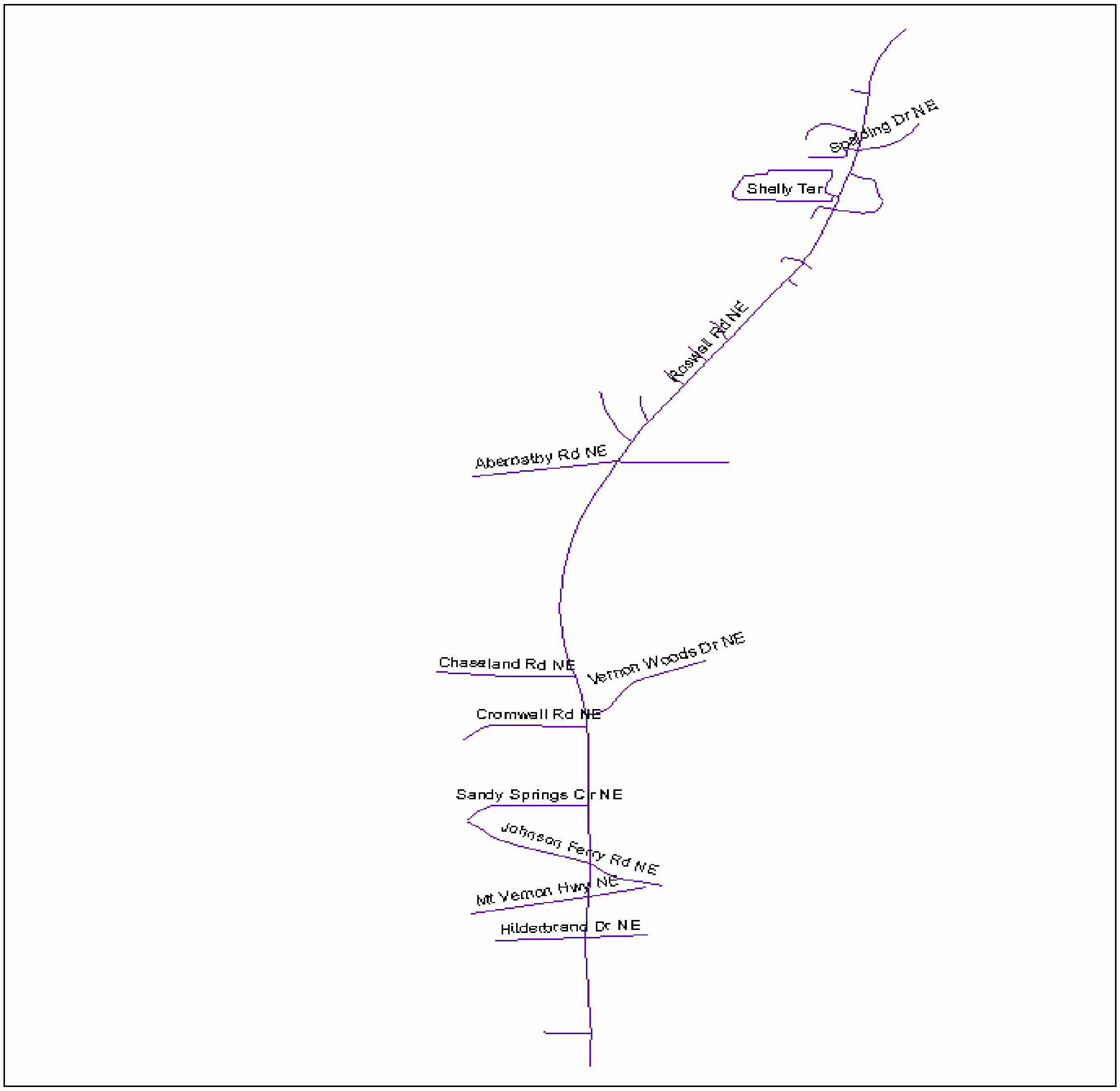


Figure A.2 GIS Image of Roswell Road (1) Corridor (Length of 2.2 Miles).

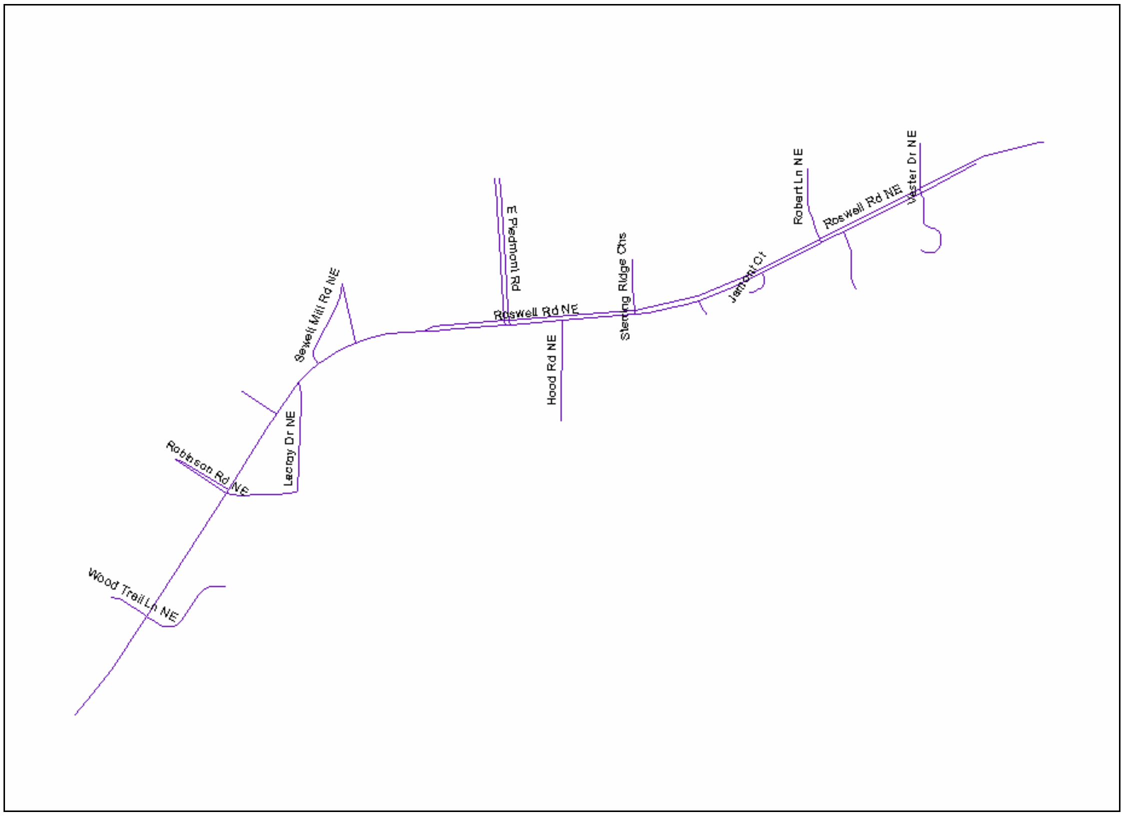


Figure A.3 GIS Image of Roswell Road (2) Corridor (Length of 2.0 Miles).

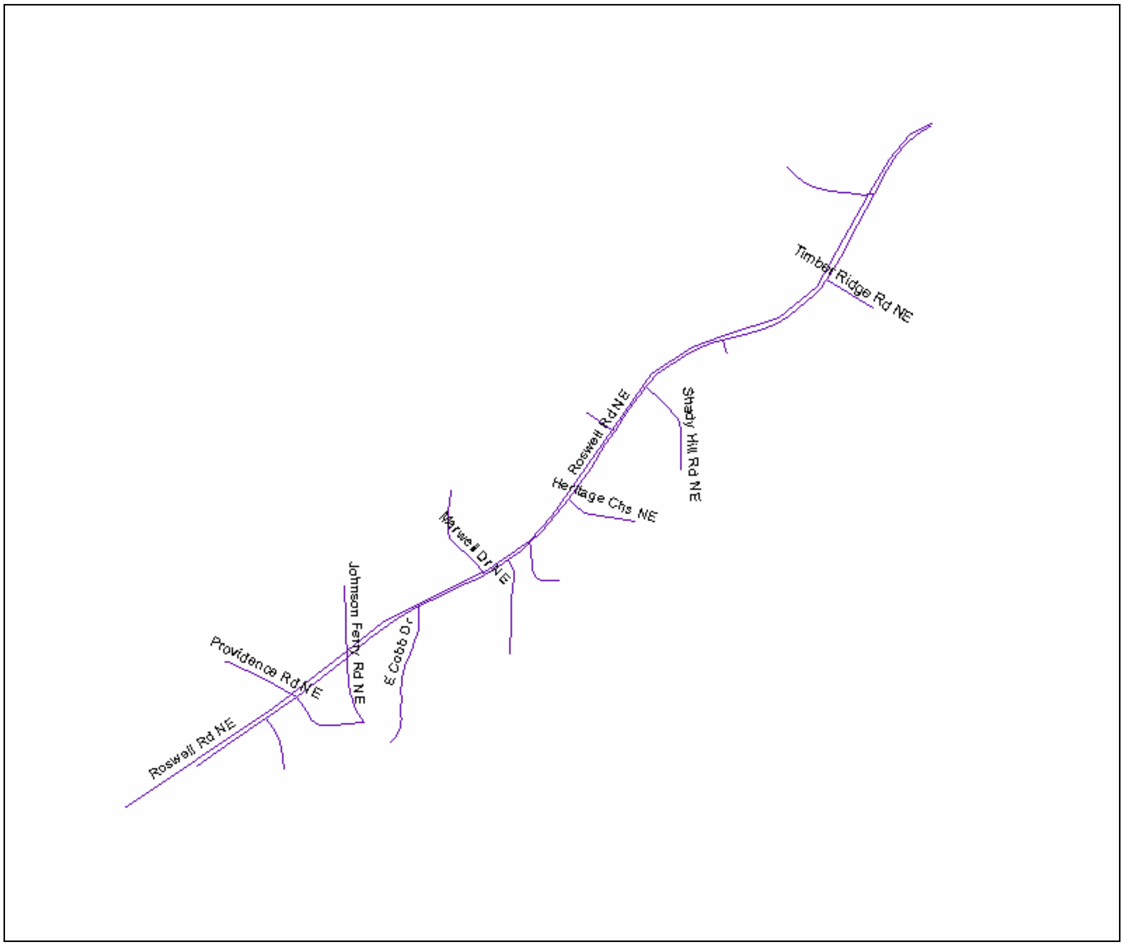


Figure A.4 GIS Image of Roswell Road (3) Corridor (Length of 2.0 Miles).

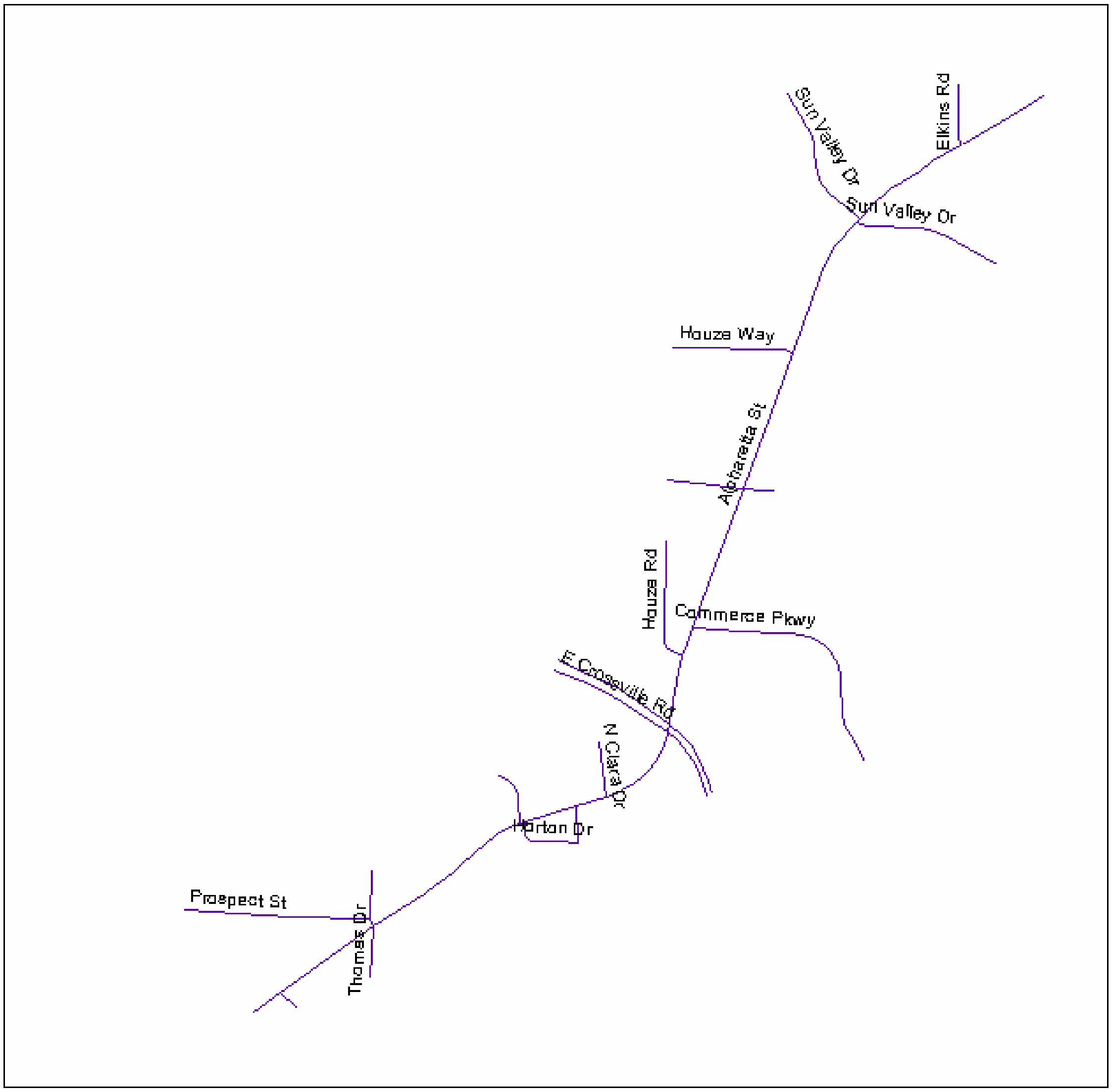


Figure A.5 GIS Image of Alpharetta Highway Corridor (Length of 2.2 Miles).

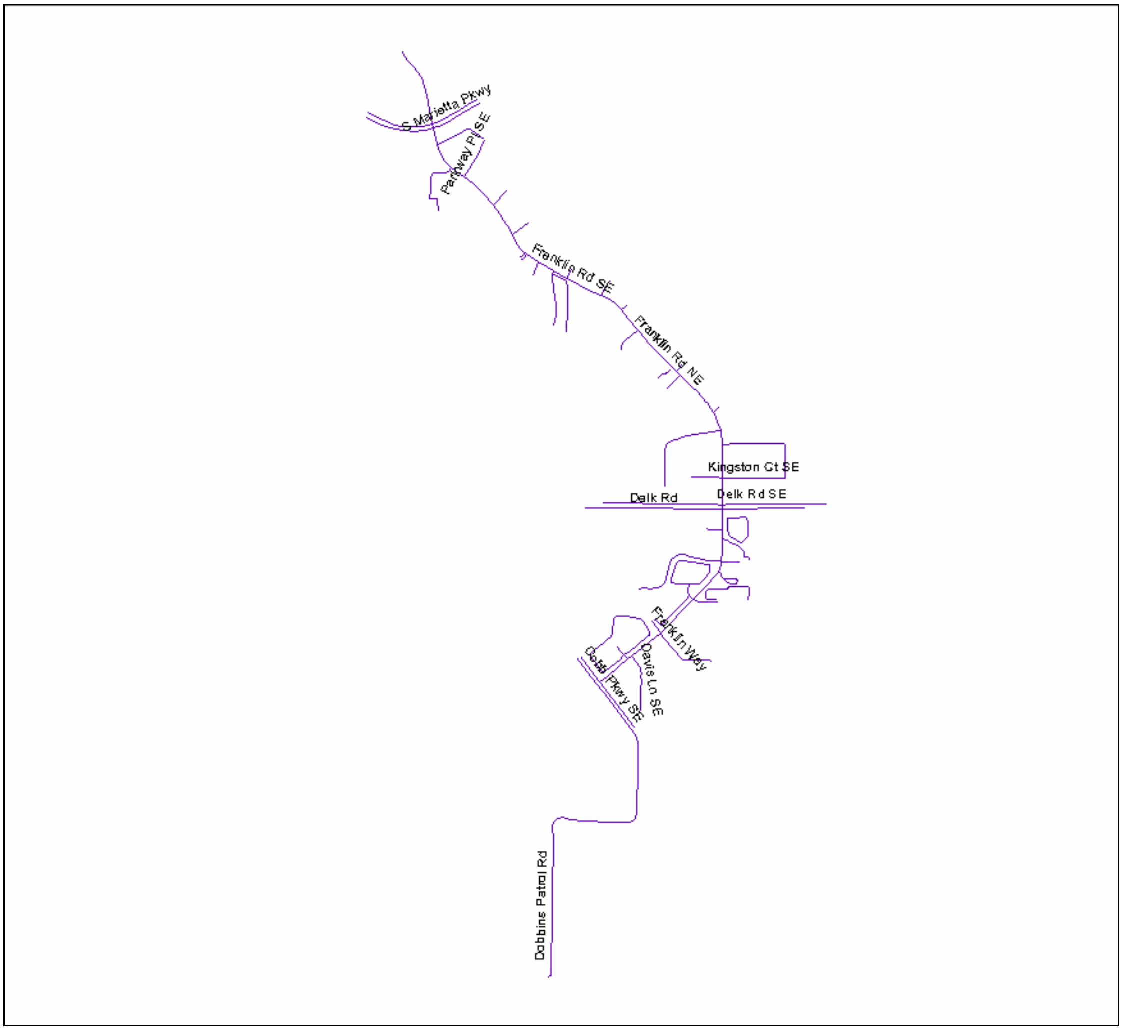


Figure A.6 GIS Image of Franklin Road Corridor (Length of 2.3 Miles).

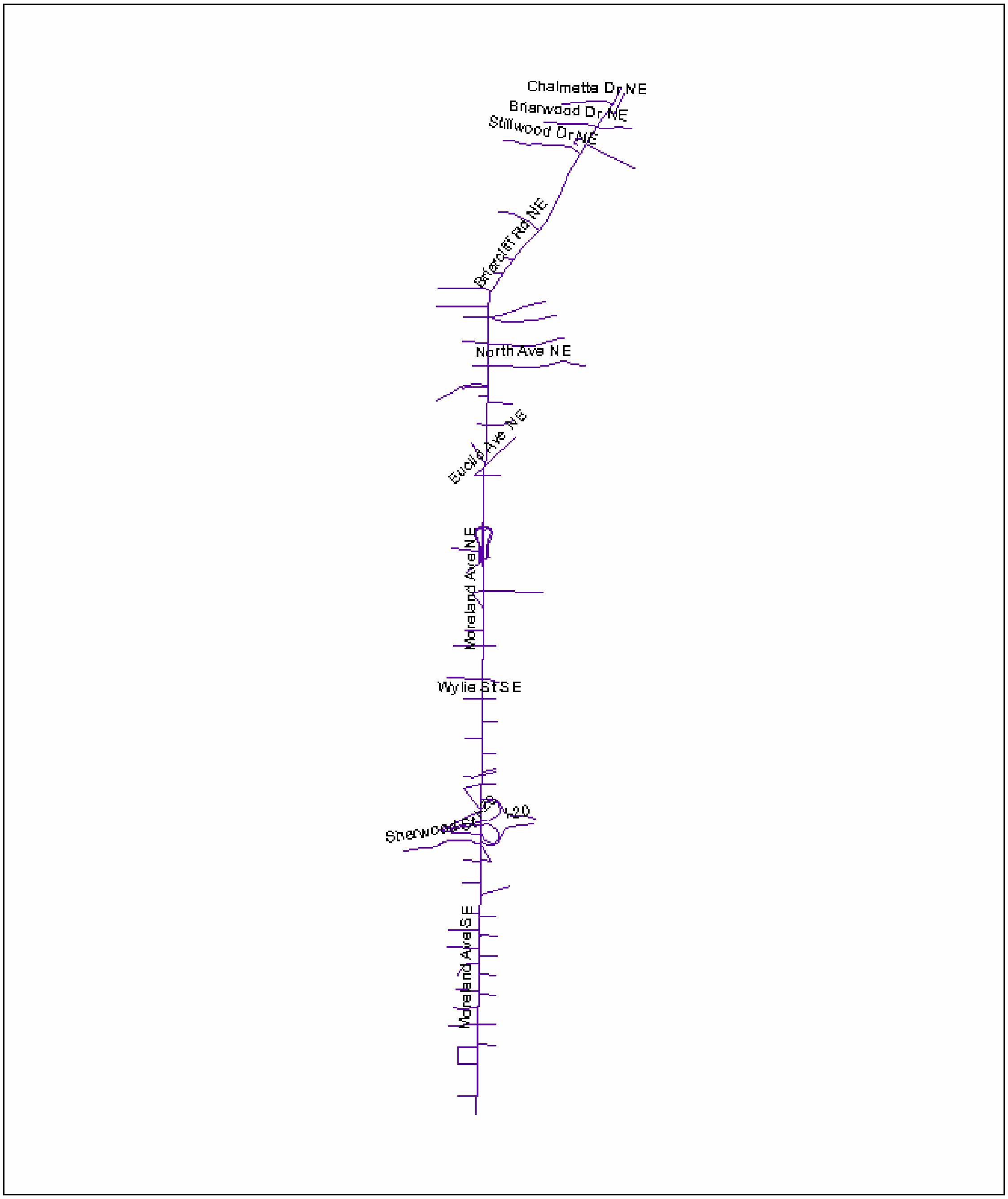


Figure A.7 GIS Image of Moreland Avenue / Briarcliff Road Corridor (Length of 4.0 Miles).

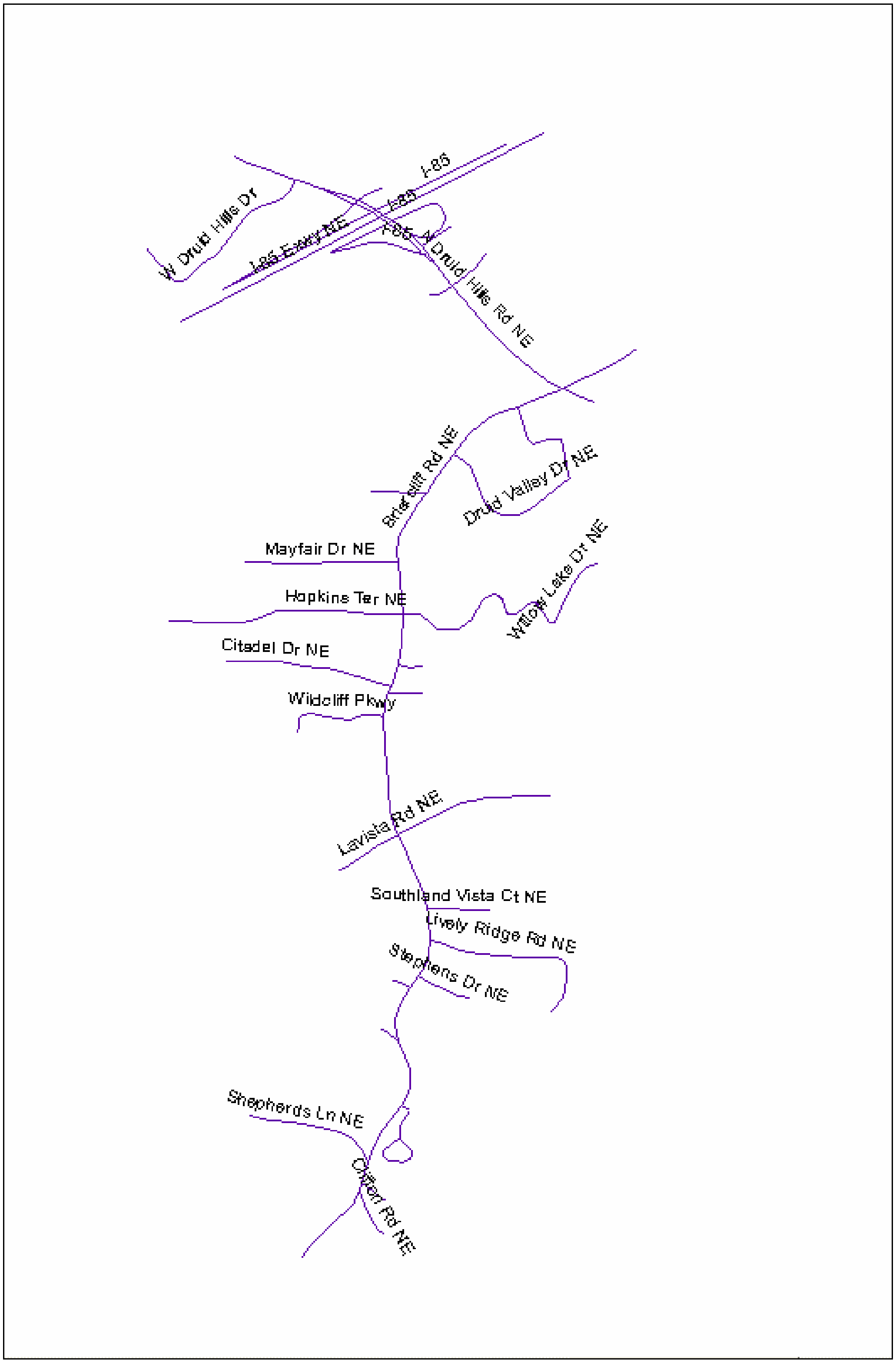


Figure A.8 GIS Image of Briarcliff Road / North Druid Hills Road Corridor (Length of 2.6 Miles).

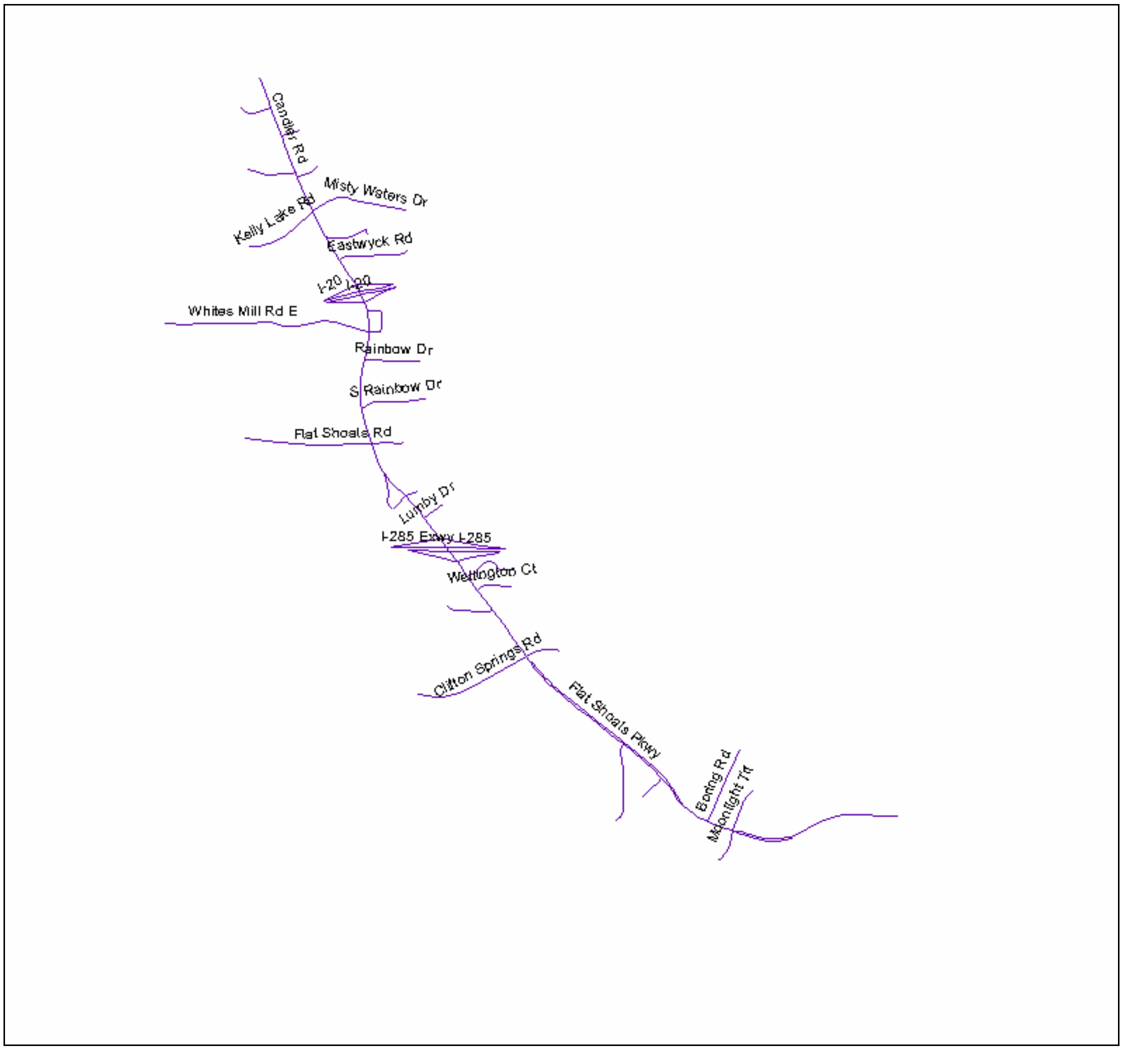


Figure A.9 GIS Image of Candler Road / Flat Shoals Parkway Corridor (Length of 3.5 Miles).

APPENDIX B

Table B.1 Crashes by type for 14th Street and Peachtree Street.

14th Street / Peachtree Street, Fulton County, Georgia								
Crash Type		2000	2001	2002	2003	2004	2005	Total
Angle/Broadside		380	401	352	264	302	305	2004
Head-On		11	15	11	12	17	14	80
Hit Object (Total)								
	Fixed Object	28	38	22	25	31	20	164
Pedestrian		12	7	13	7	9	11	59
Rear End		451	408	401	334	381	254	2229
Sideswipe (Total)								
	Sideswipe Opposite Direction	13	15	14	4	12	6	64
	Sideswipe Same Direction	214	230	191	189	184	159	1167
Total Crashes		1109	1114	1004	835	936	769	5767

Table B.2 Crashes by type for Roswell Road (1).

Roswell Road (1), Fulton County, Georgia								
Crash Type		2000	2001	2002	2003	2004	2005	Total
Angle/Broadside		253	211	211	204	176	163	1218
Head-On		9	12	12	8	12	5	58
Hit Object (Total)								
	Fixed Object	13	11	20	21	15	6	86
Pedestrian		8	9	4	7	8	10	46
Rear End		215	197	206	234	202	173	1227
Sideswipe (Total)								
	Sideswipe Opposite Direction	5	6	4	11	5	7	38
	Sideswipe Same Direction	54	52	55	43	47	44	295
Total Crashes		557	498	512	528	465	408	2968

Table B.3 Crashes by type for Roswell Road (2).

Roswell Road (2), Cobb County, Georgia								
Crash Type		2000	2001	2002	2003	2004	2005	Total
Angle/Broadside		17	12	19	9	16	17	90
Head-On		2	1	1	2	1	2	9
Hit Object (Total)								
	Fixed Object	5	13	4	6	3	6	37
Pedestrian		0	3	1	1	0	0	5
Rear End		61	85	93	103	81	72	495
Sideswipe (Total)								
	Sideswipe Opposite Direction	2	0	0	2	0	0	4
	Sideswipe Same Direction	3	4	7	0	2	4	20
Total Crashes		90	118	125	123	103	101	660

Table B.4 Crashes by type for Roswell Road (3).

Roswell Road (3), Fulton County, Georgia								
Crash Type		2000	2001	2002	2003	2004	2005	Total
Angle/Broadside		37	35	43	42	51	46	254
Head-On		0	2	2	8	1	5	18
Hit Object (Total)								
	Fixed Object	12	25	20	14	12	12	95
Pedestrian		0	0	0	0	0	0	0
Rear End		48	73	64	80	98	88	451
Sideswipe (Total)								
	Sideswipe Opposite Direction	0	1	1	0	1	1	4
	Sideswipe Same Direction	7	9	8	13	18	8	63
Total Crashes		104	145	138	157	181	160	885

Table B.5 Crashes by type for Alpharetta Highway.

Alpharetta Highway, Fulton County, Georgia								
Crash Type		2000	2001	2002	2003	2004	2005	Total
Angle/Broadside		187	226	201	230	186	186	1216
Head-On		18	11	9	16	7	7	68
Hit Object (Total)								
	Fixed Object	10	23	5	12	11	11	72
Pedestrian		3	2	3	6	2	2	18
Rear End		320	369	316	384	341	370	2100
Sideswipe (Total)								
	Sideswipe Opposite Direction	5	6	8	2	1	0	22
	Sideswipe Same Direction	55	55	52	65	61	61	349
Total Crashes		598	692	594	715	609	637	3845

Table B.6 Crashes by type for Franklin Road.

Franklin Road, Cobb County, Georgia								
Crash Type		2000	2001	2002	2003	2004	2005	Total
Angle/Broadside		105	107	82	75	78	70	517
Head-On		9	3	6	2	2	2	24
Hit Object (Total)								
	Fixed Object	5	6	11	11	16	7	56
Pedestrian		3	3	1	2	2	5	16
Rear End		87	76	74	65	61	72	435
Sideswipe (Total)								
	Sideswipe Opposite Direction	4	4	1	1	5	4	19
	Sideswipe Same Direction	31	24	16	20	17	18	126
Total Crashes		244	223	191	176	181	178	1193

Table B.7 Crashes by type for Moreland Avenue and Briarcliff Road.

Moreland Avenue / Briarcliff Road, Fulton / DeKalb County, Georgia								
Crash Type		2000	2001	2002	2003	2004	2005	Total
Angle/Broadside		209	238	233	206	235	191	1312
Head-On		13	13	10	12	7	14	69
Hit Object (Total)								
	Fixed Object	38	31	31	35	40	44	219
Pedestrian		11	13	8	7	8	13	60
Rear End		225	217	195	204	223	235	1299
Sideswipe (Total)								
	Sideswipe Opposite Direction	30	11	8	11	14	15	89
	Sideswipe Same Direction	98	96	114	102	107	123	640
Total Crashes		624	619	599	577	634	635	3688

Table B.8 Crashes by type for Briarcliff Road and N. Druid Hills Road.

Briarcliff Road / N. Druid Hills Road , DeKalb County, Georgia								
Crash Type		2000	2001	2002	2003	2004	2005	Total
Angle/Broadside		252	225	176	202	202	194	1251
Head-On		9	9	10	2	15	2	47
Hit Object (Total)								
	Fixed Object	27	12	18	10	11	10	88
Pedestrian		4	2	0	6	0	2	14
Rear End		297	265	248	251	266	255	1582
Sideswipe (Total)								
	Sideswipe Opposite Direction	13	7	6	9	24	8	67
	Sideswipe Same Direction	46	55	49	47	69	77	343
Total Crashes		648	575	507	527	587	548	3392

Table B.9 Crashes by type for Candler Road and Flat Shoals Parkway.

Candler Road / Flat Shoals Parkway, DeKalb County, Georgia								
Crash Type		2000	2001	2002	2003	2004	2005	Total
Angle/Broadside		224	252	256	198	203	229	1362
Head-On		18	13	11	9	12	16	79
Hit Object (Total)								
	Fixed Object	20	23	26	23	23	19	134
Pedestrian		7	9	11	9	8	7	51
Rear End		200	243	229	246	230	226	1374
Sideswipe (Total)								
	Sideswipe Opposite Direction	12	15	10	12	14	12	75
	Sideswipe Same Direction	46	65	61	63	60	73	368
Total Crashes		527	620	604	560	550	582	3443

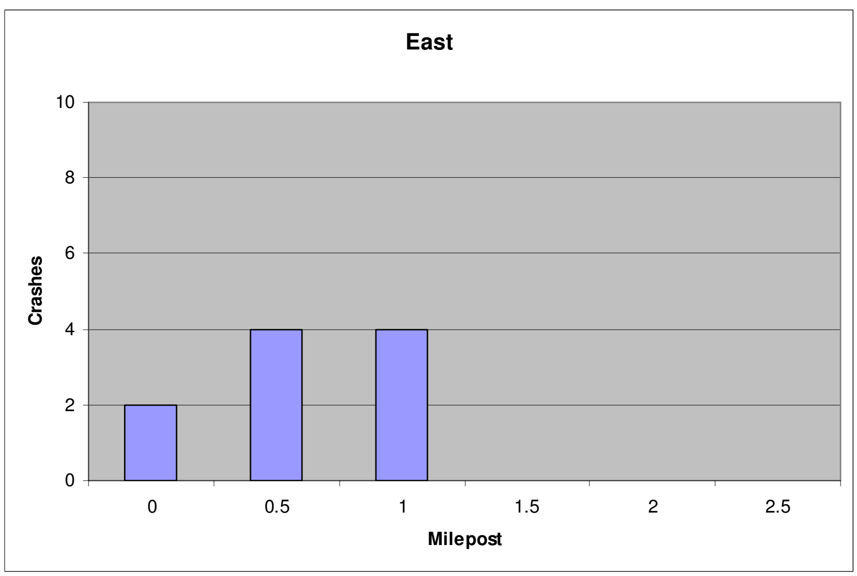


Figure B.1 Histogram of off-road fixed object collisions for the eastbound portion of 14th / Peachtree Street corridor.

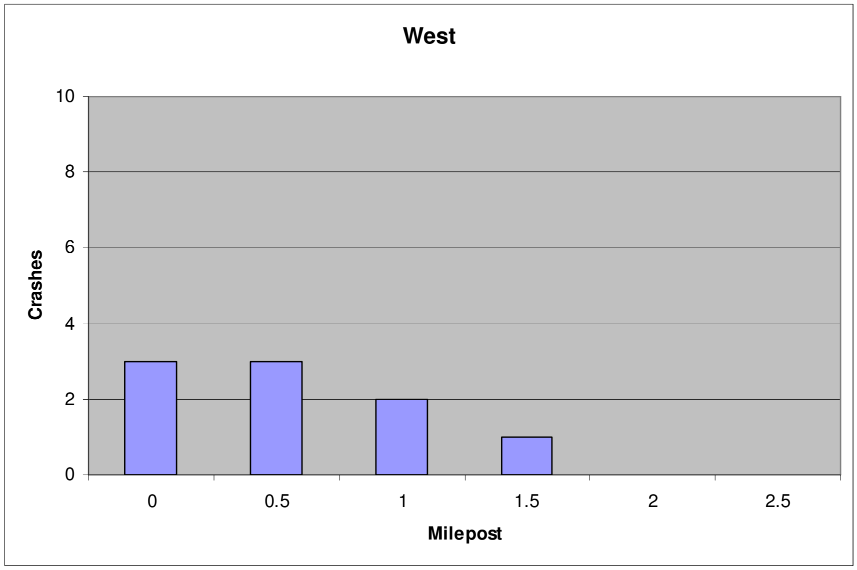


Figure B.2 Histogram of off-road fixed object collisions for the westbound portion of 14th / Peachtree Street corridor.

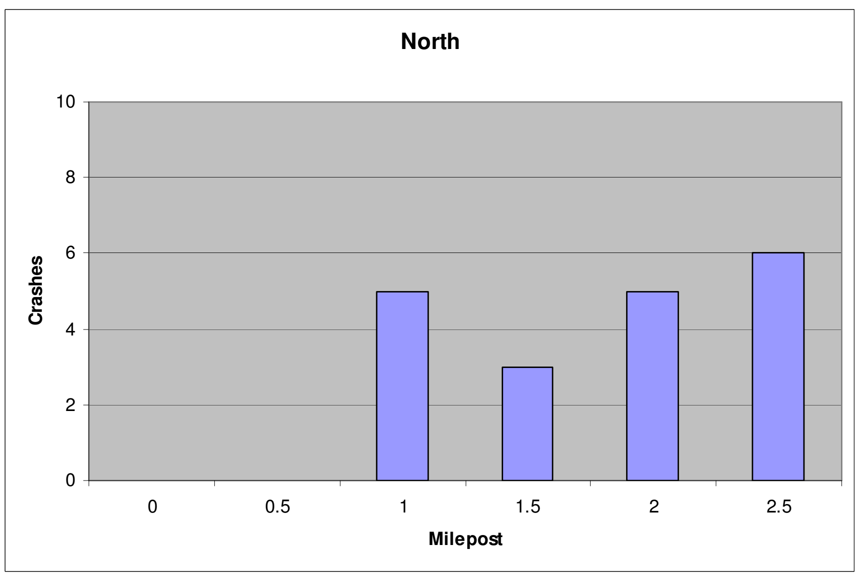


Figure B.3 Histogram of off-road fixed object collisions for the northbound portion of 14th / Peachtree Street corridor.

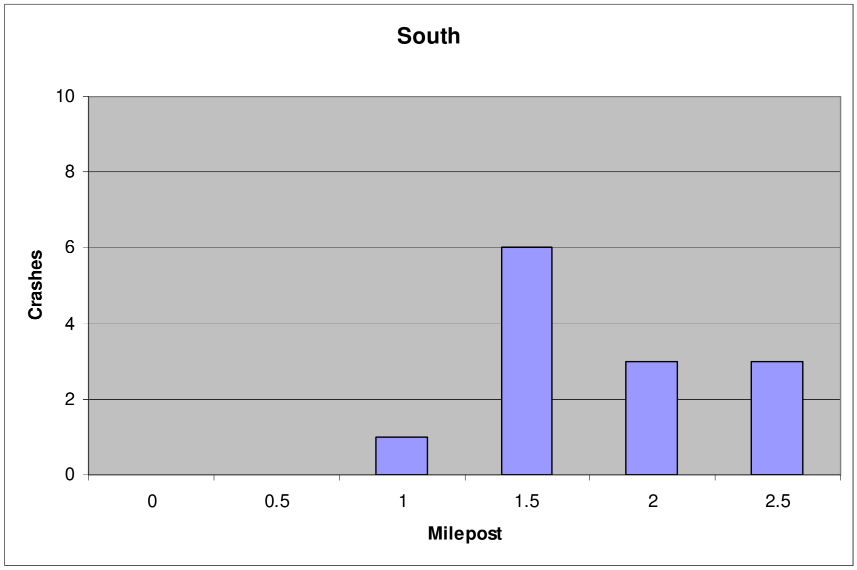


Figure B.4 Histogram of off-road fixed object collisions for the southbound portion of 14th / Peachtree Street corridor.

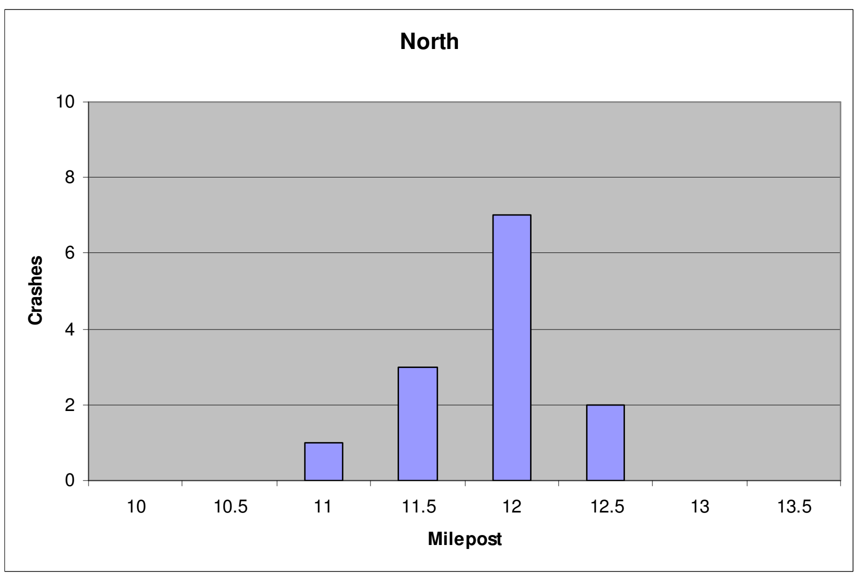


Figure B.5 Histogram of off-road fixed object collisions for the northbound portion Roswell Road (1) corridor.

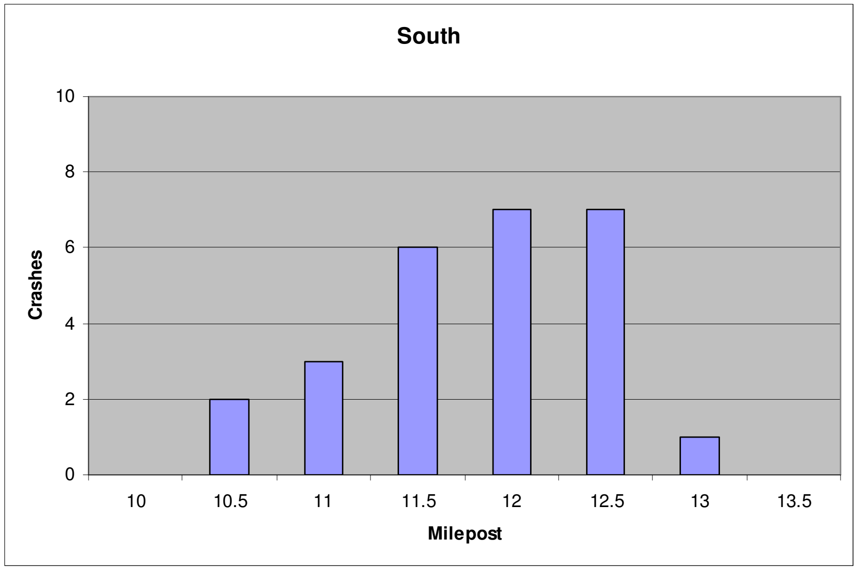


Figure B.6 Histogram of off-road fixed object collisions for the southbound portion Roswell Road (1) corridor.

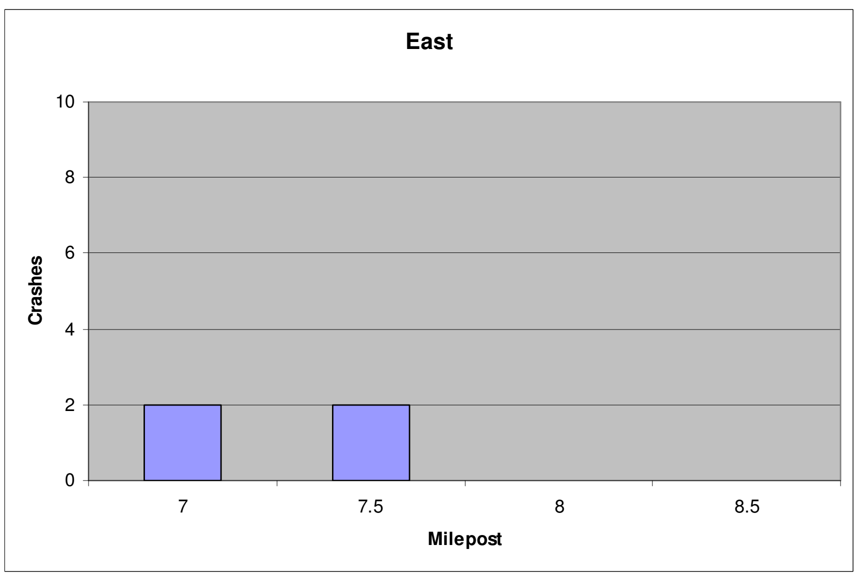


Figure B.7 Histogram of off-road fixed object collisions for the eastbound portion Roswell Road (2) corridor.

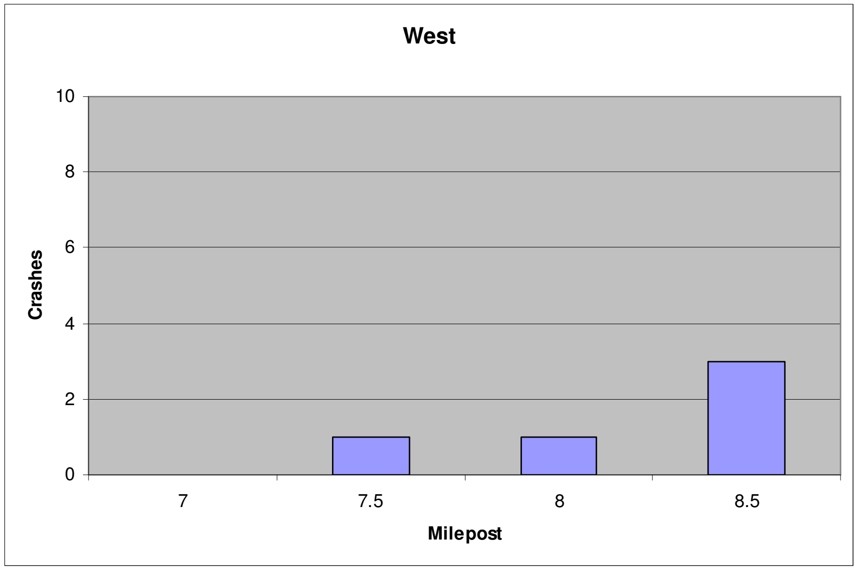


Figure B.8 Histogram of off-road fixed object collisions for the westbound portion Roswell Road (2) corridor.

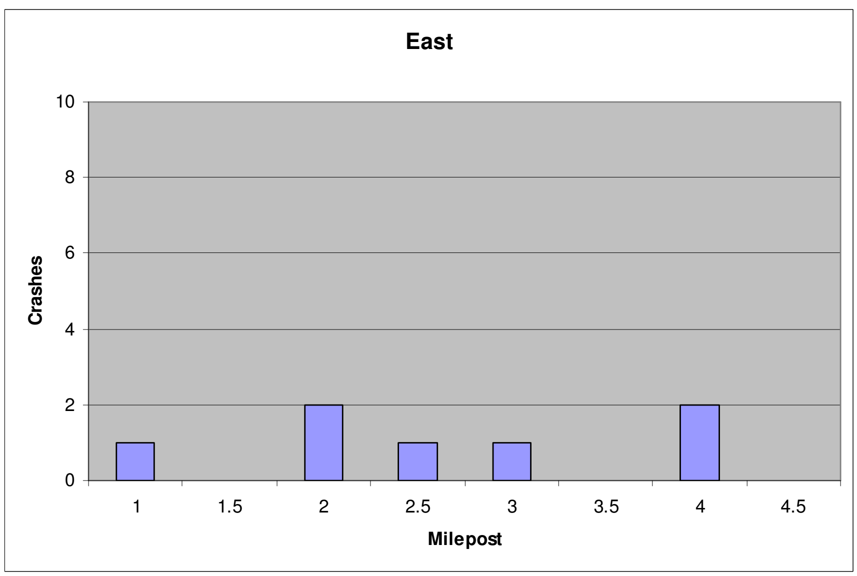


Figure B.9 Histogram of off-road fixed object collisions for the eastbound portion Roswell Road (3) corridor.

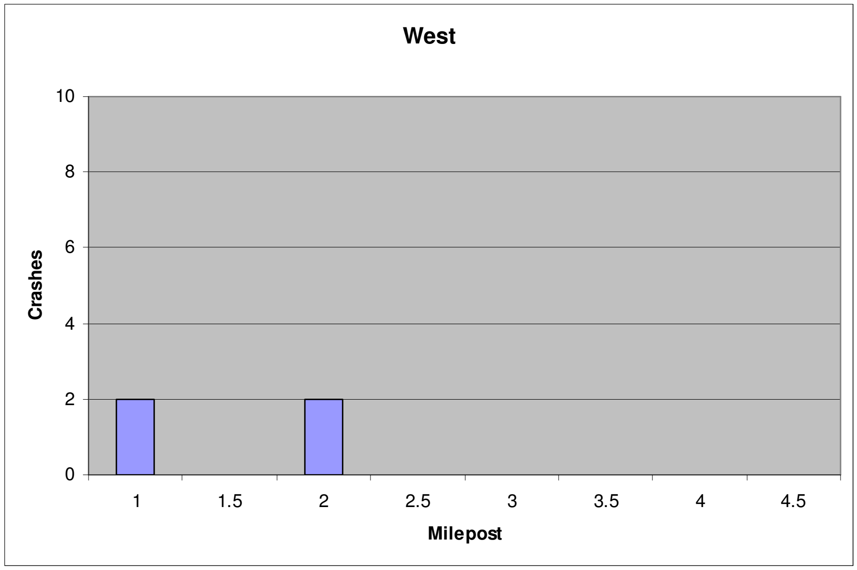


Figure B.10 Histogram of off-road fixed object collisions for the westbound portion Roswell Road (3) corridor.

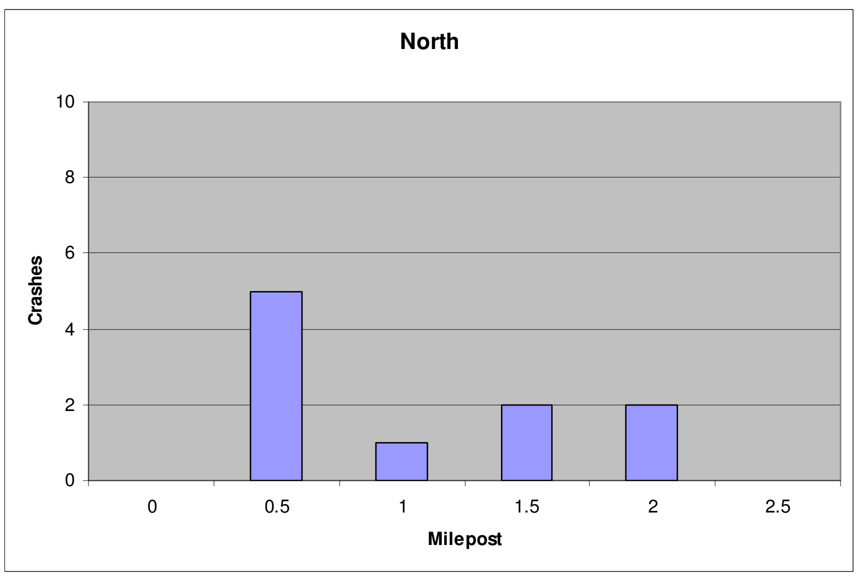


Figure B.11 Histogram of off-road fixed object collisions for the eastbound portion Franklin Road corridor.

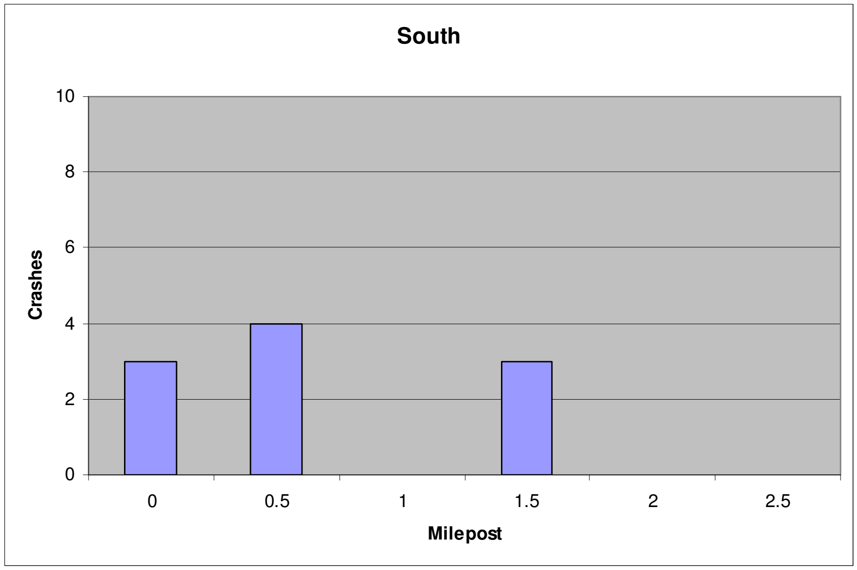


Figure B.12 Histogram of off-road fixed object collisions for the westbound portion Franklin Road corridor.

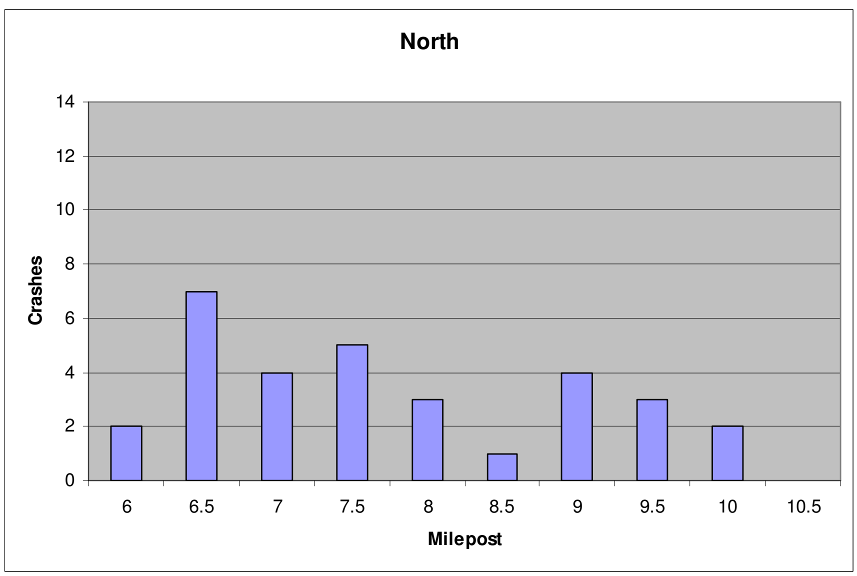


Figure B.13 Histogram of off-road fixed object collisions for the northbound portion Moreland Avenue / Briarcliff Road corridor.

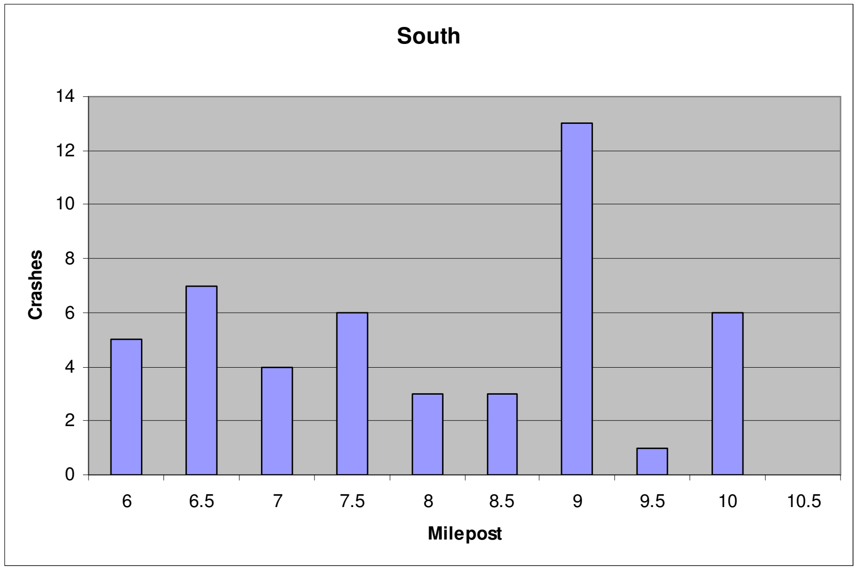


Figure B.14 Histogram of off-road fixed object collisions for the southbound portion Moreland Avenue / Briarcliff Road corridor.

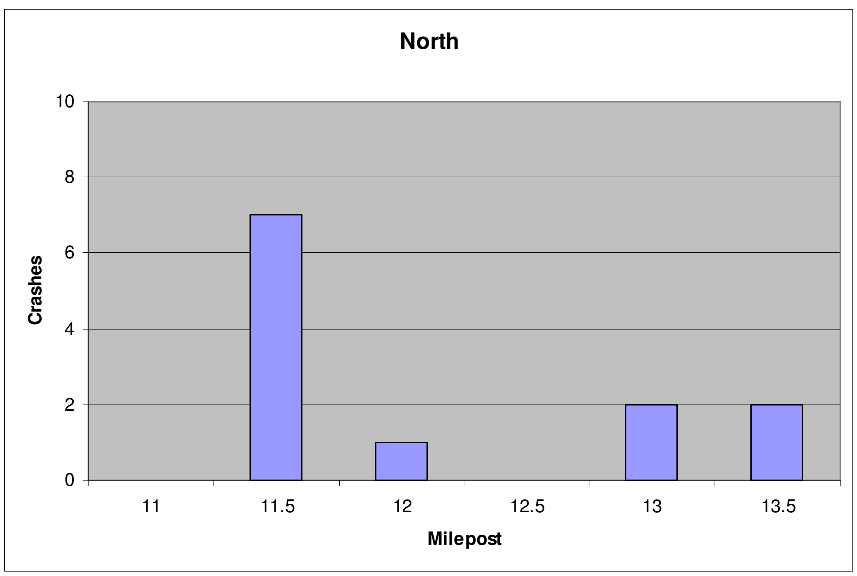


Figure B.15 Histogram of off-road fixed object collisions for the northbound portion Briarcliff Road / North Druid Hills Road corridor.

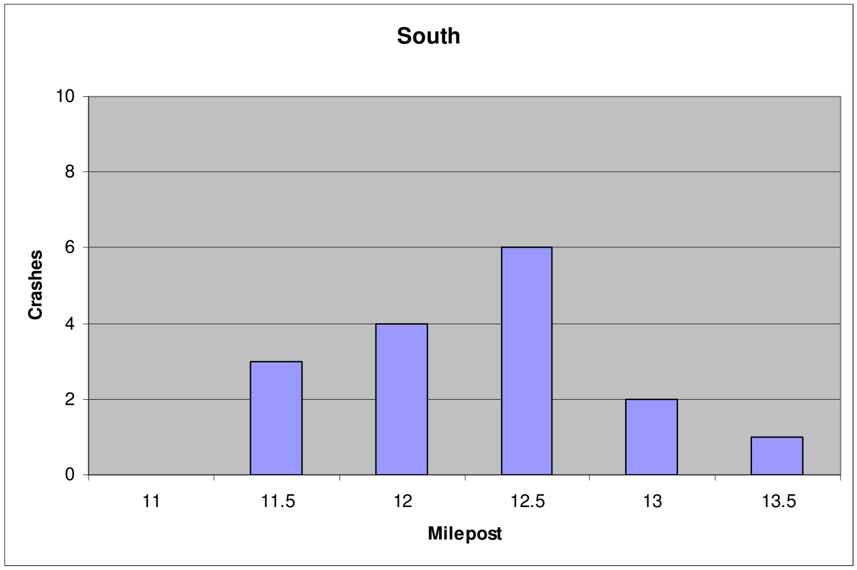


Figure B.16 Histogram of off-road fixed object collisions for the southbound portion Briarcliff Road / North Druid Hills Road corridor.

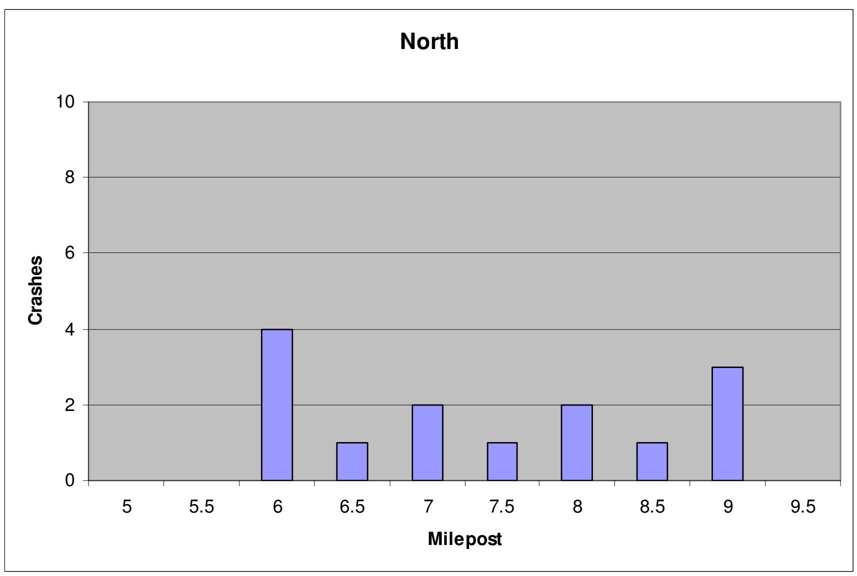


Figure B.17 Histogram of off-road fixed object collisions for the northbound portion Candler Road / Flat Shoals Parkway corridor.

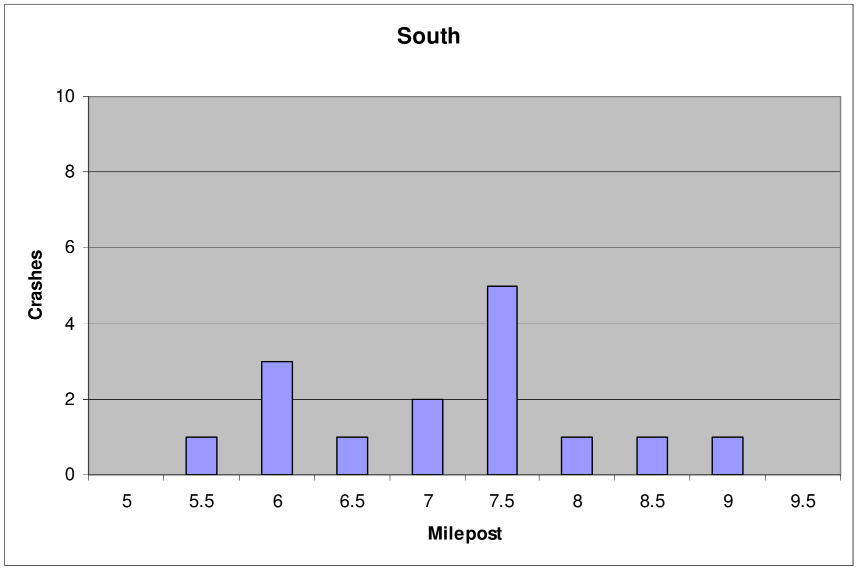


Figure B.18 Histogram of off-road fixed object collisions for the southbound portion Candler Road / Flat Shoals Parkway corridor.

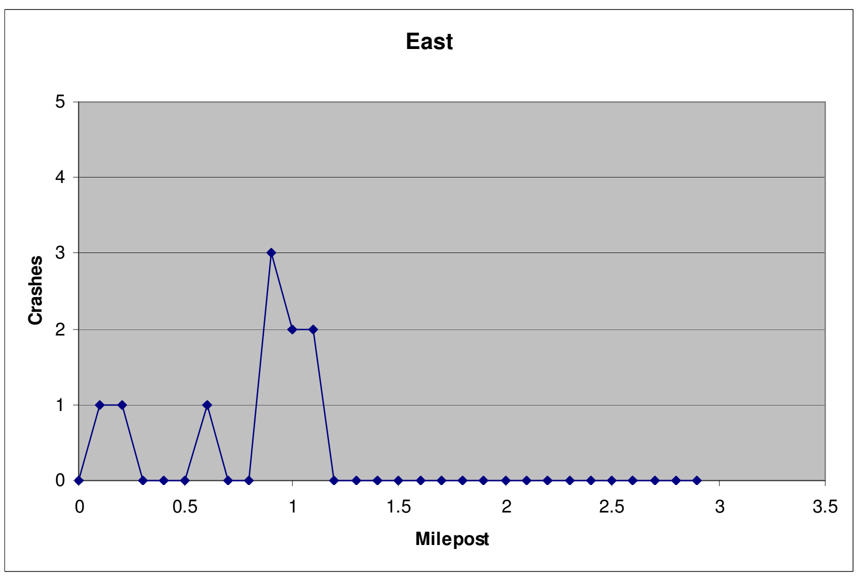


Figure B.19 Graph of the number of off-road fixed objects crashes for eastbound portion of 14th / Peachtree Street corridor.

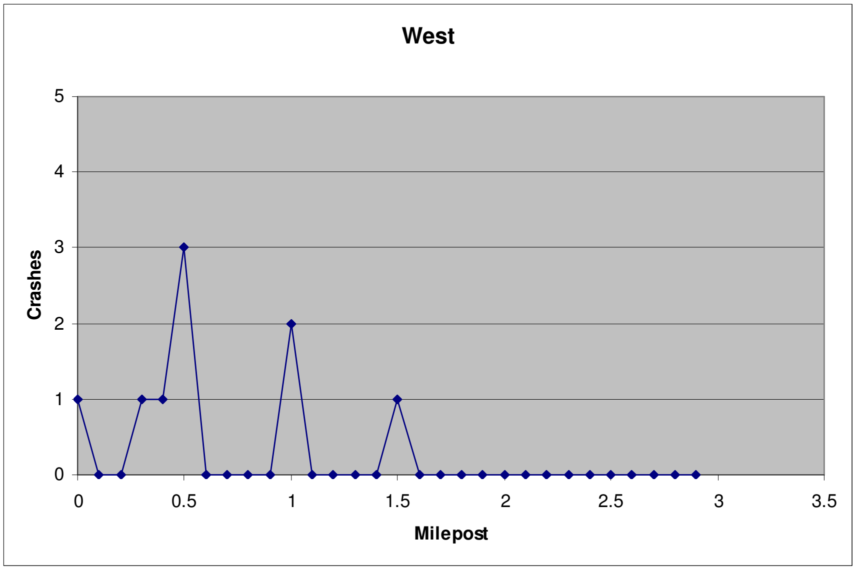


Figure B.20 Graph of the number of off-road fixed objects crashes for westbound portion of 14th / Peachtree Street corridor.

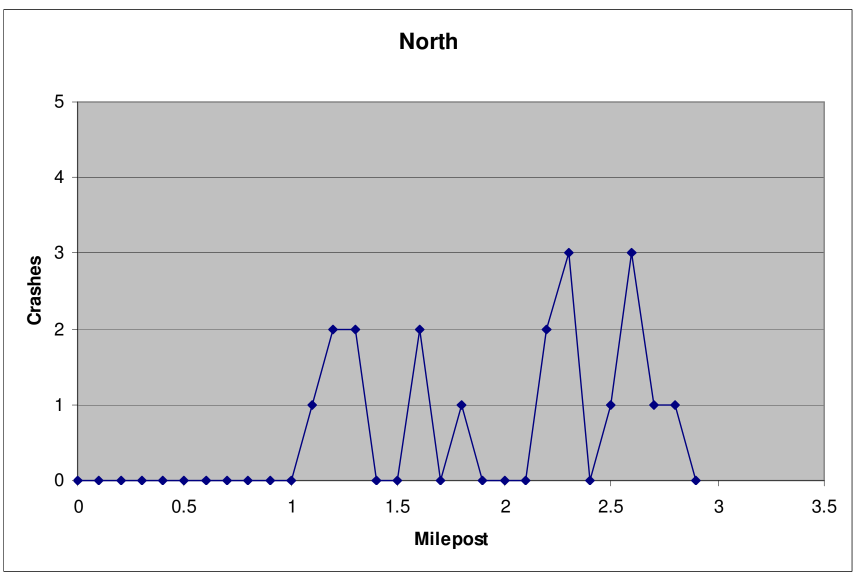


Figure B.21 Graph of the number of off-road fixed objects crashes for northbound portion of 14th / Peachtree Street corridor.

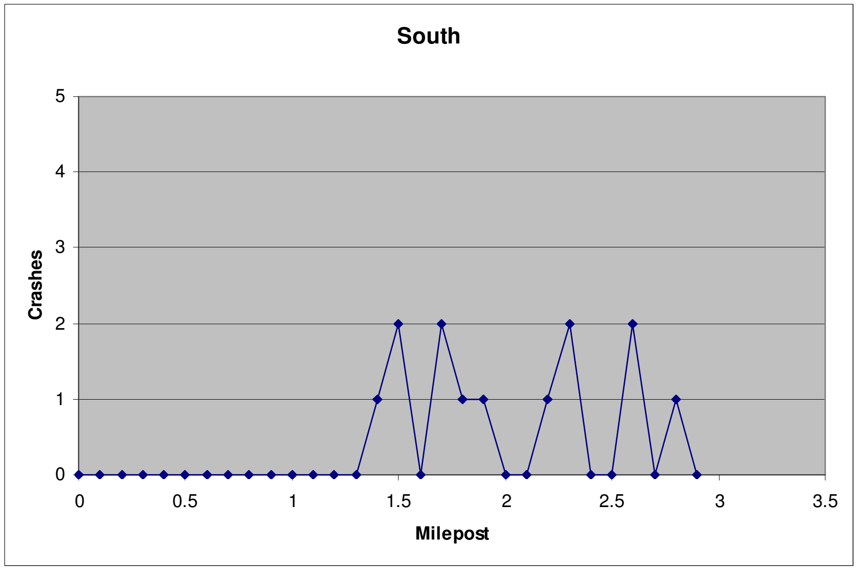


Figure B.22 Graph of the number of off-road fixed objects crashes for southbound portion of 14th / Peachtree Street corridor.

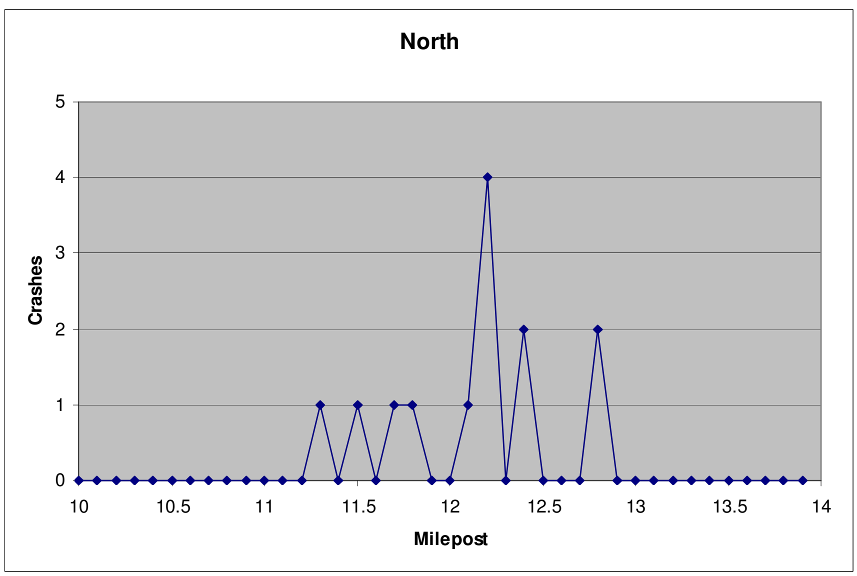


Figure B.23 Graph of the number of off-road fixed objects crashes for northbound portion of Roswell Road (1) corridor.

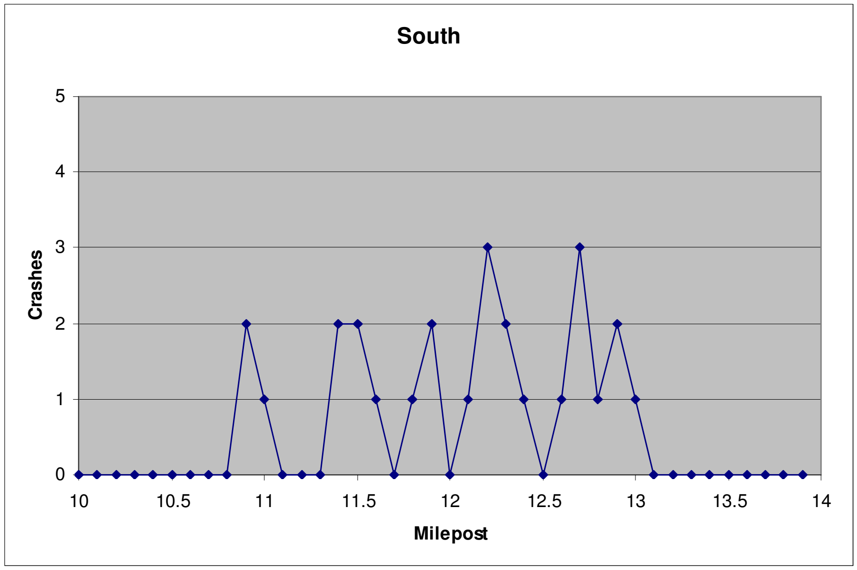


Figure B.24 Graph of the number of off-road fixed objects crashes for southbound portion of Roswell Road (1) corridor.

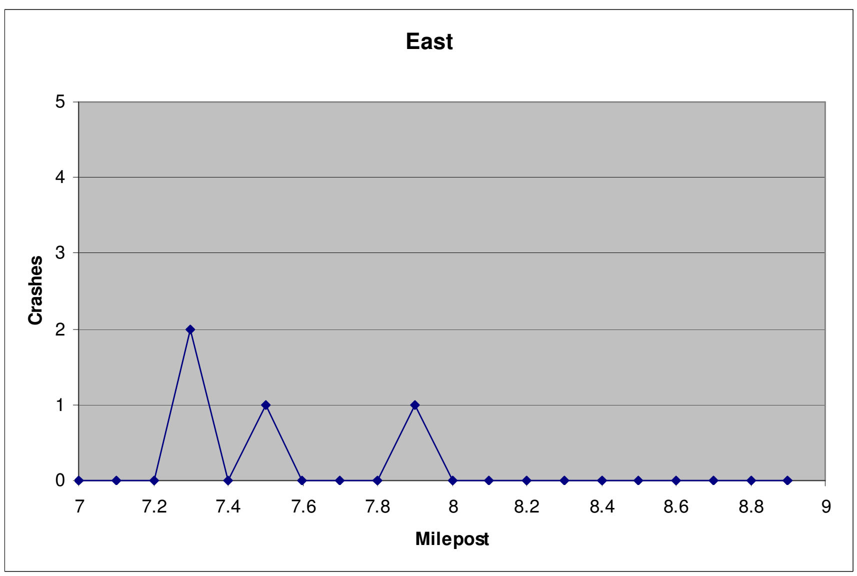


Figure B.25 Graph of the number of off-road fixed objects crashes for eastbound portion of Roswell Road (2) corridor.

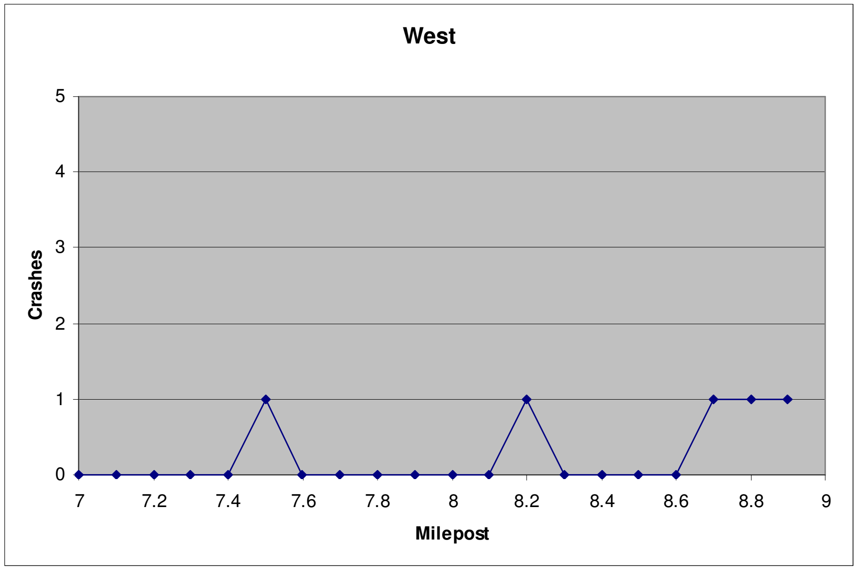


Figure B.26 Graph of the number of off-road fixed objects crashes for westbound portion of Roswell Road (2) corridor.

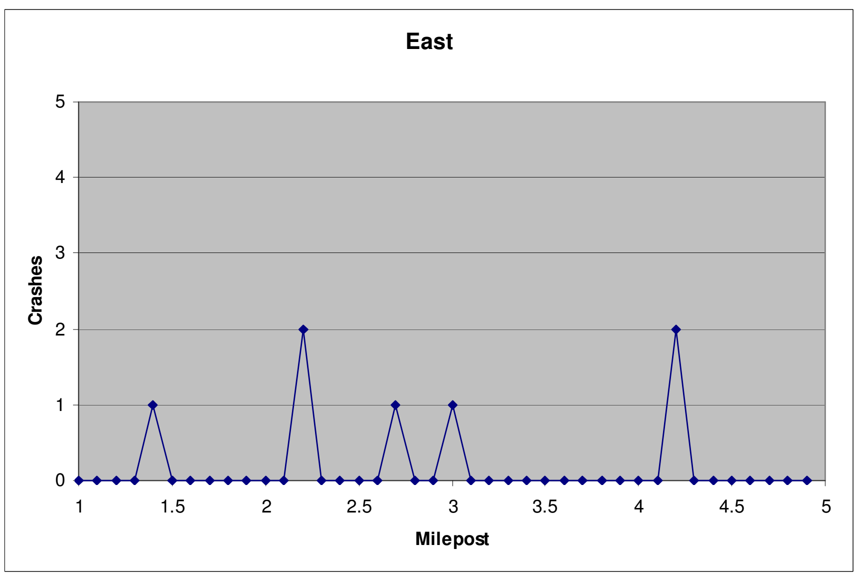


Figure B.27 Graph of the number of off-road fixed objects crashes for eastbound portion of Roswell Road (3) corridor.

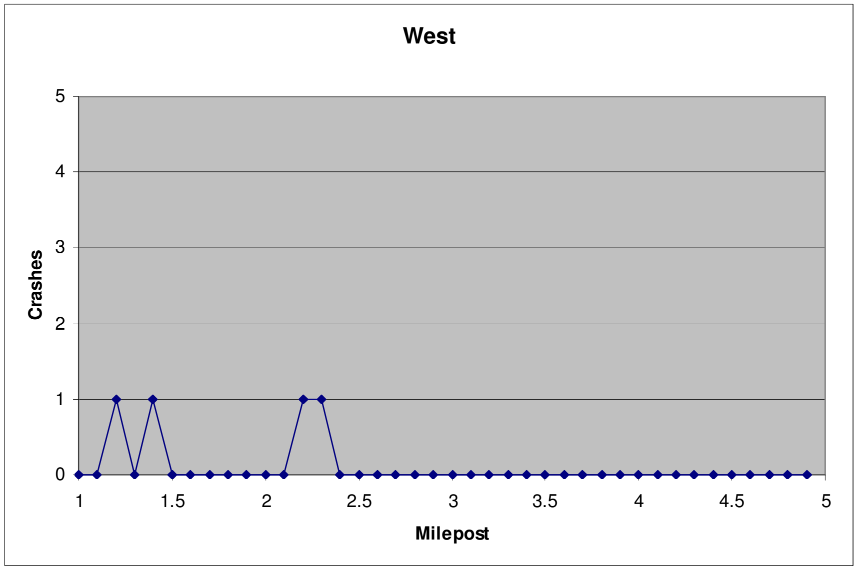


Figure B.28 Graph of the number of off-road fixed objects crashes for westbound portion of Roswell Road (3) corridor.

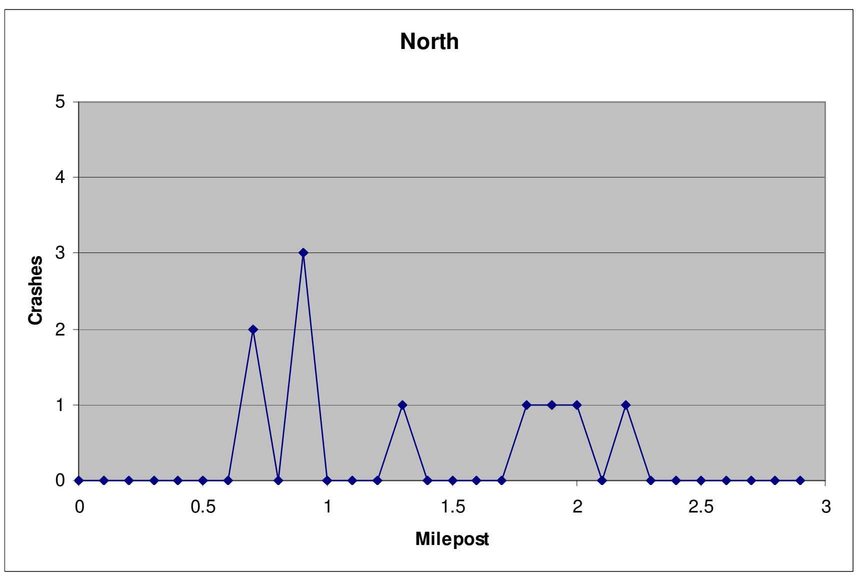


Figure B.29 Graph of the number of off-road fixed objects crashes for northbound portion of Franklin Road corridor.

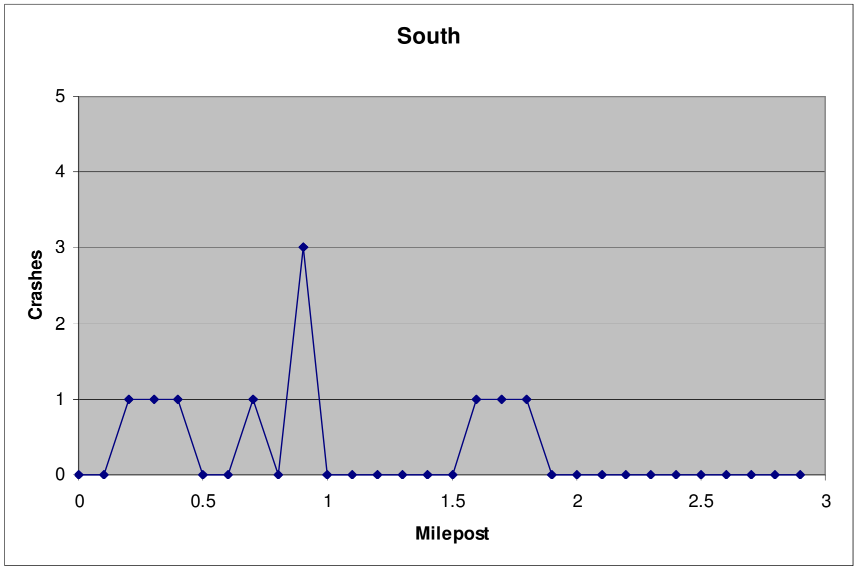


Figure B.30 Graph of the number of off-road fixed objects crashes for southbound portion of Franklin Road corridor.

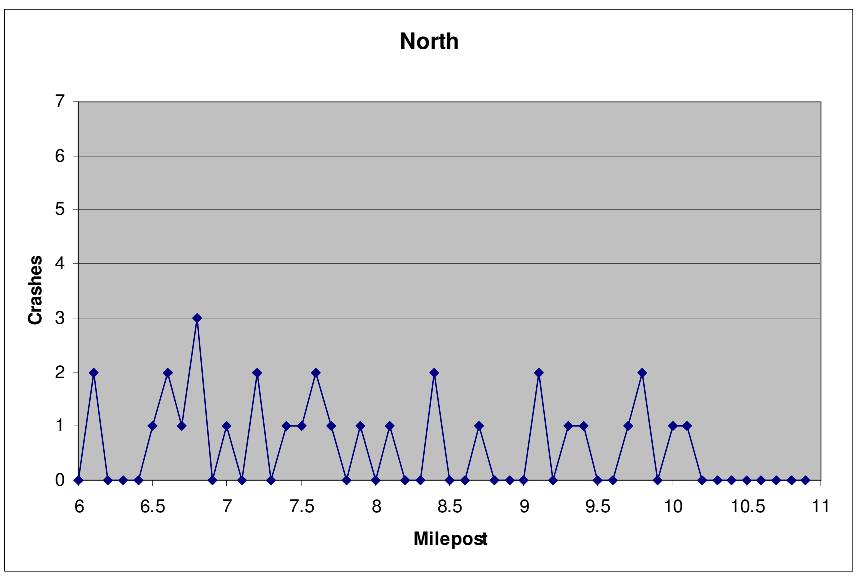


Figure B.31 Graph of the number of off-road fixed objects crashes for northbound portion of Moreland Avenue / Briarcliff Road corridor.

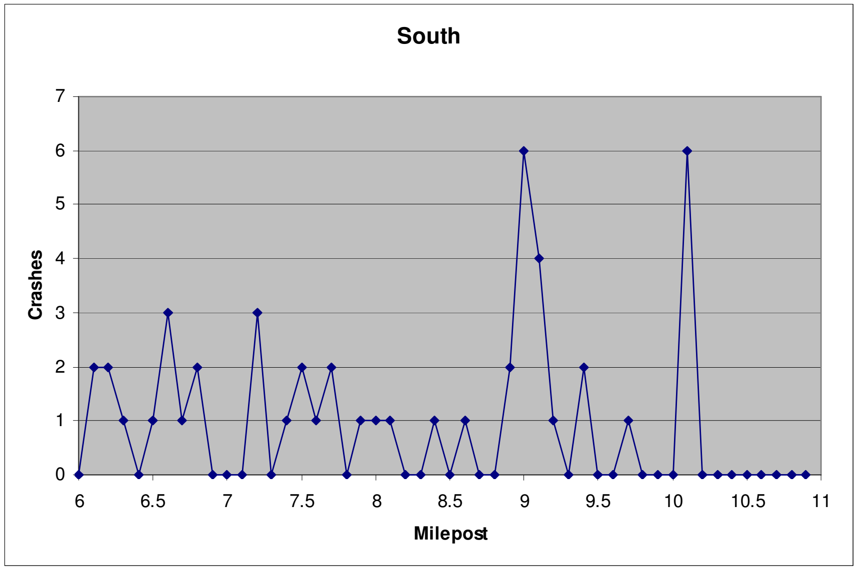


Figure B.32 Graph of the number of off-road fixed objects crashes for southbound portion of Moreland Avenue / Briarcliff Road corridor.

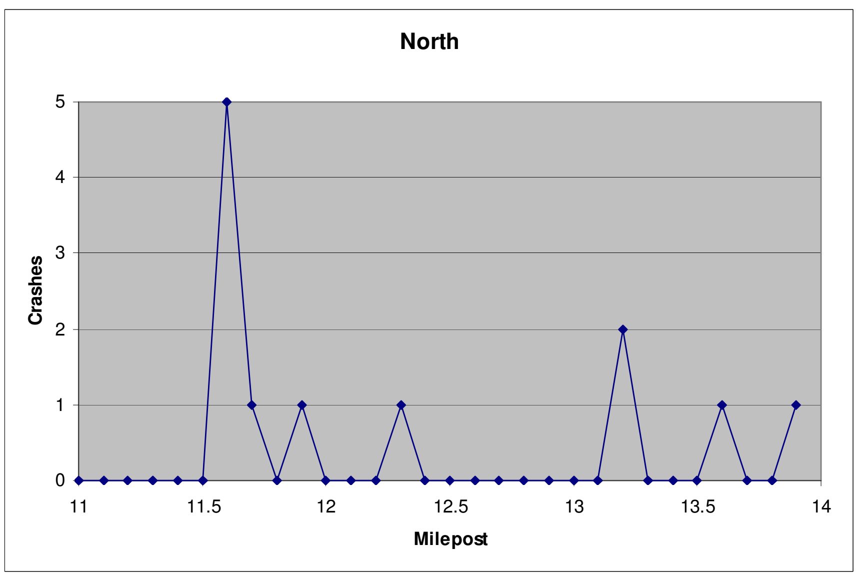


Figure B.33 Graph of the number of off-road fixed objects crashes for northbound portion of Briarcliff Road / North Druid Hills Road corridor.

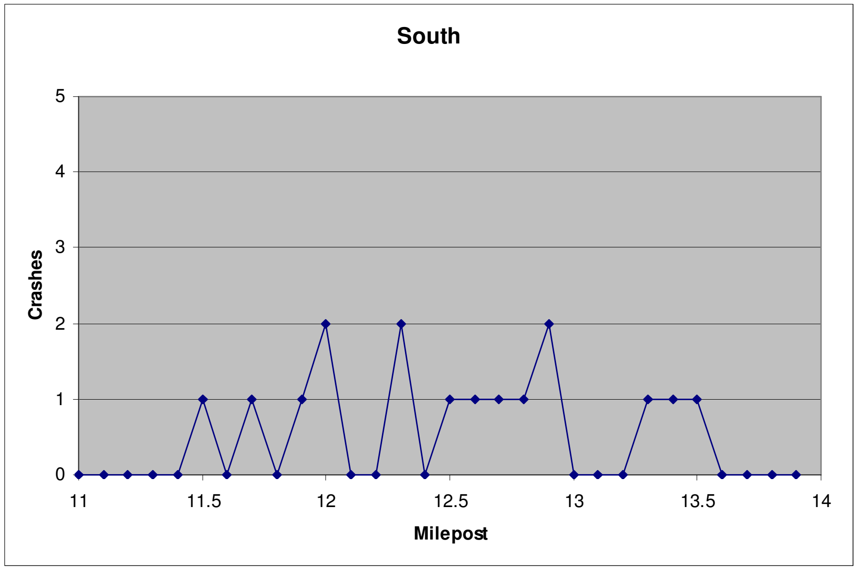


Figure B.34 Graph of the number of off-road fixed objects crashes for southbound portion of Briarcliff Road / North Druid Hills Road corridor.

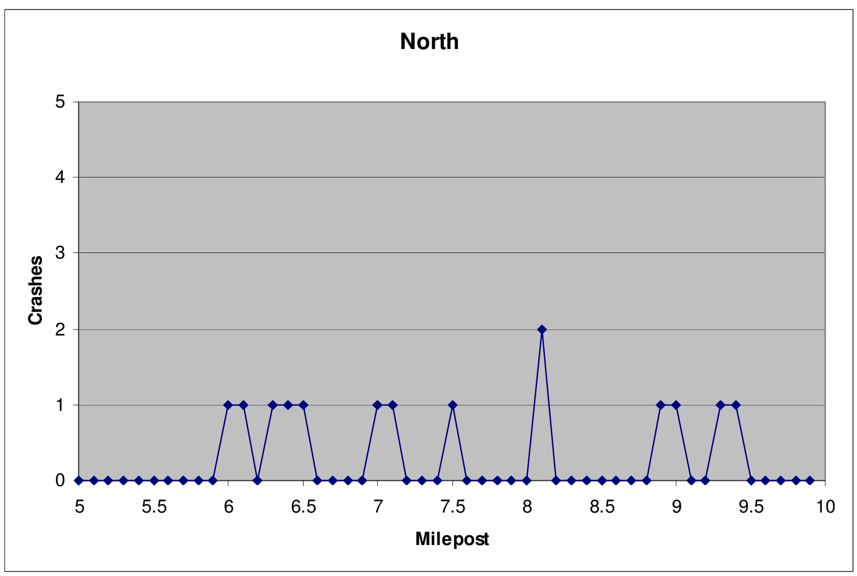


Figure B.35 Graph of the number of off-road fixed objects crashes for northbound portion of Candler Road / Flat Shoals Parkway corridor.

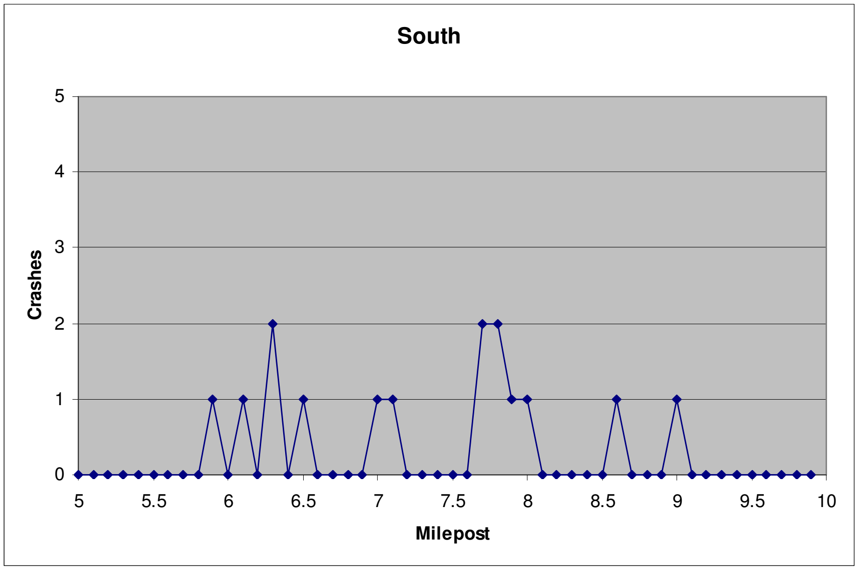


Figure B.36 Graph of the number of off-road fixed objects crashes for southbound portion of Candler Road / Flat Shoals Parkway corridor.

Table B.10 Table of utility pole crashes and their nearness to intersections on the 14th Street / Peachtree Street corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	15840.00	100.00%	44	100.00%
Within 25'	1416.54	8.94%	6	13.64%
Within 50'	2595.55	16.39%	12	27.27%
Within 100'	4378.12	27.64%	22	50.00%

Table B.11 Table of utility pole crashes and their nearness to intersections on the Roswell Road (1) corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	11616.00	100.00%	17	100.00%
Within 25'	626.69	5.40%	1	5.88%
Within 50'	1185.89	10.21%	2	11.76%
Within 100'	2270.54	19.55%	7	41.18%

Table B.12 Table of utility pole crashes and their nearness to intersections on the Roswell Road (2) corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	10665.60	100.00%	1	100.00%
Within 25'	662.32	6.21%	0	0.00%
Within 50'	1269.81	11.91%	0	0.00%
Within 100'	2497.77	23.42%	0	0.00%

Table B.13 Table of utility pole crashes and their nearness to intersections on the Roswell Road (3) corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	10718.40	100.00%	2	100.00%
Within 25'	625.00	5.83%	0	0.00%
Within 50'	1246.87	11.63%	0	0.00%
Within 100'	2498.00	23.31%	0	0.00%

Table B.14 Table of utility pole crashes and their nearness to intersections on the Alpharetta Highway corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	11510.40	100.00%	2	100.00%
Within 25'	534.97	4.65%	0	0.00%
Within 50'	993.25	8.63%	0	0.00%
Within 100'	1896.18	16.47%	0	0.00%

Table B.15 Table of utility pole crashes and their nearness to intersections on the Franklin Road corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	12144.00	100.00%	1	100.00%
Within 25'	827.50	6.81%	0	0.00%
Within 50'	1436.48	11.83%	0	0.00%
Within 100'	2430.45	20.01%	1	100.00%

Table B.16 Table of utility pole crashes and their nearness to intersections on the Moreland Avenue / Briarcliff Road corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	21172.80	100.00%	57	100.00%
Within 25'	1968.60	9.30%	17	29.82%
Within 50'	3407.11	16.09%	21	36.84%
Within 100'	5891.17	27.82%	46	80.70%

Table B.17 Table of utility pole crashes and their nearness to intersections on the Briarcliff Road / North Druid Hills Road corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	13516.80	100.00%	6	100.00%
Within 25'	1372.92	10.16%	3	50.00%
Within 50'	2605.80	19.28%	4	66.67%
Within 100'	4500.68	33.30%	6	100.00%

Table B.18 Table of utility pole crashes and their nearness to intersections on the Candler Road / Flat Shoals Parkway corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	18532.80	100.00%	9	100.00%
Within 25'	1450.00	7.82%	3	33.33%
Within 50'	2671.76	14.42%	3	33.33%
Within 100'	4977.04	26.86%	4	44.44%

Table B.19 Table of tree crashes and their nearness to intersections on the 14th Street / Peachtree Street corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	15840.00	100.00%	5	100.00%
Within 25'	1416.54	8.94%	2	40.00%
Within 50'	2595.55	16.39%	2	40.00%
Within 100'	4378.12	27.64%	2	40.00%

Table B.20 Table of tree crashes and their nearness to intersections on the Roswell Road (1) corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	11616.00	100.00%	3	100.00%
Within 25'	626.69	5.40%	0	0.00%
Within 50'	1185.89	10.21%	0	0.00%
Within 100'	2270.54	19.55%	1	33.33%

Table B.21 Table of tree crashes and their nearness to intersections on the Roswell Road (2) corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	10665.60	100.00%	3	100.00%
Within 25'	662.32	6.21%	0	0.00%
Within 50'	1269.81	11.91%	0	0.00%
Within 100'	2497.77	23.42%	0	0.00%

Table B.22 Table of tree crashes and their nearness to intersections on the Roswell Road (3) corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	10718.40	100.00%	1	100.00%
Within 25'	625.00	5.83%	0	0.00%
Within 50'	1246.87	11.63%	1	100.00%
Within 100'	2498.00	23.31%	1	100.00%

Table B.23 Table of tree crashes and their nearness to intersections on the Alpharetta Highway corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	11510.40	100.00%	4	100.00%
Within 25'	534.97	4.65%	0	0.00%
Within 50'	993.25	8.63%	0	0.00%
Within 100'	1896.18	16.47%	3	75.00%

Table B.24 Table of tree crashes and their nearness to intersections on the Franklin Road corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	12144.00	100.00%	5	100.00%
Within 25'	827.50	6.81%	2	40.00%
Within 50'	1436.48	11.83%	2	40.00%
Within 100'	2430.45	20.01%	2	40.00%

Table B.25 Table of tree crashes and their nearness to intersections on the Moreland Avenue / Briarcliff Road corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	21172.80	100.00%	11	100.00%
Within 25'	1968.60	9.30%	2	18.18%
Within 50'	3407.11	16.09%	5	45.45%
Within 100'	5891.17	27.82%	7	63.64%

Table B.26 Table of tree crashes and their nearness to intersections on the Briarcliff Road / North Druid Hills Road corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	13516.80	100.00%	7	100.00%
Within 25'	1372.92	10.16%	1	14.29%
Within 50'	2605.80	19.28%	1	14.29%
Within 100'	4500.68	33.30%	4	57.14%

Table B.27 Table of tree crashes and their nearness to intersections on the Candler Road / Flat Shoals Parkway corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	18532.80	100.00%	2	100.00%
Within 25'	1450.00	7.82%	1	50.00%
Within 50'	2671.76	14.42%	1	50.00%
Within 100'	4977.04	26.86%	1	50.00%

Table B.28 Table of utility pole and tree crashes and their nearness to intersections on the 14th Street / Peachtree Street corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	15840.00	100.00%	49	100.00%
Within 25'	1416.54	8.94%	8	16.33%
Within 50'	2595.55	16.39%	14	28.57%
Within 100'	4378.12	27.64%	24	48.98%

Table B.29 Table of utility pole and tree crashes and their nearness to intersections on the Roswell Road (1) corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	11616.00	100.00%	20	100.00%
Within 25'	626.69	5.40%	1	5.00%
Within 50'	1185.89	10.21%	2	10.00%
Within 100'	2270.54	19.55%	8	40.00%

Table B.30 Table of utility pole and tree crashes and their nearness to intersections on the Roswell Road (2) corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	10665.60	100.00%	4	100.00%
Within 25'	662.32	6.21%	0	0.00%
Within 50'	1269.81	11.91%	0	0.00%
Within 100'	2497.77	23.42%	0	0.00%

Table B.31 Table of utility pole and tree crashes and their nearness to intersections on the Roswell Road (3) corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	10718.40	100.00%	3	100.00%
Within 25'	625.00	5.83%	0	0.00%
Within 50'	1246.87	11.63%	1	33.33%
Within 100'	2498.00	23.31%	1	33.33%

Table B.32 Table of utility pole and tree crashes and their nearness to intersections on the Alpharetta Highway corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	11510.40	100.00%	6	100.00%
Within 25'	534.97	4.65%	0	0.00%
Within 50'	993.25	8.63%	0	0.00%
Within 100'	1896.18	16.47%	3	50.00%

Table B.33 Table of utility pole and tree crashes and their nearness to intersections on the Franklin Road corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	12144.00	100.00%	6	100.00%
Within 25'	827.50	6.81%	2	33.33%
Within 50'	1436.48	11.83%	2	33.33%
Within 100'	2430.45	20.01%	3	50.00%

Table B.34 Table of utility pole and tree crashes and their nearness to intersections on the Moreland Avenue / Briarcliff Road corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	21172.80	100.00%	68	100.00%
Within 25'	1968.60	9.30%	19	27.94%
Within 50'	3407.11	16.09%	26	38.24%
Within 100'	5891.17	27.82%	53	77.94%

Table B.35 Table of utility pole and tree crashes and their nearness to intersections on the Briarcliff Road / North Druid Hills Road corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	13516.80	100.00%	13	100.00%
Within 25'	1372.92	10.16%	4	30.77%
Within 50'	2605.80	19.28%	5	38.46%
Within 100'	4500.68	33.30%	10	76.92%

Table B.36 Table of utility pole and tree crashes and their nearness to intersections on the Candler Road / Flat Shoals Parkway corridor.

	Length (ft)	Percentage of Corridor	Crashes	Percentage of Crashes
Corridor	18532.80	100.00%	11	100.00%
Within 25'	1450.00	7.82%	4	36.36%
Within 50'	2671.76	14.42%	4	36.36%
Within 100'	4977.04	26.86%	5	45.45%

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