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Clear Zone - A synthesis of practice and an evaluation of the benefits of meeting the ten-foot clear zone goal on urban streets

Christian Ryan Sax
Iowa State University

Clear Zone – A synthesis of practice and an evaluation of the benefits of meeting the ten-foot clear zone goal on urban streets

By

Christian Ryan Sax

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Program of Study Committee:
Thomas H. Maze, Major Professor
Reginald R. Souleyrette
Alicia L. Carriquiry

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ABSTRACT

In urban communities, there are often limited amounts of right-of-way available for establishing a large setback distance from the curb for fixed objects. Urban communities must constantly weigh the cost of purchasing additional right-of-way for clear zones against the risk of fixed object crashes. From 2004 to 2006, this type of crash on curbed roads represented 15% of all fatal crashes and 3% of all crashes in the state of Iowa. Many states have kept the current minimum AASHTO recommendations as their minimum clear zone standards; however, other states have decided that these recommendations are insufficient and have increased the required minimum clear zone distance to better suit the judgment of local designers.

This thesis presents research on the effects of the clear zone on urban curbed streets. The research was conducted in two phases. The first phase involved a synthesis of practice that included a literature review and a survey of practices in jurisdictions that have developmental and historical patterns similar to those of Iowa. The second phase involved investigating the benefits of a 10 ft clear zone, which included examining urban corridors in Iowa that meet or do not meet the 10 ft clear zone goal. The results of this study indicate that a consistent fixed object offset results in a reduction in the number of fixed object crashes, a 5 ft clear zone is most effective when the goal is to minimize the number of fixed object crashes, and a 3 ft clear zone is most effective when the goal is to minimize the cost of fixed object crashes.

Key Words: clear zone – clear zone enforcement – fixed object offset – state of practice – urban clear zone

CHAPTER 1. INTRODUCTION

In urban communities, there are often limited amounts of right-of-way available to establish a clear run-out zone. On roadway projects, the clear zone recommended by the administering jurisdiction is sometimes not implemented because of the presence of established buildings, trees, or other fixed objects, any of which would be too difficult or costly to remove. These obstacles present hazards to drivers when the fixed objects are located too close to the roadway to allow drivers to recover when they run off the road. However, the obstacles also provide a protective barrier for pedestrians when a sidewalk is located behind the fixed objects. Moreover, a uniform horizontal distance from the edge line of the road to the fixed object allows drivers to establish an appropriate speed and to focus on the roadway edge, while non-uniform distances do not reinforce this behavior. However, in all cases, fixed object crashes are reduced when fixed objects are located further back from the roadway edge.

Beginning in the 1960s, the American Association of State Highway and Transportation Officials (AASHTO) began creating clear zone standards. However, these standards co-developed with state and local standards, resulting in inconsistent clear zone standards for the location of fixed objects on urban curbed roads.

If the AASHTO guidance alone were to be used in defining the clear zone limits on an urban roadway reconstruction or improvement project, the design engineer would have to weigh the costs of clearing aboveground utilities, buildings, walls, and other fixed objects back from the roadway against the benefits of having additional space for an errant vehicle to recover (above 18 in.). Naturally, because every situation in unique, the design engineer and design reviewers must make trade-offs between the construction costs and the benefits of making a decision that has unique circumstances. For each situation, the costs of providing additional clear zone (removing fixed objects) can be estimated, but the associated safety benefits of clearing 10 ft back from the curb or some distance less than 10 ft are unclear. In some cases, providing wider clear zones may even be counter to traffic calming treatments or context-sensitive design concepts.

Most design engineers understand that providing a clear zone of 10 ft or more away from the edge of the road is an acceptable practice in most urban situations. However, exceptions to the 10 ft goal might include traffic calming treatments and context-sensitive solutions. More design guidance is needed to understand when it is practical and cost-effective to provide less than 10 ft of clear zone. Furthermore, urban roadway design engineers and municipal engineers need some assurance that their design will be approved when they consider all engineering criteria. It is not practical, in all situations, for designers to provide 10 ft of clear zone distance in order for their project will be positively reviewed by the Iowa Department of Transportation (Iowa DOT). In some cases, engineers from local agencies have reported that the costs associated with creating a 10 ft clear zone has become a "project buster" for some safety improvement projects.

According to computations based on the Iowa DOT crash database, fixed object collisions on urban curbed roads constitute approximately 3% of all crashes in Iowa. Crash severities for fixed object collisions are similar to those for crashes overall. However, fixed object collisions make up 15% of fatal urban crashes, while only 6% of urban crashes are fixed object crashes. This suggests that there is a tendency for fixed object crashes to be more severe than other urban crash types. Table 1-1 compares the number of total crashes, urban crashes, and urban fixed object crashes in Iowa from 2004 to 2006.

Table 1-1. Iowa crashes, average annual crashes from 2004 to 2006

	Fatal	Major Injury	Minor Injury	Possible	Property Damage Only	Total
Total Crashes	380	1,643	5,498	10,263	39,756	57,540
Urban Crashes*	66	584	2,649	6,429	22,797	32,525
Urban Fixed Object Crashes	10	51	186	357	1,240	1,844
% of all Crashes	3%	3%	3%	3%	3%	3%
% of all Urban Crashes	15%	9%	7%	6%	5%	6%

*Urban crashes are those crashes that take place on curbed roads.

The crash rate of urban fixed object collisions decreases as the average annual daily traffic (AADT) increases, as illustrated in Table 1-2. Table 1-2 also shows that the crash density increases due to higher traffic.

Table 1-2. Iowa crashes, average annual crash exposure from 2004 to 2006

AADT	Total Segment Length	Total Annual VMT	Fixed Object Crashes	Crash Rate	Crash Density
0-1000	6,404	1,061,400,804	687	65	0.1
1000-5000	1,888	1,642,203,339	576	35	0.3
5000-15000	826	2,597,116,710	506	19	0.6
15000-30000	190	1,399,106,889	212	15	1.1
Above 30000	12	217,911,539	36	17	3.0

The present thesis seeks to increase the level of knowledge regarding the benefits and drawbacks associated with the urban roadway clear zone width goal of 10 ft. The research for this thesis was conducted in two phases. The first phase included a synthesis of practice through a literature review and a survey of practices in jurisdictions with development and historical patterns similar to those of Iowa. The second phase investigated the benefits of a 10 ft clear zone by examining urban corridors in Iowa that meet or do not meet the 10 ft clear zone goal.

CHAPTER 2. LITERATURE REVIEW

2.1. Introduction

The 2004 AASHTO publication *A Policy on Geometric Design of Highways and Streets, 5th Edition* (i.e., "The Green Book") defines a clear zone as "the unobstructed, relatively flat area provided beyond the edge of the traveled way for the recovery of errant vehicles. The clear zone includes any shoulders or auxiliary lanes" (AASHTO 2004). This definition does not provide a specific clear zone width, but only provides guidance on absolute recommended minimum clear zone dimensions. Therefore, jurisdictions have different interpretations of the distance it takes for an errant vehicle to recover.

The concept of a roadside clear zone had emerged in a 1967 AASHTO report that was referred to as the "Yellow Book." The report stated, "For adequate safety, it is desirable to provide an unencumbered recovery area up to 30 ft from the edge of the traveled way; studies have shown that 80 percent of the vehicles in run-off-road accidents did not travel beyond this limit" (AASHTO 1967).

AASHTO further emphasized the clear zone in its 1977 *Guide for Selecting, Locating, and Designing Traffic Barriers*, or the barrier guide. The guide presents the results of a large amount of research and was the first publication to outline the specific criteria used to select the appropriate safety treatments within the clear zone (AASHTO 1977). The barrier guide was the first guide to provide tables, charts, formulas, and example calculations to roadway designers who were concerned about obstacles adjacent to the roadway. The guide was certain to acknowledge that its guidance should only be applied with the engineers' judgment and was not an absolute answer to fixed objects adjacent to the roadway.

The emphasis on safety increased when AASHTO published its first version of "The Green Book" in 1984. "The Green Book" dedicated several portions to the clear zone and identified lateral clearances for various obstacles. These clearances varied based on roadway type, speed, slope, and average daily traffic (ADT) (AASHTO 1984).

The latest national guidance has been given by the AASHTO *Roadside Design Guide*, published in 2006. This guide continues with the variable width clear zone based on roadway type, speed, slope, and traffic patterns. The guide also provides an approximate distance to the center of a range of clear zone distances that can be used in a given design. This guide acknowledges that the provided distances are not exact and that engineering judgment should be used when determining the clear zone width (AASHTO 2006).

2.2. Description of Current Standards

Many organizations have developed independent concepts and definitions of the clear zone and various standards for different types of obstacles in the clear zone. When new concepts of the clear zone emerged and evolved, the guidance changed rapidly and interpretation of design guidance varied by jurisdiction, resulting in jurisdictions with conflicting standards.

The 2006 AASHTO *Roadside Design Guide* breaks required clear zone distances into groups based on design speed, design ADT, and the slope of the fill or cut adjacent to the roadway. Fill and cut slopes adjacent to the roadway require different clear zones because gravity affects the distance a vehicle traverses after it leaves the roadway. The design speed determines how severe a crash could potentially be, and ADT is used to determine whether the roadway has enough traffic to warrant spending the funds to meet a higher standard of clear zone distance.

A review of all four AASHTO publications, from 1967 to 2006, shows a number of inconsistencies in how clear zone is defined. There are four basic consistency questions raised that should be addressed. These include the precise technical definition of clear zone, whether the presence of curbs by definition precludes clear zone requirements, the publication of specific dimensional guidance for clear zones, and the relationship of the term clear to “horizontal clearance” (Neuman et al. 2004).

Due to the lack of national uniform guidelines for clear zone requirements, many states have taken the initiative to reinforce and expand the guidance given by AASHTO (i.e., making stricter clear zone requirements). This has resulted in differing design standards in many states. Table 2-1 shows the distribution of 32 state standards that were reviewed for this research. Many of the states reviewed have kept the current minimum AASHTO recommendation of 1.5 ft (AASHTO 2006) as their minimum standard. However, other states decided that these recommendations were insufficient and have increased the required minimum clear zone distance to fit the judgment of local designers.

Table 2-1. State minimum clear zone distances on curbed roads (ft)

1.5 ft (AASHTO) (13 states)

- California Department of Transportation (Caltrans). *Highway Design Manual*. [page 300-322]
- Colorado Department of Transportation. Design Guide 2005 [4.5, page 4-12]
- Connecticut Department of Transportation. Highway Design Manual [page 5]
- Florida Department of Transportation. Deign Manual [page 3-69]
- Illinois Department of Transportation. Illinois DOT Bureau of Local Roads & Streets Manual – 2005 Edition [page 23]
- Indiana Department of Transportation. The Indiana Design Manual [49-2.03(05)]
- Minnesota Department of Transportation. Minnesota Road Design Manual. [4-6.05]
- North Dakota Department of Transportation. A policy for Accommodation of Utilities on State Highway Right-of-Way. [page 7]
- Ohio Department of Transportation. Location and Design Manual. [page 6-3]
- City of Rapid City, SD. Design Standards. [page 4]
- Tennessee Department of Transportation. Roadway Design Guidelines. [1-310.35]
- Texas Department of Transportation. Roadway Design Manual. [page 2-54]
- Utah Department of Transportation. Roadway Design Manual of Instruction. May 2007 [page 85]

1.5–5 ft (13 states)

- Arkansas State Highway Commission. *Utility Accommodation Policy*. Arkansas State Highway and Transportation Department. [401.3]
- City of Tampa. Technical Standards for Transportation [page 23]
- Iowa Department of Transportation. Iowa DOT: Office of Design Manual [page 5]
- City of Lexington, Kentucky Lexington: Street Tree Selection and Care. [page 2]
- Kansas City Missouri. Supplement to Design Criteria, Section 5200 streets [page 6]
- City of Springfield, MO. Design Standards for Public Improvements.
- Nebraska Department of Roads. Roadway Design Manual. [page 1-4]
- City of Lincoln, NE. Design Standards. [page 12]
- City of Cincinnati, OH. Street Restoration Book. [II-C]
- South Dakota Department of Transportation. Road Design Manual. [page 10-5]
- City of Sioux Fall, SD. Engineering Design Standards. [Figure 4.1-6]
- City of Nashville, TN. Downtown Streetscape Elements Design Guidelines. [page 52]
- Wisconsin Department of Transportation. Facilities Development Manual [page 16]

5.0–10 ft (5 states)

- Los Angeles Bureau of Engineering [E222.111]
- Massachusetts Department of Transportation. Massachusetts DOT [Exhibit 5-19]
- City of Ann Arbor Public Services Department Standard Specifications. 1992. [Drawing No. SD-GU-1]
- Oregon Department of Transportation. Highway Design Manual. [Table 5-9]
- Washington Department of Transportation. Design Manual. [Figure 700-1]

10 + ft (1 state)

- Michigan Department of Transportation. Road Design Manual [9.03.01]

Turner et al. (1989) attributes the variation of clear zone requirement to the reasons listed below and notes that these variations have caused some states to be slow to establish minimum guidelines:

1. Cost. Clear zone projects must compete for funding with other highway projects and functions. Thus, some agencies initially viewed the clear zone as a diversion of sorely needed funds that could be better used for construction or maintenance.
2. Development on several fronts. The clear zone premise is not contained in a single book or document. Many agencies, organizations, and committees simultaneously contributed to development of the concept, which has resulted in multiple guidelines.
3. Constant change in standards. During the approximately 40 years of experience with the clear zone, safety research has caused improvements in the understanding of fixed object crashes and in ways to minimize their effects. Legal issues have raised additional concerns and, consequently, the policies have been modified several times.
4. No detailed criteria. Even though many documents contain clear zone guidance, few contain specific numerical criteria. Instead of a table of dimensions for various situations, the documents require the user to have a full understanding of the clear zone concept, use a series of references, perform a series of calculations, and exercise good judgment. This lack of detailed criteria discourages individuals from mastering and using the concept.
5. Existing facilities. One of the major points of resistance to clear zones has been that there are hundreds of thousands of miles of roadways containing existing objects that are not in compliance with clear zone criteria. State transportation agencies and utility owners have been slow to embrace a concept that would drain their funds to perform corrective work on existing facilities. Although many guidelines provide some distinctions between existing and new work, there is no universal principle that allows existing facilities to meet a lower standard than new ones.
6. Right-of-way already crowded. Some of the most difficult clear zone problems occur in urban or suburban areas where the roads are old and many utilities are already in place. The clear zone criteria do not seem to fit these sites because there is too little right-of-way and simply no location left for new utilities.
7. Liability. Clear zone law is emerging on a case-by-case basis. The opinions of the courts are sometimes confusing and contradictory, further complicating the issue and making it more difficult for transportation agencies and utility companies.

The State of Iowa began using clear zone standards when the 1988 AASHTO *Roadside Design Guide* was published (AASHTO 1988). Designers used tables and figures as a general basis and then made adjustments to the suggested values based on experience and site conditions. The state’s current goal is to maintain a 3 ft minimum clear zone in urban areas. The optimum clear zone is 10 ft, with 6 ft being dedicated to a sidewalk and 6 ft for snow storage.

2.3. Controlling the Clear Zone Standards

The Federal Highway Administration (FHWA) answered whether the clear zone is a controlling criterion in a document by Obenberger (2007) titled "Clear Zone and Horizontal Clearance Frequently Asked Questions.". Obenberger stated that the controlling criteria of the National Highway System (NHS**)** design standards include 13 items or elements that require a formal design exception when the adopted minimum value is not met on a project. The list of controlling criteria was developed to ensure that deviations less than the adopted value for a critical element were adequately considered in the design of a project. When the original list was developed in 1985, "clear zone" was considered to be synonymous with "horizontal clearance." Subsequently, in 1990, following adoption of AASHTO's *Roadside Design Guide*, it was decided that clear zone width would no longer be considered as an element requiring a formal design exception. In the rulemaking to adopt the *Roadside Design Guide*, it was defined that a clear zone width should not be controlled by a fixed, nationally applicable value. The various numbers in the guide associated with "clear zone" are not considered to be exact distances but rather ranges of values within which judgment should be exercised to make design decisions. Fixed objects or terrain features that fall within the appropriate clear zone are typically shielded, so a design exception is not needed.

The FHWA believes that a consistent design approach, guided by past crash history and an analysis of cost-effectiveness, is the most responsible method for determining the appropriate clear zone width for a roadway. While these are not controlling criteria for the purpose of applying "The Green Book" to the NHS, an exception to a clear zone for a project does need to be noted, approved, and documented in the same manner as exceptions to other non-controlling criteria when the established value is not met. The FHWA recommends that documentation be included in project meetings notes or by other appropriate means.

2.4. The Relationship between Clear Zone Distance and Collisions

A study conducted by Turner and Barnett (1989) investigated the effect of utility poles located in the urban clear zone. This study conducted field investigations at the site of 385 pole collisions. The collision data revealed that about 90% of the accidents occurred within 10 ft of the pavement edge. Within this range, the relationship between accident frequency and offset distance was linear (Turner and Barnett 1989).

Although the study found a relationship between collisions and offset distance, it did not look into the effects of other objects along the side of the road, such as buildings, trees, or parked cars. While the recommendations from the study offer effective methods for the placement of poles and signs, those principles cannot be directly applied to other obstacles in the clear zone.

While there is no single strategy to meet minimum lateral clearance distances, Turner and Barnett made recommendations about how the design engineer can effectively reduce the number of hazardous poles in the clear zone. These recommendations are as follows:

- In general, utility poles are to be placed to the maximum extent practical at the outer limits of the right-of-way (or additional utility easement)
- Where insufficient right-of-way is available, an engineering analysis should determine whether purchase of additional easement is the best course of action.
- Distribution lines would be best placed in an underground conduit in new developments. Ancillary aboveground equipment should be constructed in compliance with lateral clearances for utilities.
- Where constructing underground distribution lines is impractical or cost-prohibitive (e.g., due to the cost of rock excavation), poles are to be located in the rear of the building lot wherever possible. This may call for the creation of a dedicated utility easement.
- Where overhead lines must be located along the front of the lot, it is desirable to place them at least 10 ft behind the curb.
- Where utility poles are to be installed along curved sections (including 200 ft of tangent section adjacent to each end on the outside of horizontal curves) or on roadways that have open drainage systems, consideration should be given to locating poles along the inside of the curve, unless the poles can be placed outside a non-traversable ditch section on the outside of the curve.

Although these guidelines can be followed and may result in a reduced number of crashes, Turner and Barnett did not identify the severity or the frequency of crashes that would be avoided, and hence did not identify the safety benefits of following their guidance. Thus, design engineers can exactly calculate the cost of removing utility poles from the edge of the roadway, but they have no measure of the benefits resulting from the relocation expenditure.

2.5. Relationship between Run-off-the-Road Crashes and Turning Movements

Dumbaugh (2005) investigated the relationship between run-off-the-road crashes and turning movements. He noted that urban roadside crashes appear to be strongly associated with vehicle turning movements, an association not currently considered in roadside design practice. The current standards focus on the assumption that the farther an object is placed from the edge of the roadway, the greater the safety. There are no current standards that address the safety hazard posed by objects placed in the potential run-off-the-road areas at the intersection of a main arterial and a side road.

Dumbaugh found that between 65% and 83% of all fixed objects involved in roadside crashes are located behind a driveway or intersection, not at random locations along the roadway. Dumbaugh suggests that the current approach assumes that the farther a roadside object is set from the traveled way, the lower the probability of a fixed object crash. However, the roadside object most likely to be involved in a roadside crash is often not that which is closest to the traveled way, but that which is located behind a driveway or intersection. The result of using forgiving design values is that drivers will travel at a speed that limits their ability to respond to the vehicle and pedestrian hazards that naturally occur in these environments. Dumbaugh claims that "Under design conditions where land access is a major function of a roadway, or where there are frequent driveways and intersections, lower-speed and less-forgiving designs can substantially enhance a roadway's safety" (Dumbaugh 2005).

2.6. Relationship between Landscape Improvements and Midblock Crashes

The findings from a pilot study conducted by Naderi (2003) indicate that a positive correlation exists between the landscape improvements along the roadside and a reduction in midblock accidents. These landscape improvements include raised concrete planters, shrubs, decorative lights, decorative paving, decorative noise barriers, sculptures, and trees, as shown in Figure 2-1. While nearly all of the tree planting and landscape improvements occurred within the clear zone, midblock accidents decreased from between 5% to 20%. The data generated from these case studies indicates that there may be a positive effect of having a well-defined edge, which may result in an overall decrease in run-off-the-road collisions with objects. The street tree may define the edge of the road space by providing a diverse visual edge that also is repetitively simple in color, texture, and form (Naderi et al. 2008). According to Berlyne (1971), optimum levels of complexity that maximize attentiveness fall within this mean: a visual landscape that is diverse but not overwhelmingly so, and a landscape that is simple but not boring. It should be noted that design standards that incorporate the safety benefit of street trees on drivers and other roadway users must be performance-based and tested (Naderi et al. 2008).

Figure 2-1. Landscape improvements

Dumbaugh (2005) analyzed the relationship between run-off-the-road crash severity and urban clear zone usage. The results show a paradigm shifting relationship between clear zone distance and safety. According to the study, a smaller clear zone can actually increase safety on an urban roadway.

Dumbaugh defines livable street treatments as wide sidewalks, lawn ornaments close to the edge of the roadway, a narrow clear zone, and trees between the sidewalk and the roadway. The author found that the places where these treatments were used experienced a reduced probability of roadside crashes and an increase in the roadway's safety performance.

Widening shoulders, increasing clear zones, and adding livable street treatments were also found to dramatically reduce midblock, multiple-vehicle, and pedestrian crashes and injuries. Neither a roadway's fixed object offset nor the provision of a paved shoulder was found to meaningfully enhance a roadway's safety performance in Dumbaugh's 2005 study. Lynch (1960) had theorized that a distinct roadway edge contributes to the legibility of the city, engendering a feeling of familiarity and comfort. The resultant comfort and reduction in stress could have a positive effect on drivers (Lynch 1960).

A survey done by Naderi et al. (2008) indicated that people perceived suburban streets with trees as the safest streets and urban streets without trees as the least safe streets. In terms of edge definition, suburban streets with trees were perceived as the streets with the most defined edges; urban streets with no trees were perceived as the streets with the least defined edges. For the suburban landscape, the presence of trees significantly dropped the cruising speed of drivers by an average of 3.02 mph. Faster drivers and slower drivers both drove more slowly with the presence of trees. Thus, Naderi et al. (2008) concluded that increases in drivers' perception of safety had a significant relationship to increases in drivers' perception of the roadway edge. The addition of curbside trees significantly increased driver perception of spatial edge.

Two issues emerge with regard to trees and the guidelines. First, transportation designers may fail to heed the flexibility implied and framed by the Green Book and implement recommendations (and local derivations) as "standards." Transportation officials are encouraged to mitigate the effects of environmental impacts using "thoughtful design processes” because standards have been “less rigorously derived” for urban settings (AASHTO 2004). Second, most geometric design criteria apply to high-speed and rural roads, so their use in urban areas may be inappropriate. Engineers often take a conservative approach, where the engineer chooses to use a larger clear zone distance to increase safety rather than consider that using a smaller clear zone distance could achieve the same outcome (Wolf and Bratton 2006).

2.7. The Effect of a Consistent Clear Zone

An increase in consistent clear zone requirements in an urban area could reduce the number of severe crashes. Evidence follows intuitive thinking that the consistency of the clear zone could be more important for safety then the minimum offset distance. For example, if most objects are 10 ft from the roadway but one tree is only 4 ft from the roadway, that one tree is going to be the cause of a severe accident. This idea can also be applied to corridors where the clear zone distance may change from “X” ft to “Y” ft. At the location of the change in clear zone distance, there is a higher likelihood that a severe accident will occur.

The consistent application of clear zone guidance could address some of the factors that relate to causing a run-off-the-road crash. The following are some of the reasons a vehicle may leave the pavement and encroach on the roadside (Dumbaugh 2005):

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

CHAPTER 3. STATE SYNTHESIS

3.1. Introduction

To evaluate the administration of clear zones within various states, a survey was sent to 20 state agencies. The survey included six questions regarding federal aid projects and six questions regarding state aid projects. The survey is included in Appendix A. The individuals representing the state agencies were also asked to provide additional contacts at the local level who could be interviewed about design exception practices within the jurisdiction. A summary of each state's response to the survey is included in Appendix B.

3.2. Summary of State Synthesis

The 20 states surveyed and the personnel interviewed provided many different standards that they currently use. These standards ranged from a minimum clearance of 1 ft to 35 ft. These differing standards suggest that there is no universal standard that neither is nor should be applied to every urban community.

The State of Iowa's clear zone standards require a generous amount of setback in comparison to many of the states surveyed for this project. Many of the states surveyed had desirable setbacks requirement similar to Iowa's minimum. Of those states that had a desirable setback requirement similar to Iowa's minimum, many had a minimum requirement of only 1.5 ft from the face of curb.

CHAPTER 4. DATA COLLECTION

4.1. Introduction

To conduct the evaluation of the significance of the clear zone, a project database was created. The project database included 11 corridors in the Des Moines metropolitan area and two corridors in the Waterloo/Cedar Falls area. At each of the corridor sites, the lateral offset distance to each fixed object in the right-of-way was measured from the face of the curb using a laser distance meter. The location of each object was also collected using a global positioning system (GPS) device.

4.2. Selection of Corridors

Corridors in Des Moines were recommended by the City of Des Moines city engineer. The corridors in Waterloo were recommended by the City of Waterloo city engineer. The 11 corridors used for evaluation in the Des Moines area are listed in Table 4-1 and shown in Figures 4-1 and 4-3. The two corridors used for evaluation in the Waterloo area are listed in Table 4-2 and shown in Figures 4-2 and 4-4.

Table 4-1. List of Des Moines corridors

Road Name	Begin	End
2nd Avenue	Aurora Avenue	University Avenue
Army Post Road	SW 14th Street	SE 14th Street
Beaver Avenue	Aurora Avenue	Urbandale Avenue
East University Avenue	East 30th Street	Winegardner Road
East University Avenue	East 6th Street	East 17th Court
Euclid Avenue	Martin Luther King Jr Parkway	6th Avenue
Hubbell Avenue	East Tiffin Avenue	East Euclid Avenue
Merle Hay Road	Meredith Drive	Hickman Road
NE 14th	NE 44th Avenue	East University Avenue
SW 9th Street	SW 14th Street	SE 14th Street
University Avenue	63rd Street	42nd Street

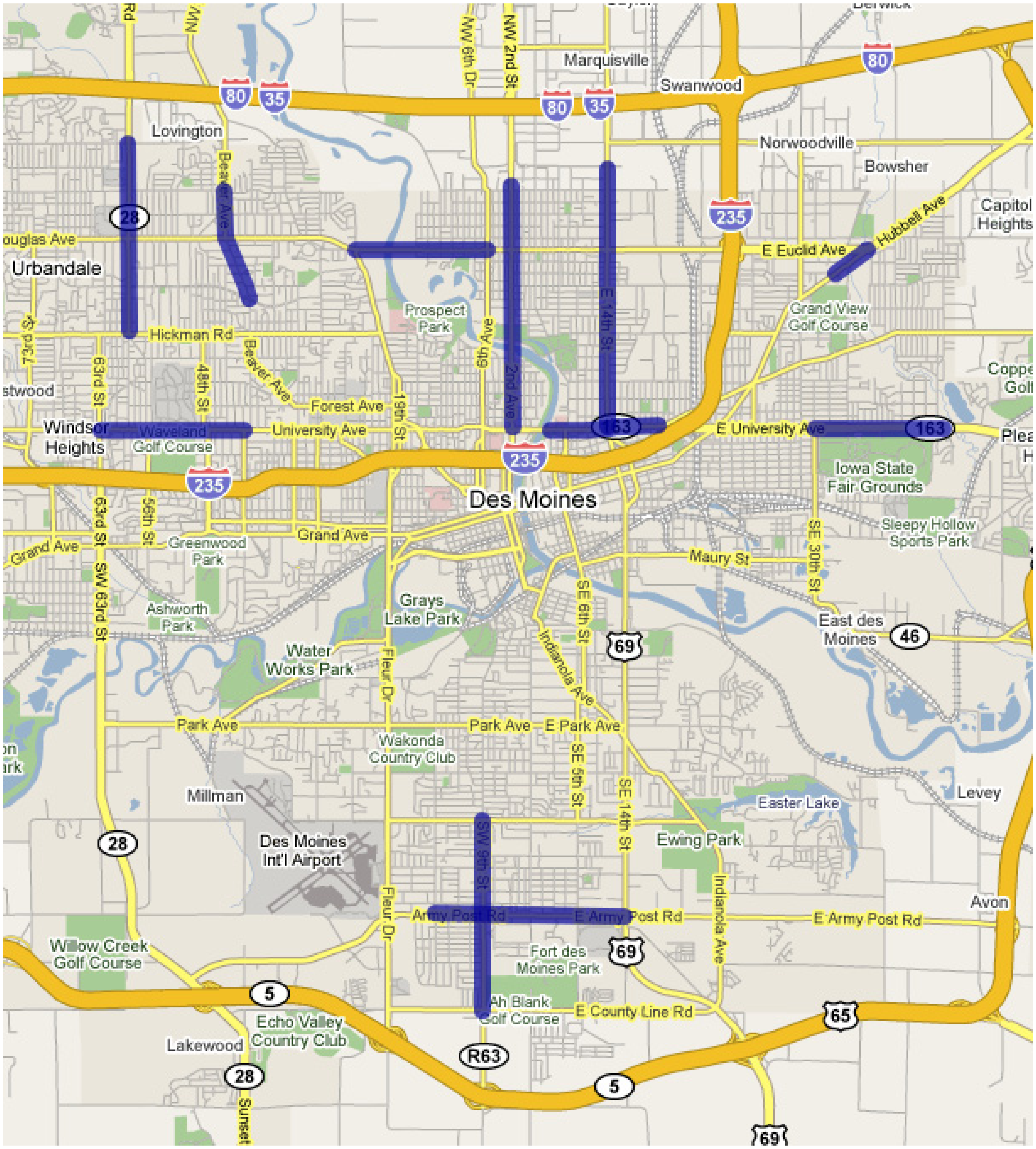

Figure 4-1. Map of Des Moines corridors

Table 4-2. List of Waterloo corridors

Road Name	Begin	End
Williston Ave	Kimball Ave	Washington St
East 4th St	Newell St	Franklin St

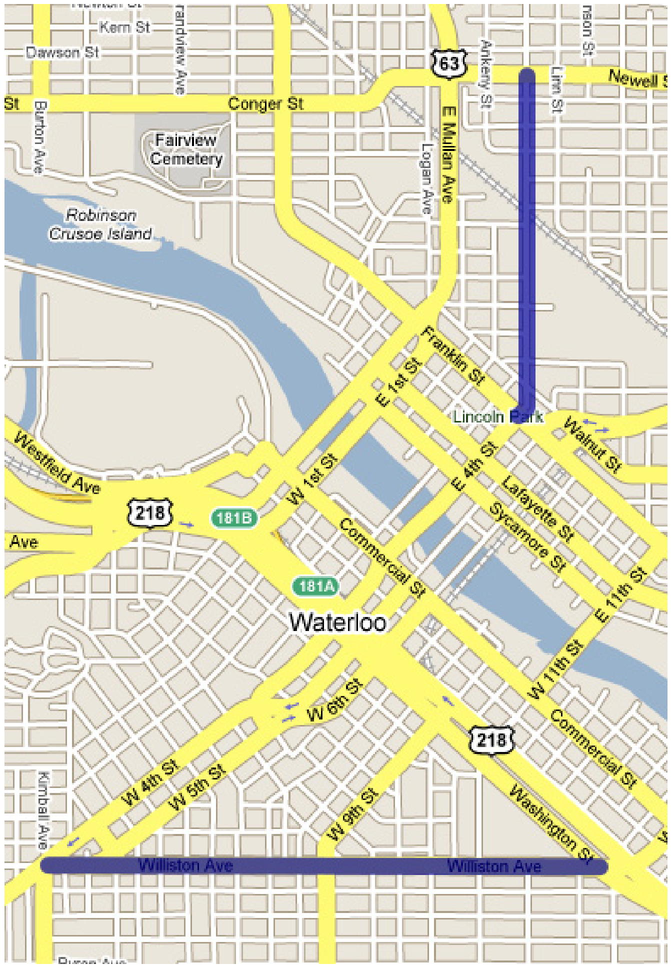

Figure 4-2. Map of Waterloo corridors

Figure 4-3. University Avenue in Des Moines, Iowa

Figure 4-4. East 4th Street in Waterloo, Iowa

4.3. Physical Characteristics Collected

It was determined that six physical characteristics would be recorded for each fixed object along each corridor. Those characteristics included location, fixed object type, setback distance from the face of the curb, roadway name, roadway speed limit, and side of roadway.

4.4. Surveying Strategy

The six characteristics listed above were to be recorded into a Hewlett Packard (HP) handheld computer (Figure 4-3) running ESRI ArcMap software. The information was recorded by two researchers driving the corridor and stopping at each fixed object. When stopped, one researcher determined the latitude and longitude by using an I-Blue wireless GPS receiver (Figure 4-5), linked via Bluetooth to the HP handheld computer. The other researcher used a DISTO classic 5 laser distance meter (Figure 4-4) to measure the distance from the face of the curb to the face of the fixed object. The first researcher typed the characteristics associated with the fixed object into the HP handheld computer, and then the researchers drove to the next fixed object.

Figure 4-3. HP handheld computer

Figure 4-4. DISTO Classic 5 laser distance meter

Figure 4-5. I-Blue wireless GPS receiver

4.5. Data Compilation

After the physical characteristics of each fixed object were collected, the characteristics were compiled into a geographic information system (GIS) program called ArcView GIS 3.3. The objects on each roadway were divided into three types of sections: segments, blocks, and 15 m sections. The corridors were divided in this fashion to evaluate the significance of the fixed object attributes based on three different measurements of the linear length of the roadway.

4.5.1. Fixed Object Crashes

Fixed object crashes from the years 2001 to 2006 were extracted from the Iowa DOT's crash database. The Iowa DOT's geographic information management system (GIMS) contains a data set of centerlines for public roads, including interstates, U.S. and state highways, county roads, city streets, park roads, and institutional roads (Iowa DOT 2008a). The roads in this database have been digitized from the Iowa DOT's GIMS database and updated through construction and maintenance updates and field inventories. Construction and maintenance updates are performed annually, and data for county roads is collected and inventoried using field inspections for all 99 Iowa counties performed within the previous year. Road data is inventoried and collected from field inspections for city streets, park roads, and institutional roads on a four-year cycle.

The crashes used in this study are from the crash database maintained by the Iowa DOT. The locations of the crashes used for this study are those that have been documented in the crash database to have occurred within 50 m of a curbed roadway. Each fixed object crash used in this research has been documented in the crash database as a crash in which the first harmful event is the collision with the fixed object and in which the collision is with a bridge/bridge rail/overpass, underpass/structure support, culvert, ditch/embankment, curb/island/raised median, guardrail, concrete barrier, tree, pole, sign post, mailbox, impact attenuator, or other fixed object.

Segments were created for this study by analyzing the entire corridor and breaking it into lengths that were several blocks long and that shared similar characteristics, such as a residential area, commercial area, or industrial area. Even though some of these segments had a large variation in the given fixed object offset, it was important to be able to analyze relatively longer lengths of roadway to evaluate the significance of the fixed object setback. Each of the segments received a segment identification number to be used in the project database.

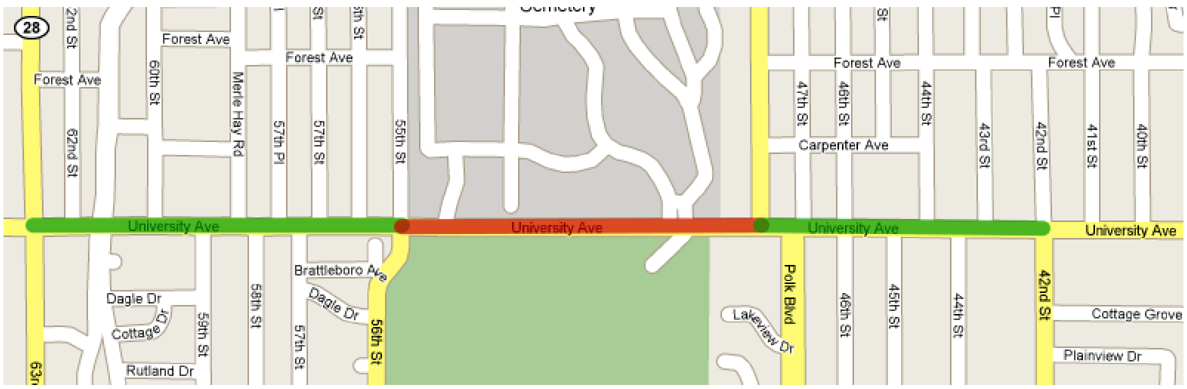

Figure 4-6. Division of corridors into segments

Blocks were created by breaking the entire corridor into individual blocks. Blocks were considered to be an important distance to analyze because it was considered to be highly likely that the roadway characteristics would be consistent over the length of a block. Each of the blocks received a block identification number to be used in the project database.

The 15 m sections were created by segmenting the entire corridor into 15 m long sections, as measured by the centerline of the roadway. The 15 m sections are important because the fixed object setback is most likely to be the most consistent over a short distance, such as 15 m. Each of the 15 m sections received a section identification number to be used in the project database.

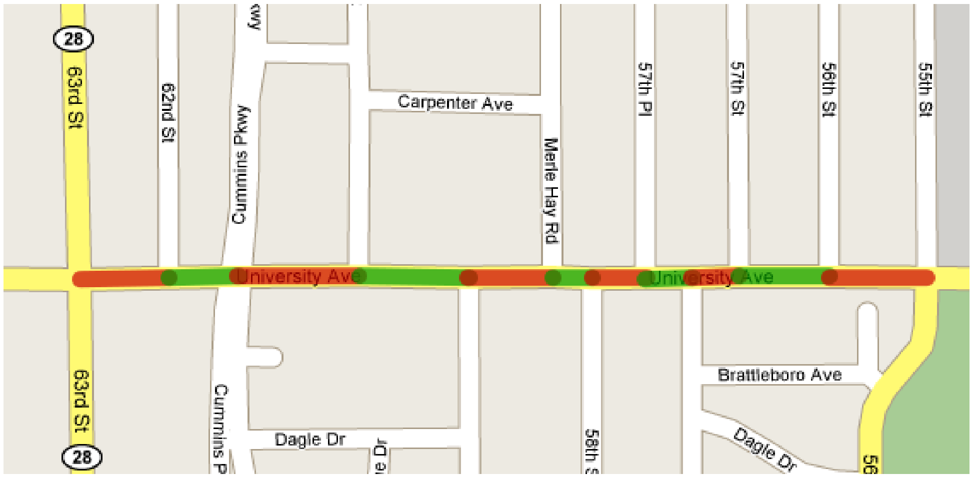

Figure 4-7. Division of corridors into blocks

Figure 4-8. Division of corridor into 15 m sections

4.6. Data Sets

The segment data set includes 43 segments. For each of the segments, the following information was recorded:

- Setback distance (minimum setback, average setback, and 15th percentile setback)
- Area of influence violations (for 2, 3, 4, 5, 6, 7, 8, 9, and 10 ft areas of influence and the average setback area of influence)
- Speed limit

- Length of segment
- Number of fixed objects
- Density of fixed objects
- ADT
- Number of fixed object crashes per year (from 2001 to 2006)
- Average crashes per year
- The severity of each crash per year (fatalities, major injuries, minor injuries, possible injuries, unknown injuries, and property damage amount)
- The average severity of crashes per year

The block data set includes 226 sections. The block spreadsheet includes the same columns as the segment spreadsheet, and the same information was recorded.

The 15 m data set includes 2,140 sections. The 15 m spreadsheet includes the same columns as the segment and block spreadsheets, but with one exception. In the segment and block spreadsheets, the violation column includes a count of the number of times the area of influence is violated. In the 15 m spreadsheet, the violation column includes a "1" if there are any violations of the area of influence and a "0" if there are no violations of the area of influence.

CHAPTER 5. ANALYSIS

5.1. Introduction

A descriptive analysis was completed to evaluate the significance of the clear zone distance. The predictors included minimum setback, average setback, 15th percentile setback (the offset distance that 85% of fixed objects are behind), intersection area of influence, violations to the area of influence, speed limit, and fixed object density. Three additional analyses were completed to measure the optimal clear zone distance: cumulative percent crashes, cumulative percent cost, and an economic analysis that evaluated the dollar benefit of increasing the fixed object setback by an incremental amount. The three measurements—minimum setback, average setback, and 15th percentile setback—were used as a proxy for the consistency of the fixed object setback for the length of a section. While these three predictors were used in each analysis, the minimum setback measurement was determined to be the most useful because it is the most accurate measurement of the clear zone. The example roadway section in Figure 5-1 has a minimum clear zone of 2 ft, an average clear zone of 4.1 ft, and a 15th percentile clear zone of 2 ft.

To assess the significance of the clear zone distance, these three predictors were evaluated over three different lengths of linear sections, including segments, blocks, and 15 m lengths. The segments are of varying linear distances, which range from a few blocks to a mile in length, depending on roadway characteristics. The blocks are the linear distance of the particular street block. The 15 m lengths are 15 m long sections as measured along the centerline of the roadway. The segment measurement was determined to be the most useful because the driver is able to adjust to the driving conditions of the longer length of roadway.

5.2. Minimum Setback

The minimum setback is defined as the setback distance of the object that is closest to the face of the curb over the length of the section. In summary, only in the segment analysis did an increase in the minimum setback affect the number of fixed object crashes; the block and 15 m analyses showed no relation between these variables.

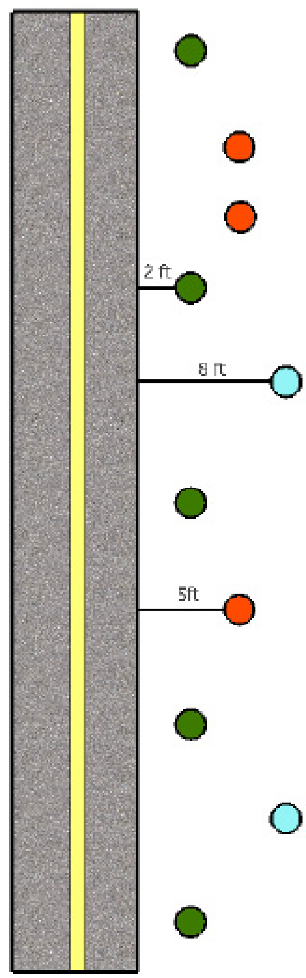

Figure 5-1. Example roadway section

5.2.1. Segment Analysis

In the segment analysis, the minimum setback showed a relationship to the average number of fixed object crashes. Figure 5-2 illustrates the average number of crashes per year in relation to the minimum setback. This figure shows that as the minimum setback is increased, the average number of fixed object crashes per year decreases.

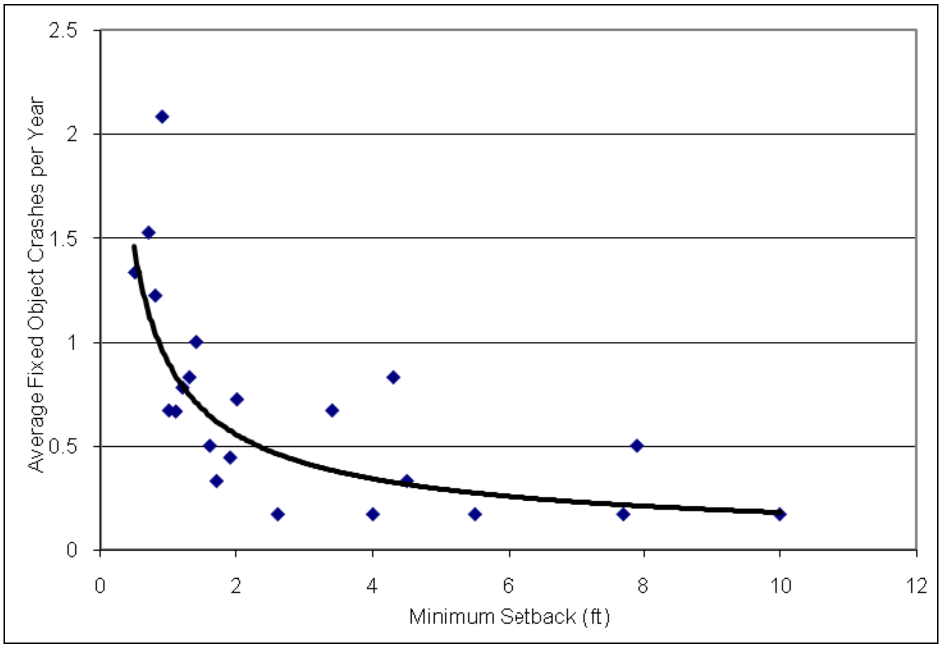

Figure 5-2. Minimum setback in segment analysis

5.2.2. Block Analysis

In the block analysis, the minimum setback did not show a relationship to the average number of fixed object crashes. Figure 5-3 illustrates the average number of crashes per year in relation to the minimum setback. This figure shows that as the minimum setback is increased, the average number of fixed object crashes per year is not affected. This indicates that the minimum setback is not a significant factor to be taken into account when designing the roadside placement of fixed objects.

5.2.3. 15 m Analysis

In the 15 m analysis, the minimum setback did not show a relationship to the average number of fixed object crashes. Figure 5-4 illustrates the average number of crashes per year in relation to the minimum setback. This figure shows that as the minimum setback is increased, the average number of fixed object crashes per year is not affected. As with the block analysis, the minimum setback is not a significant factor to be taken into account when designing the roadside placement of fixed objects.

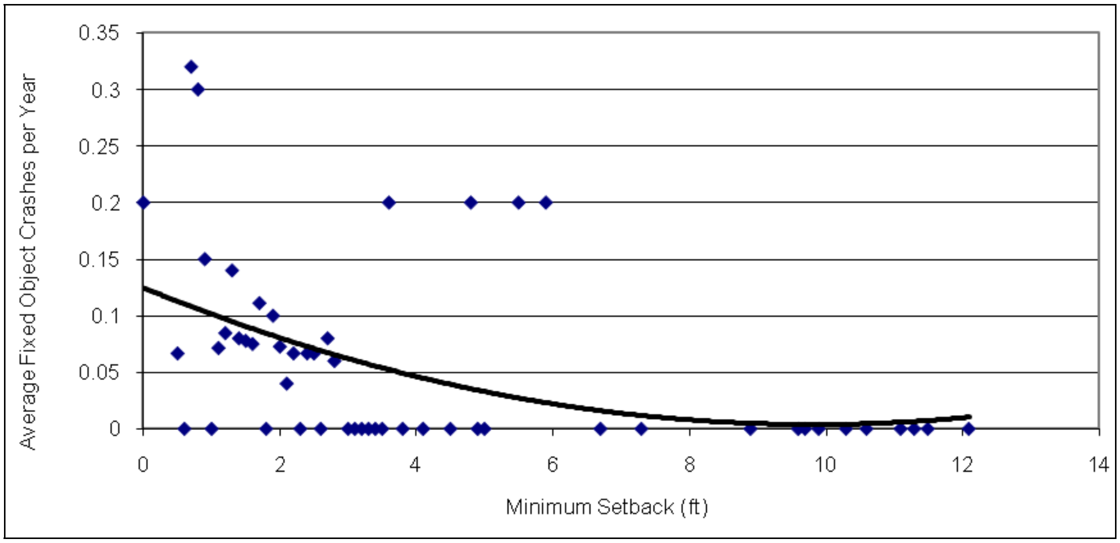

Figure 5-3. Minimum setback in block analysis

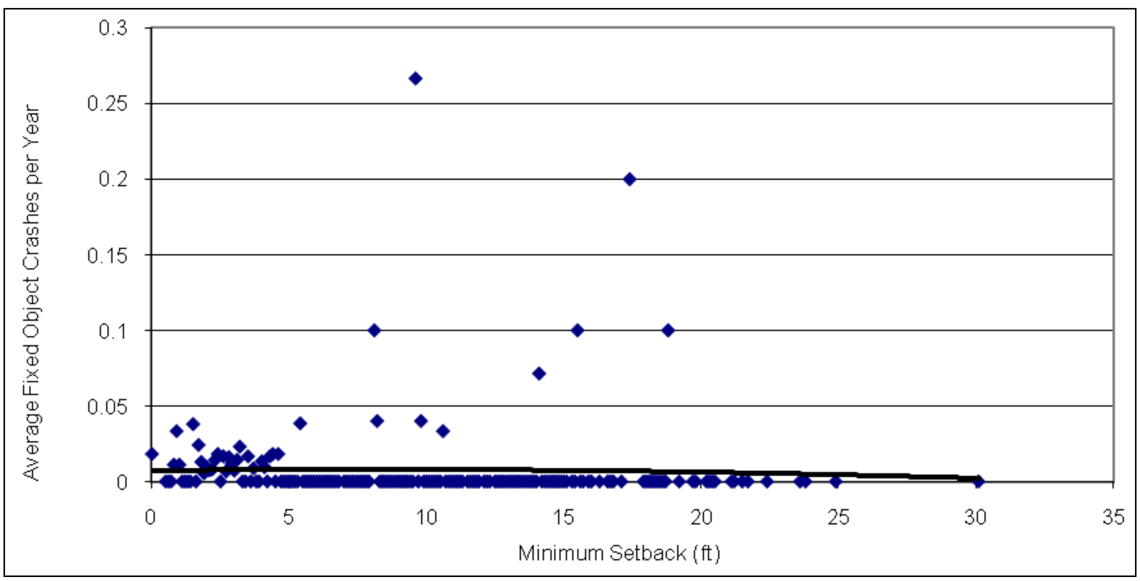

Figure 5-4. Minimum setback in 15 m analysis

5.3. Average Setback

The average setback is defined as the average distance between the face of the curb and all the fixed objects in the segment. As shown in Figures 5-5 through 5-7, the average width of the clear zone does not have any quantifiable impact on the number of fixed object crashes that may occur.

5.3.1. Segment Analysis

In the segment analysis, the average setback did not show a relationship to the average number of fixed object crashes. Figure 5-5 illustrates the average number of crashes per year in relation to the average setback. This figure does not show any significant relationship between the average setback and the average number of fixed object crashes per year. This conclusion is similar to the conclusions of the minimum setback analyses: that the setback distance does not affect the number of fixed object crashes.

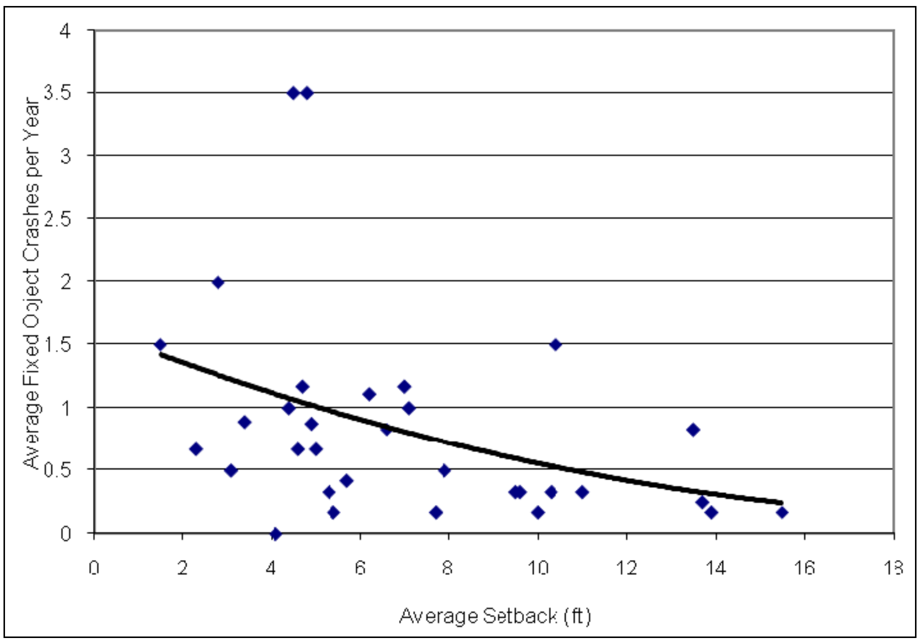

Figure 5-5. Average setback in segment analysis

5.3.2. Block Analysis

In the block analysis, the average setback did not show a relationship to the average number of fixed object crashes. Figure 5-6 illustrates the average number of fixed object crashes per year in relation to the average setback. This figure does not show any significant relationship between the average setback and the average number of fixed object crashes per year. The conclusion to be drawn from this analysis is the same as in the segment analysis: that the setback distance does not affect the number of fixed object crashes.

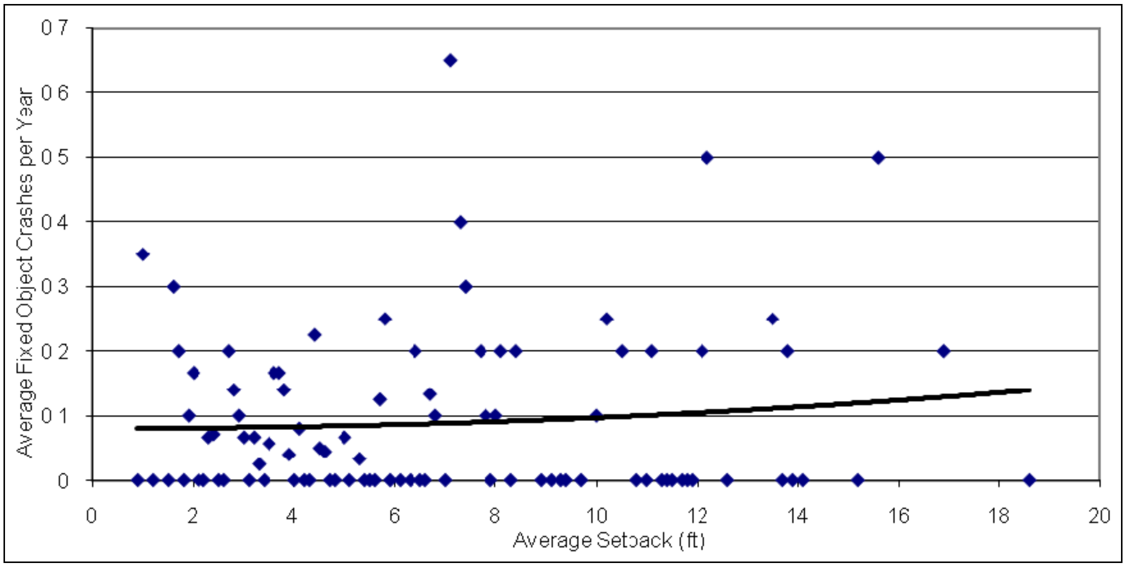

Figure 5-6. Average setback in block analysis

5.3.3. 15 m Analysis

In the 15 m analysis, the average setback did not show a relationship to the average number of fixed object crashes. Figure 5-7 illustrates the average number of crashes per year in relation to the average setback. This figure shows that as the average setback increases, the average number of fixed object crashes per year is not affected. The conclusion is the same as for the segment and block analyses: that the setback distance does not affect the number of fixed object crashes.

5.4. 15th Percentile Setback

The 15th percentile setback used in this analysis is the offset distance that 85% of fixed objects are behind. For example, if the 15th percentile setback is 6 ft for a segment with 100 fixed objects, 85 of those fixed objects would have an offset greater than 6 ft, and 15 of those fixed objects would have an offset less than 6 ft. As shown by Figures 5-7 through 5-9, the 15th percentile width of the clear zone does not have any quantifiable impact on the number of fixed object crashes that may occur.

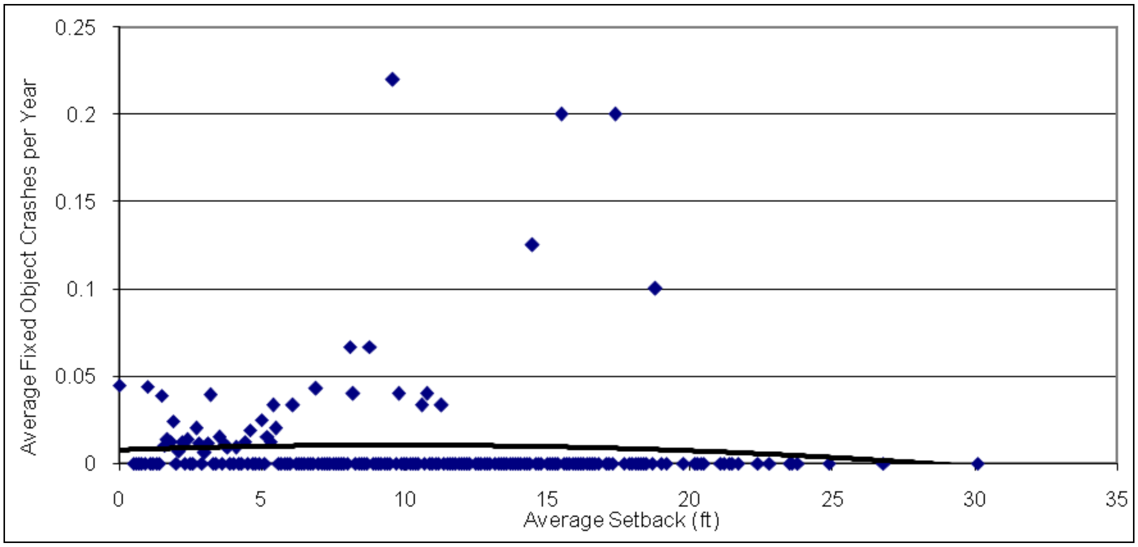

Figure 5-7. Average setback in 15 m analysis

5.4.1. Segment Analysis

In the segment analysis, the 15th percentile setback did not show a relationship to the average number of fixed object crashes. Figure 5-8 illustrates the average number of crashes per year in relation to the 15th percentile setback. This figure shows that as the 15th percentile setback increases, the average number of fixed object crashes per year is not affected. This conclusion agrees with that drawn from the minimum setback and average setback analyses: that the setback distance does not affect the number of fixed object crashes.

5.4.2. Block Analysis

In the block analysis, the 15th percentile setback did not show a relationship to the average number of fixed object crashes. Figure 5-9 illustrates the average number of crashes per year in relation to the 15th percentile setback. This figure shows that as the 15th percentile setback increases, the average number of fixed object crashes per year is not affected. This is the same conclusion from the segment analysis: that the setback distance does not affect the number of fixed object crashes.

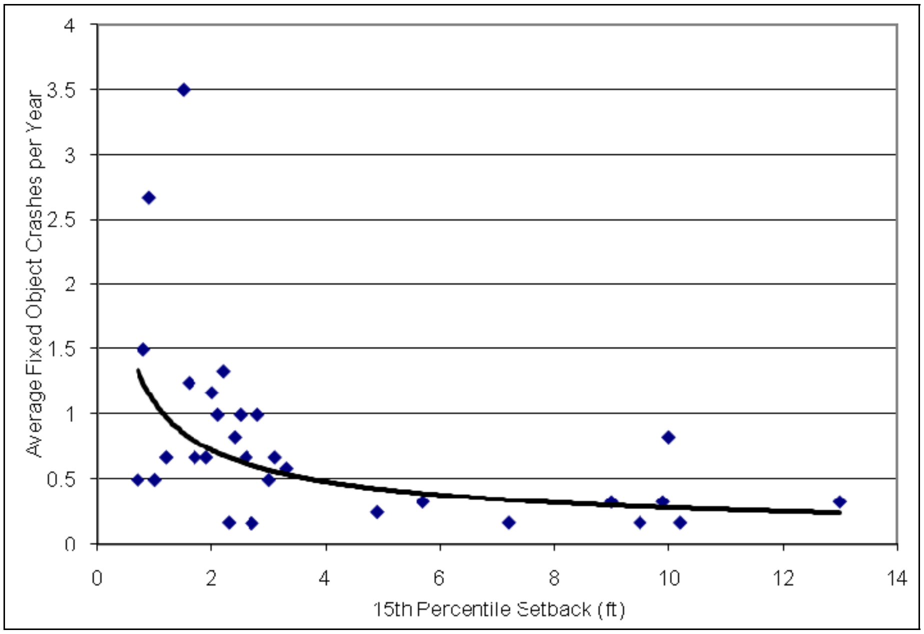

Figure 5-8. 15th percentile setback in segment analysis

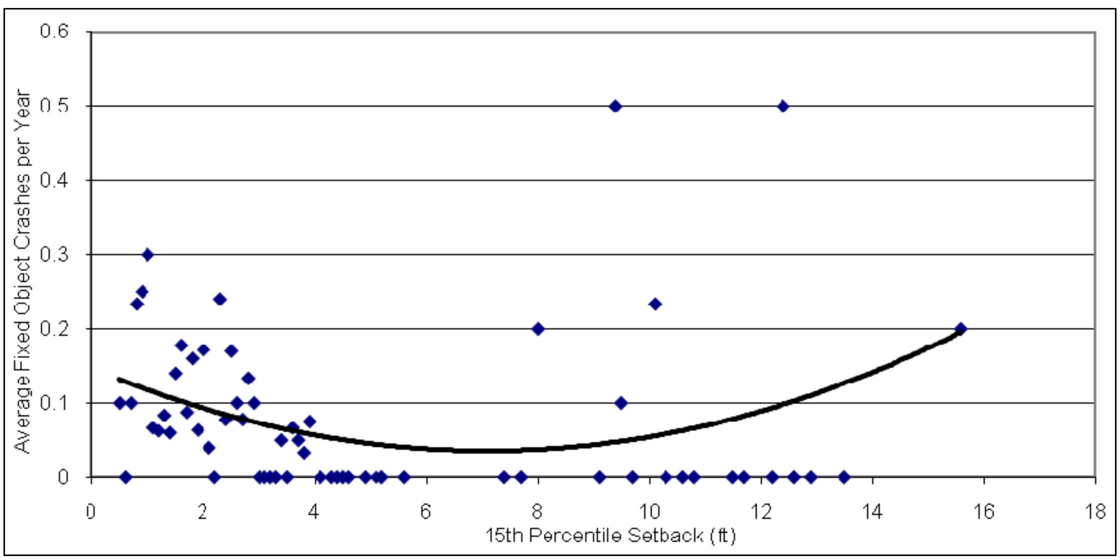

Figure 5-9. 15th percentile setback in block analysis

5.4.3. 15 m Analysis

In the 15 m analysis, the 15th percentile setback did not show a relationship to the average number of fixed object crashes. Figure 5-10 illustrates the average number of crashes per year in relation to the 15th percentile setback. This figure shows that as the 15th percentile setback is increased, the average number of fixed object crashes per year is not affected. This is the same conclusion from the segment and block analyses: that the setback distance does not affect the number of fixed object crashes.

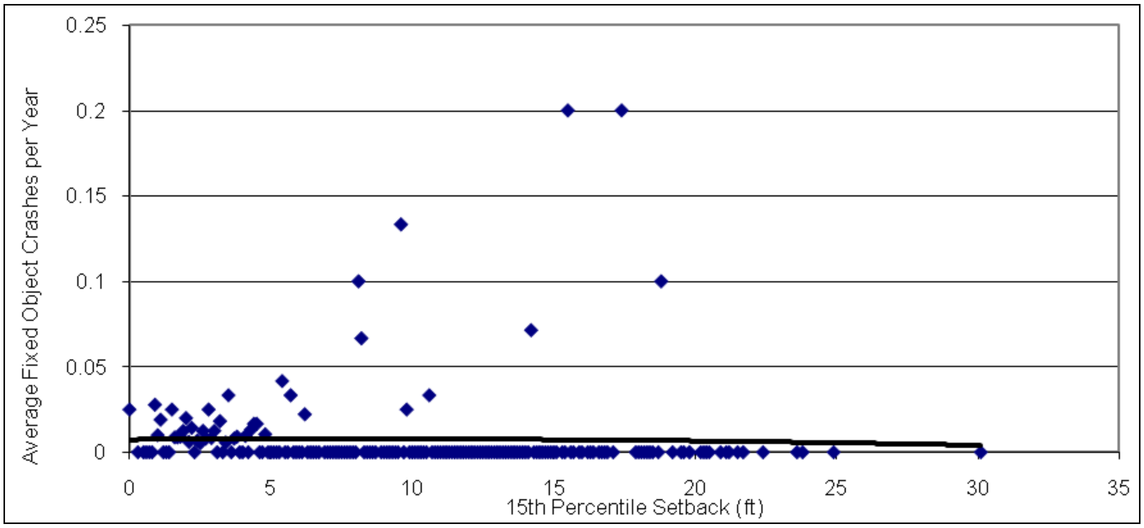

Figure 5-10. 15th percentile setback in 15 m analysis

5.5. Intersection Area of Influence

The intersection area of influence in this analysis is defined as the area that is within 45 m of the intersection centerline. A 15 m segment that is within 45 m of the intersection centerline is considered to be influenced by the intersection. The intersection was found to be a significant factor in the number of fixed object crashes.

5.5.1. 15 m Analysis

In the 15 m analysis, the intersection area of influence showed a relationship to the average number of fixed object crashes. Figure 5-11 illustrates the average number of crashes per year in relation to the intersection area of influence. A “0” indicates that the 15 m segment is within 45 m of the intersection centerline and is considered to be influenced by the intersection. A “1” indicates that the 15 m segment is outside of the intersection area of influence and is not considered to be influenced by the intersection. The figure shows that segments within the intersection's area of influence have greater average number of fixed object crashes per year than other segments. This demonstrates that the characteristics of an intersection do have an impact on the number of fixed object crashes, possibly a result of the inconsistent setback allowed for roadside objects such as trees, signing, and signal poles.

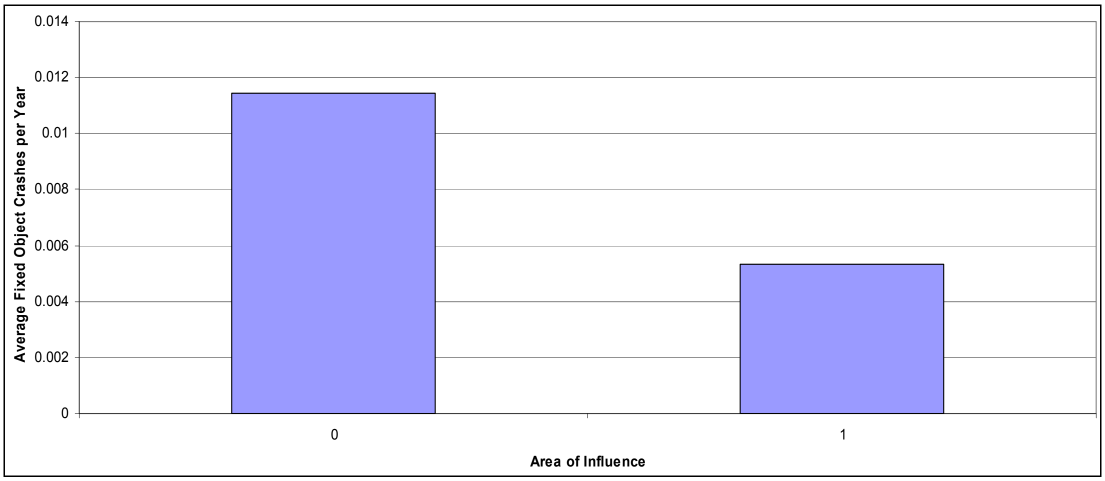

Figure 5-11. Area of influence at intersections in 15 m analysis

A significance test of the effect of the intersection was conducted to determine whether the difference in the number of fixed object crashes illustrated in Figure 5-11 is great enough to warrant mention. The test used was a "t-Test: Two-Sample Assuming Unequal Variance." The results of this test are shown in Table 5-1. The test finds that, because the absolute value of the t-stat is greater than the absolute value of t-critical, the effect of the intersection is statistically significant.

Table 5-1. Results of intersection significance test

t-Test: Two-Sample Assuming Unequal Variances		
	Intersection	*Non-Intersection*
Mean	0.005319149	0.011455331
Variance	0.001676063	0.003177981
Observations	752	1388
Hypothesized Mean Difference	0	
df	1964	
t Stat	-2.886722254	
P(T<=t) one-tail	0.00196766	
t Critical one-tail	1.645629846	
P(T<=t) two-tail	0.003935321	
t Critical two-tail	1.961172544	

It was also concluded from the area of influence analysis that midblock sections are safer than intersection sections. This may be the result of an inconsistent clear zone width at the intersection. While other factors may account for the safety differential—such as changes in speed, congestion, pedestrians, more signing, reduced sight distance, or collision avoidance—an inconsistent clear zone width can only be increasing the hazards associated with an intersection.

5.6. Violation of Area of Influence

An extensive analysis of violations was conducted on a range of offset distances. The results of these analyses were used to determine the safety impact of having a consistent clear zone. In the segment and block analyses, a violation was counted as the number of fixed objects that have a setback less than the distance for that evaluation (e.g., 2 ft, 3 ft, 4 ft). In the 15 m analysis, a violation was counted if any object in the section had an offset less than the determined distance. In each of these analyses, the number of fixed object crashes increased when the number of violations increased.

5.6.1. Segment Analysis

Figures 5-12 through 5-21 illustrate the relationship between average fixed object crashes and the number of violations of the area of influence for offsets ranging from 2 ft to 10 ft. In all of these figures, the average number of fixed object crashes increases as the number of fixed objects that violate the offset minimum increases.

5.6.2. Block Analysis

Figures 5-22 through 5-31 illustrate the relationship between average fixed object crashes and the number of violations of the area of influence for offsets ranging from 2 ft to 10 ft. In all of these figures, the average number of fixed object crashes increases as the number of fixed objects that violate the offset minimum increases.

5.6.3. 15 m Analysis

Figures 5-32 through 5-41 illustrate the relationship between average fixed object crashes and the number of area of influence violations for offsets ranging from 2 ft to 10 ft. In all of these figures, the average number of fixed object crashes increases when the offset minimum was violated. A "0" indicates that there was not a violation in the section and a "1" indicates that there was a violation. The relationship between fixed object crashes and area of influence violations is similar to the relationships found in the segment and block analyses: that a section with a consistent clear zone is safer than a section with an inconsistent clear zone.

A significance test of each area of influence violation was conducted to determine whether the differences in the number of fixed object crashes illustrated in Figures 5-32 through 5-41 were great enough to warrant mention. The test used for each violation was a "t-Test: Two-Sample Assuming Unequal Variance." The results of each test are shown in Tables 5-2 through 5-11. If the test for each area of influence violation found that the absolute value of the t-stat was greater than the absolute value of t-critical at a confidence level of 0.01, then the effect of having a violation at that area of influence was significant. It was found that Figures 5-33, 5-34, 5-37, and 5-38 were significant.

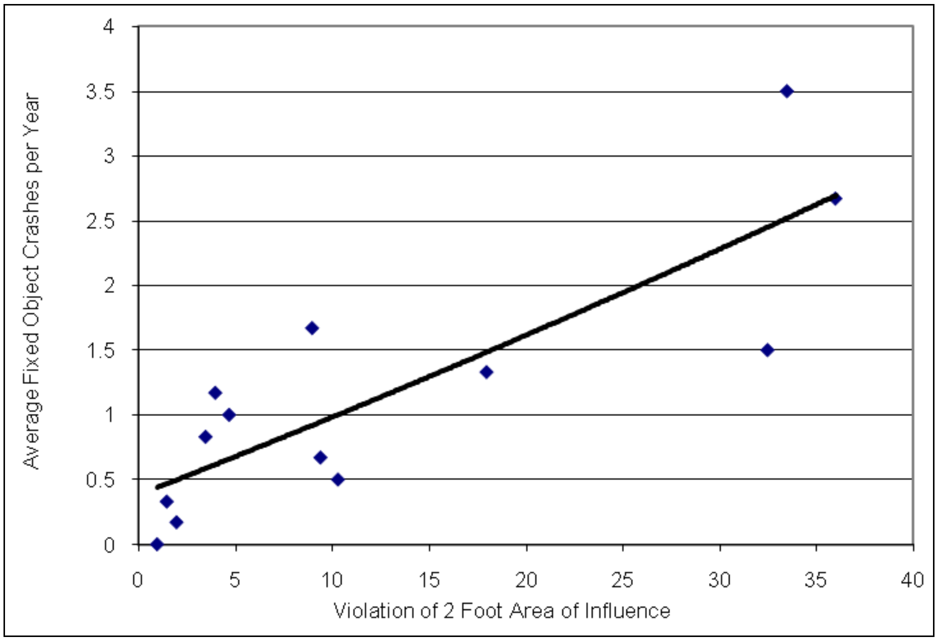

Figure 5-12. Violation of 2 ft area of influence in segment analysis

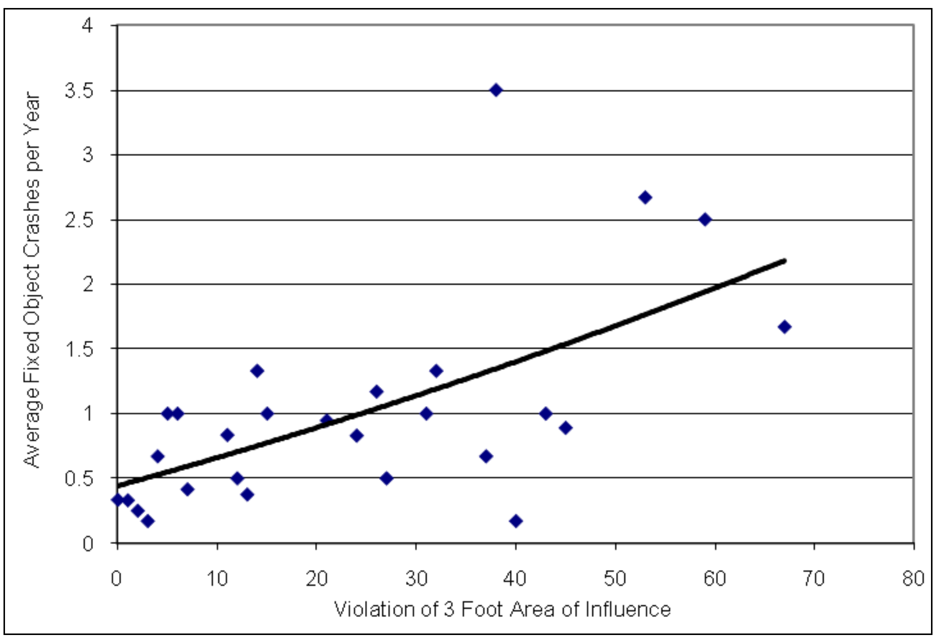

Figure 5-13. Violation of 3 ft area of influence in segment analysis

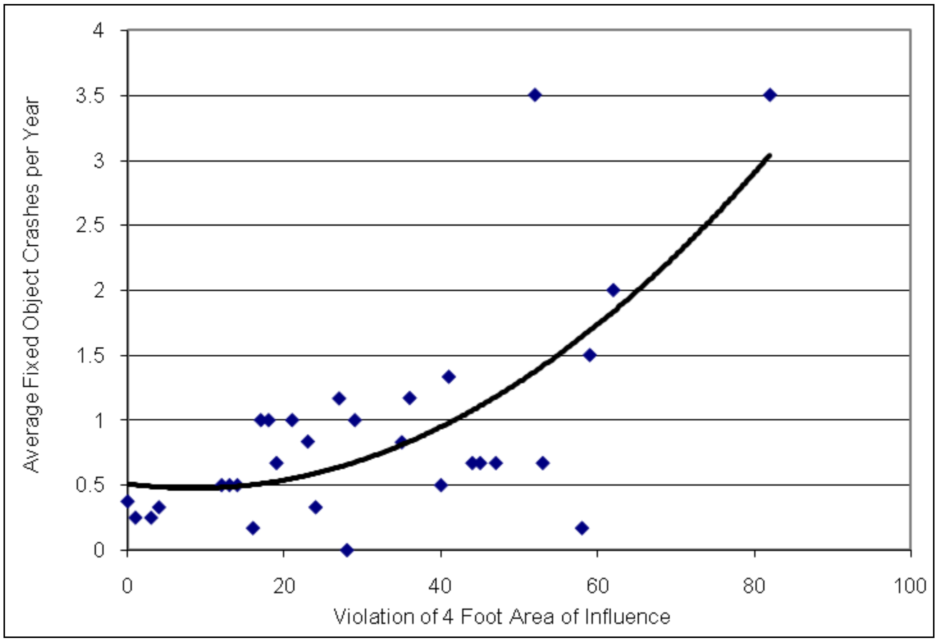

Figure 5-14. Violation of 4 ft area of influence in segment analysis

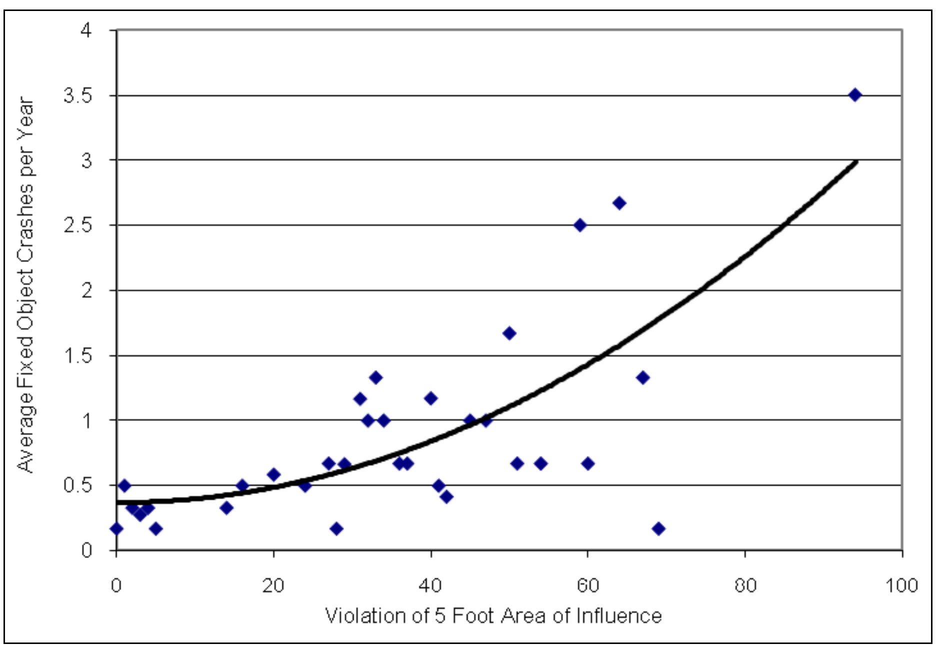

Figure 5-15. Violation of 5 ft area of influence in segment analysis

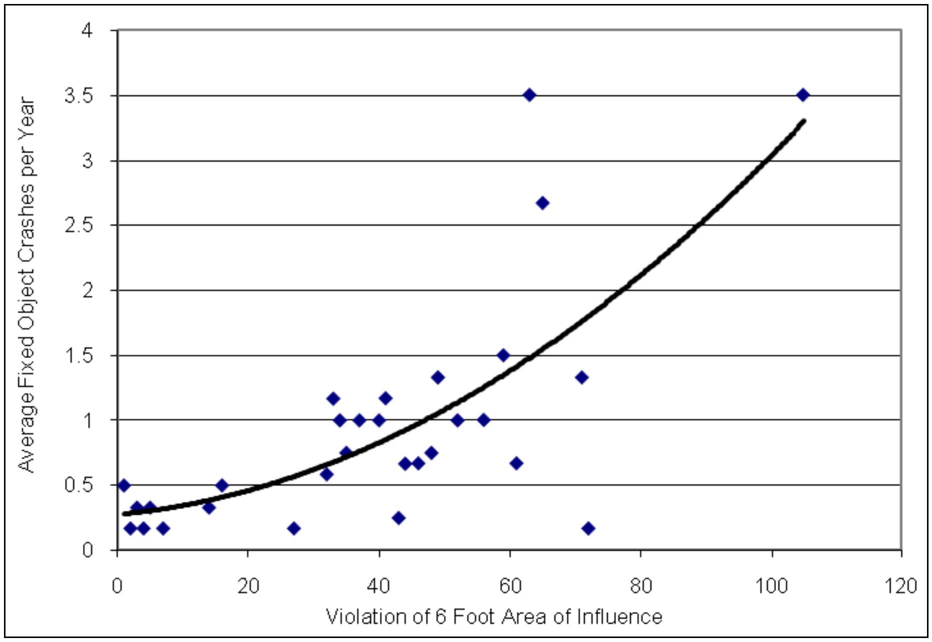

Figure 5-16. Violation of 6 ft area of influence in segment analysis

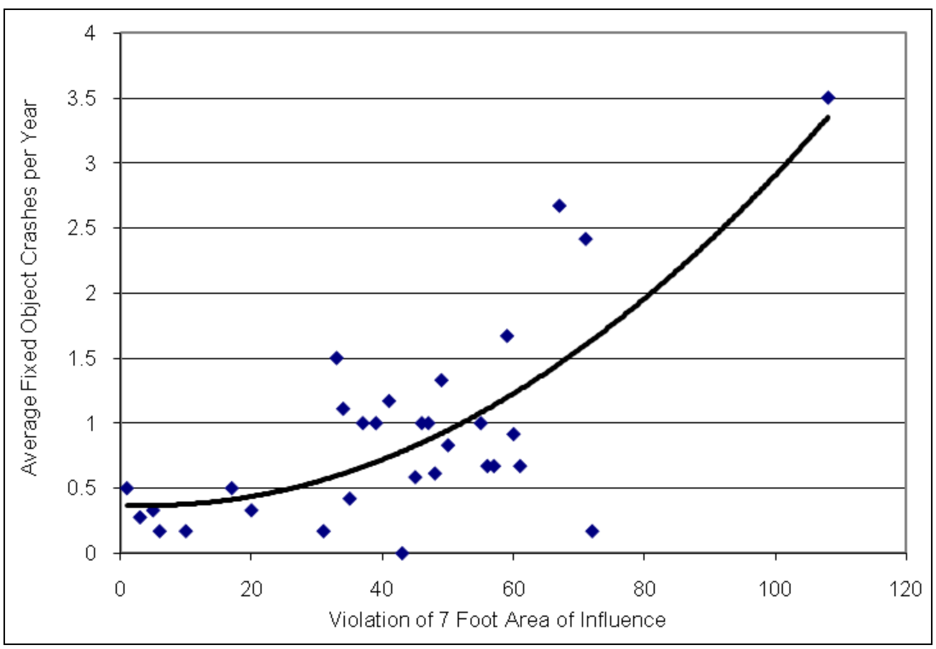

Figure 5-17. Violation of 7 ft area of influence in segment analysis

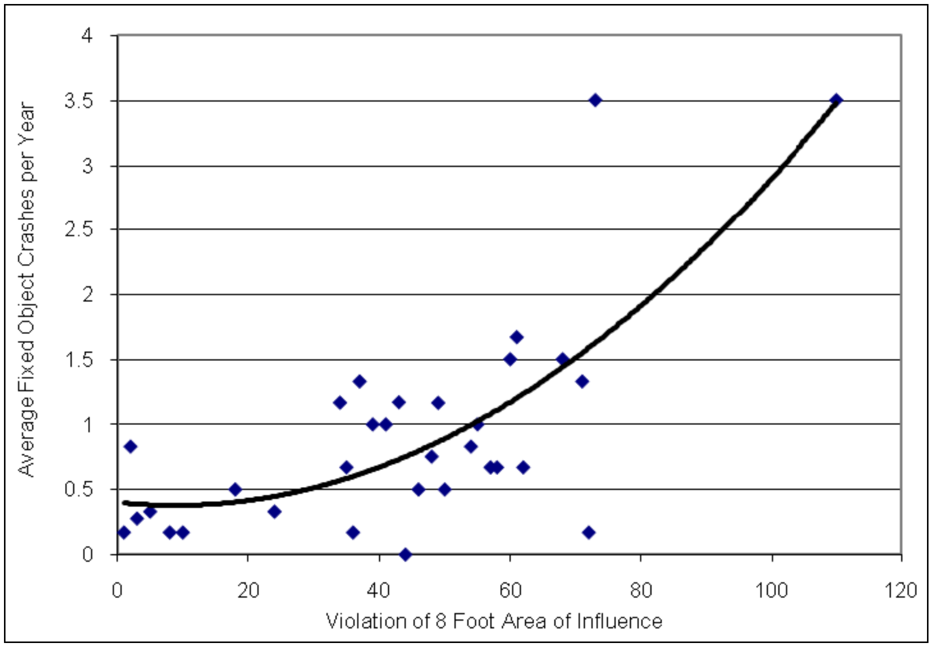

Figure 5-18. Violation of 8 ft area of influence in segment analysis

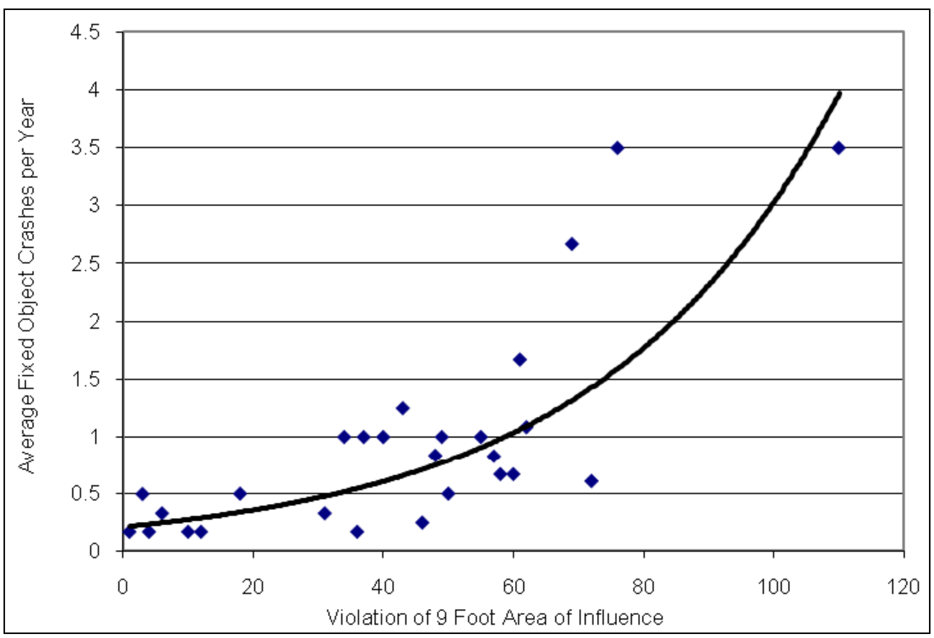

Figure 5-19. Violation of 9 ft area of influence in segment analysis

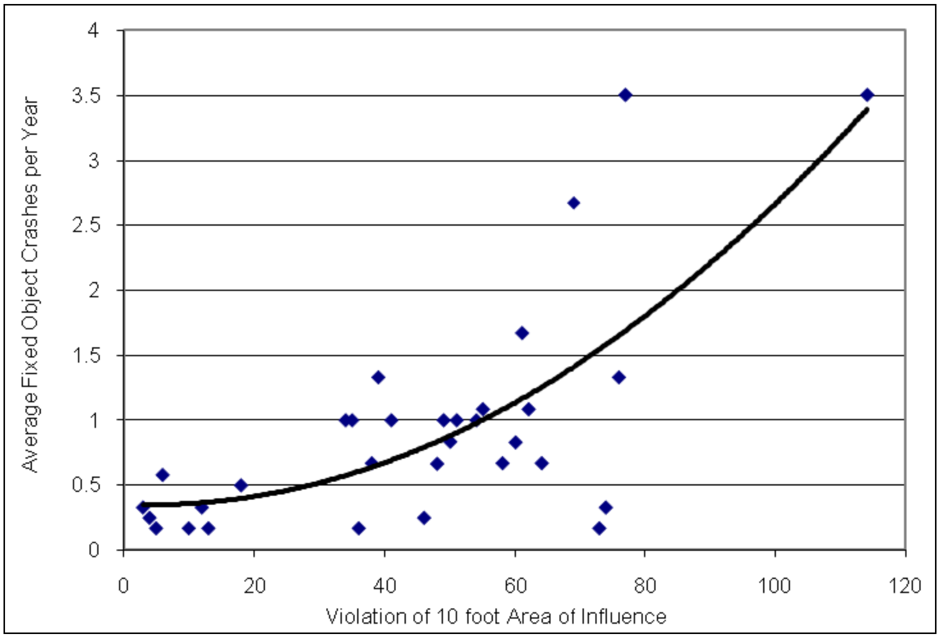

Figure 5-20. Violation of 10 ft area of influence in segment analysis

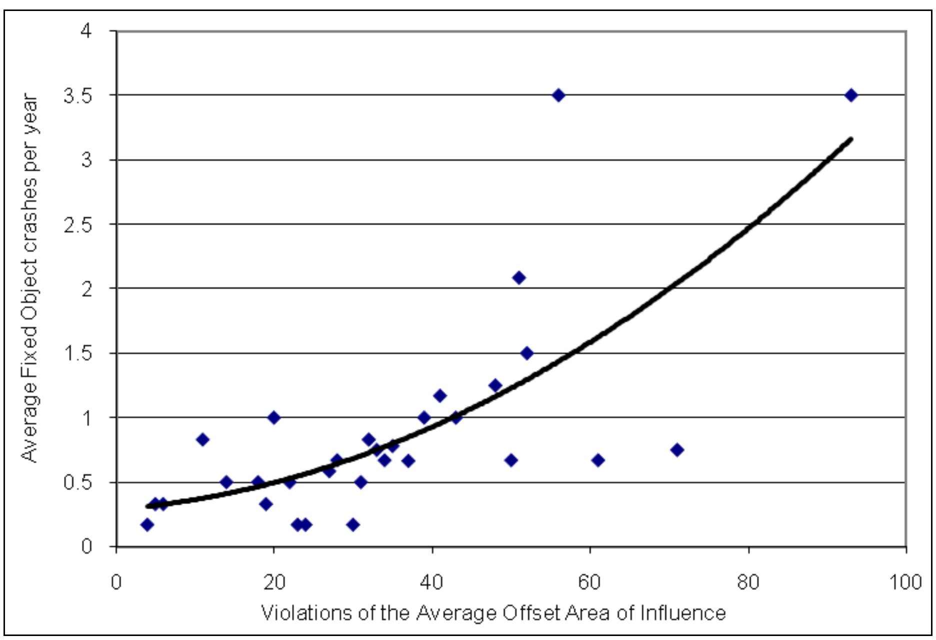

Figure 5-21. Violation of average offset area of influence in segment analysis

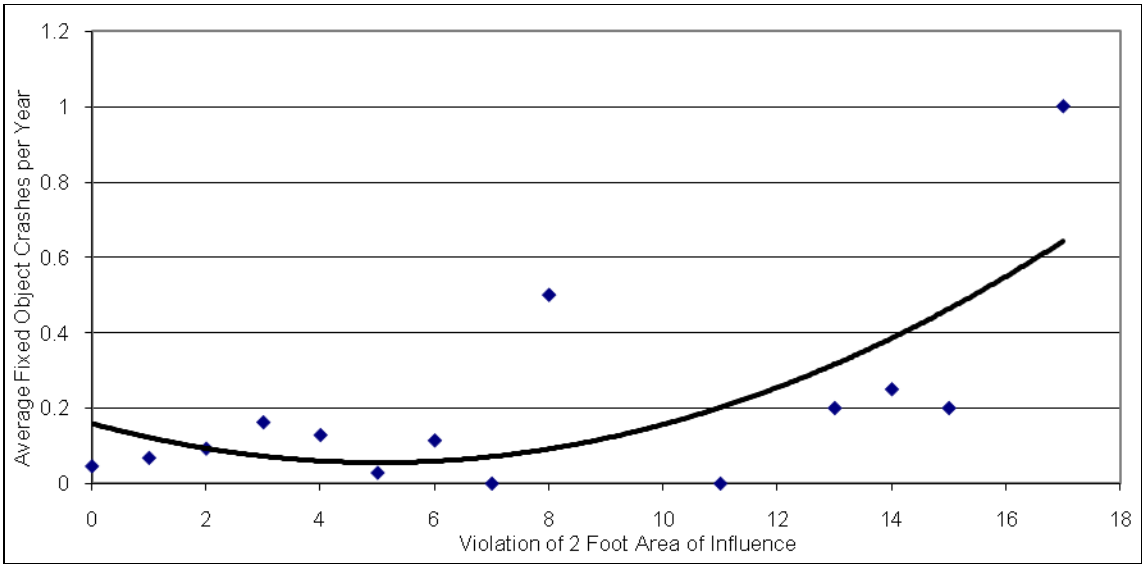

Figure 5-22. Violation of the 2 ft area of influence in block analysis

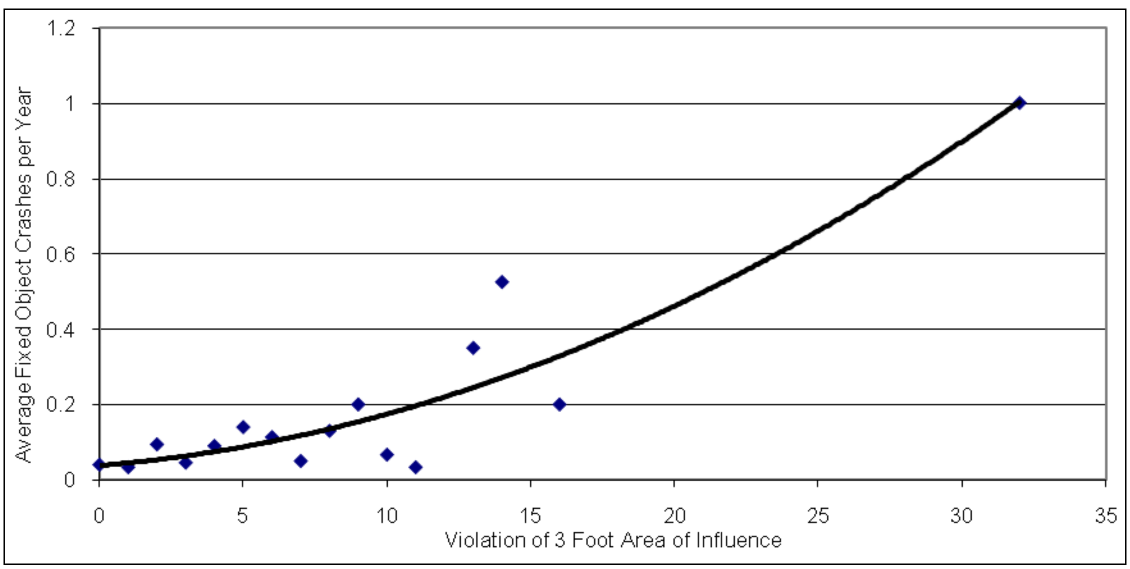

Figure 5-23. Violation of the 3 ft area of influence in block analysis

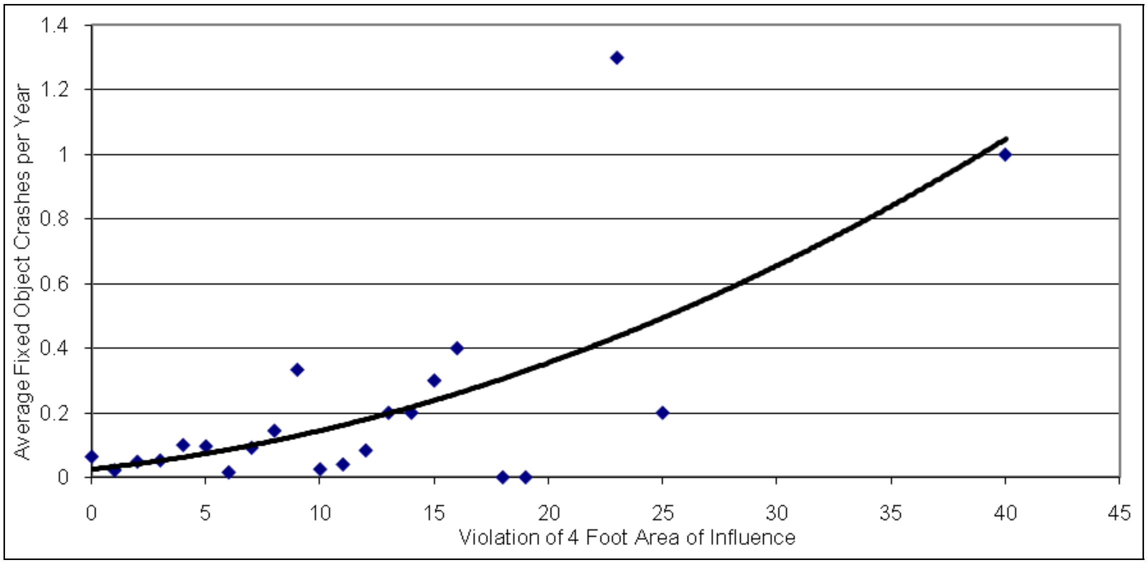

Figure 5-24. Violation of the 4 ft area of influence in block analysis

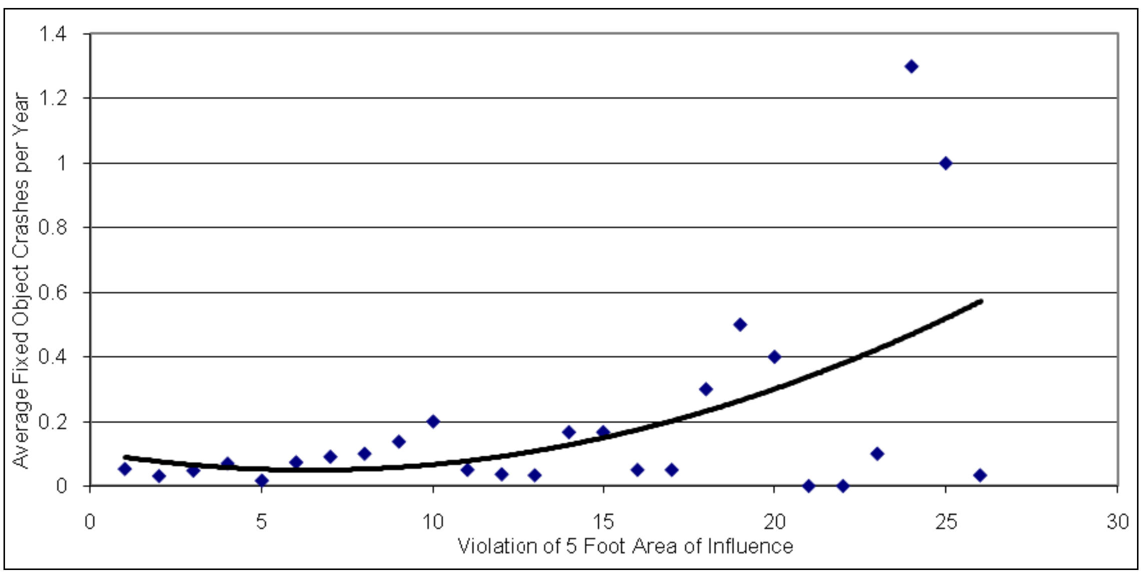

Figure 5-25. Violation of the 5 ft area of influence in block analysis

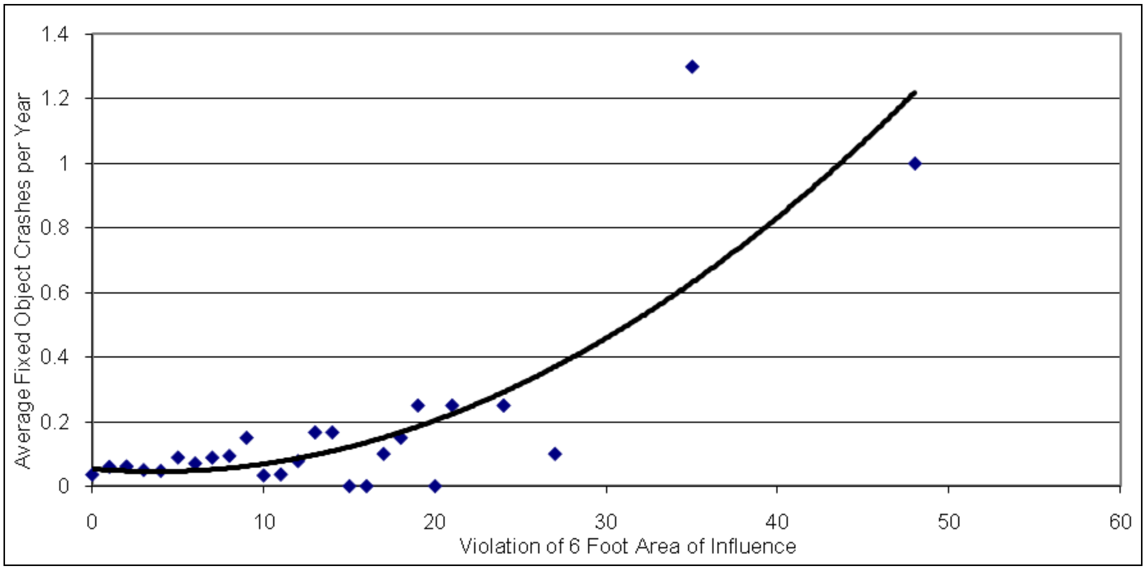

Figure 5-26. Violation of the 6 ft area of influence in block analysis

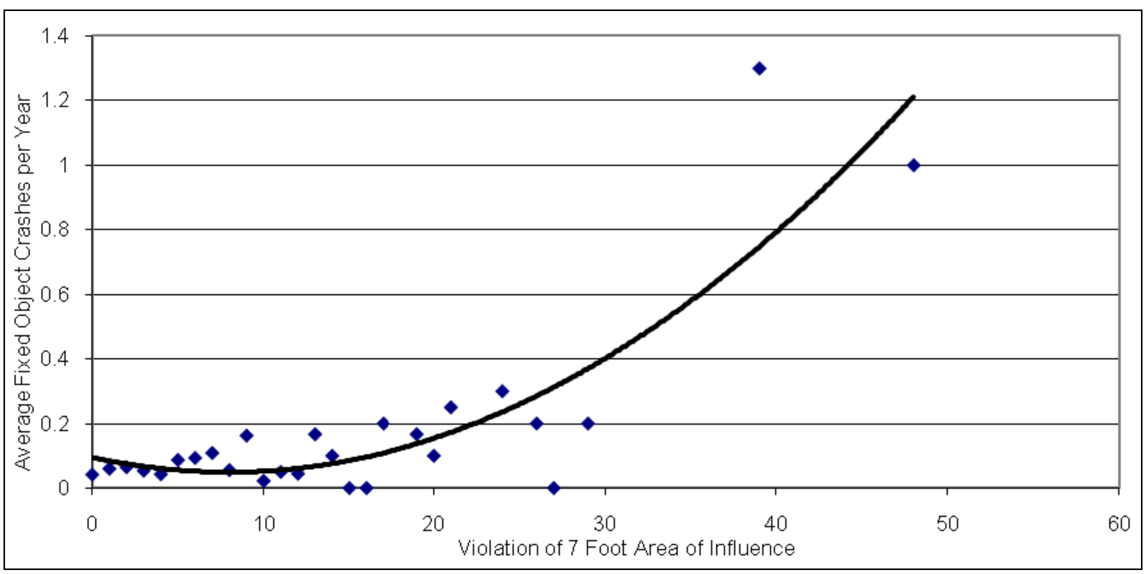

Figure 5-27. Violation of the 7 ft area of influence in block analysis

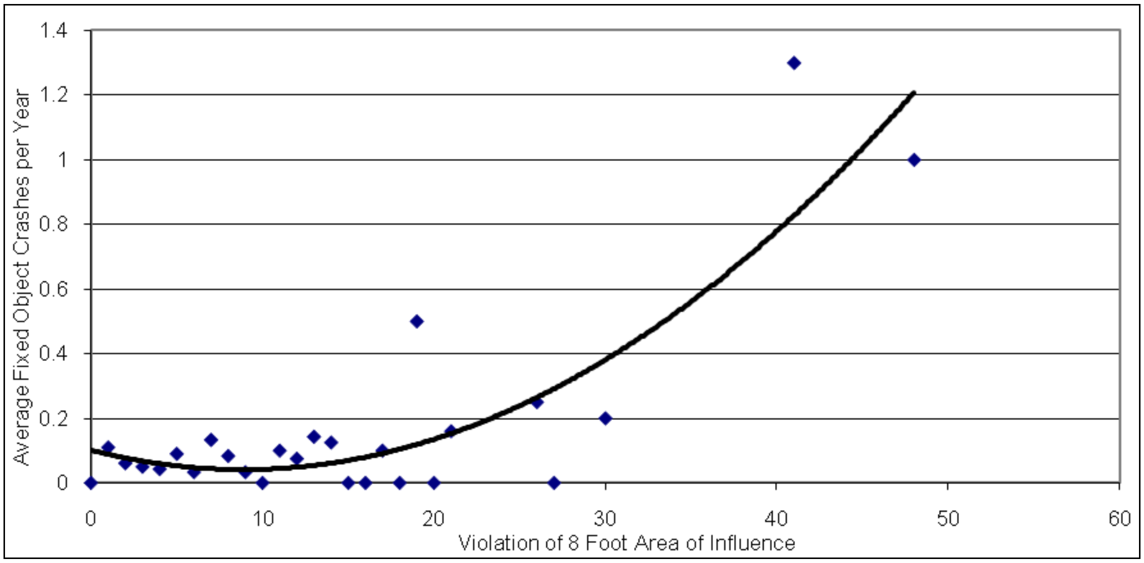

Figure 5-28. Violation of the 8 ft area of influence in block analysis

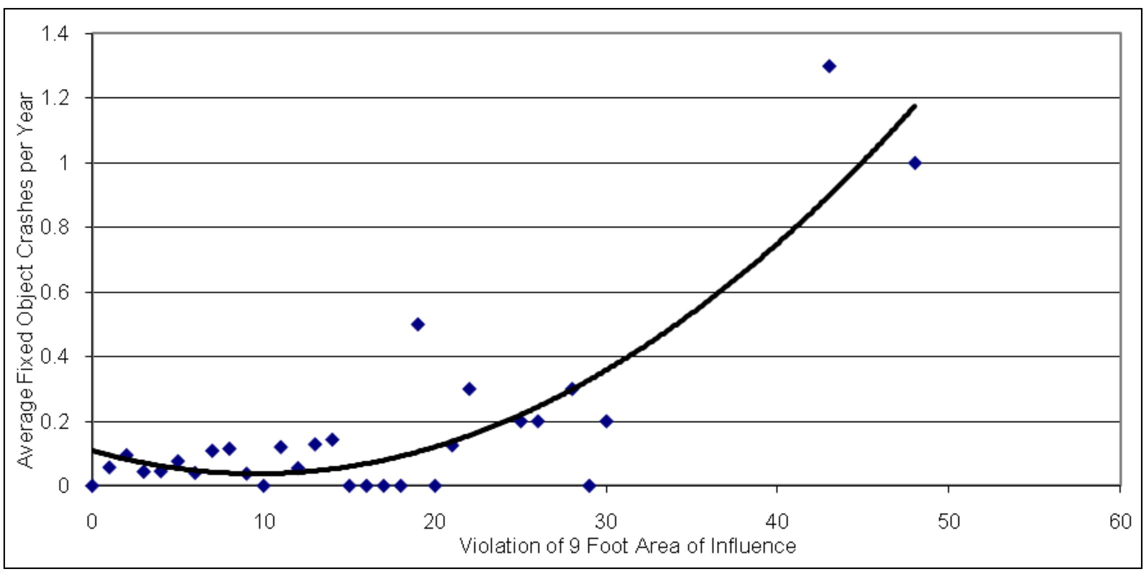

Figure 5-29. Violation of the 9 ft area of influence in block analysis

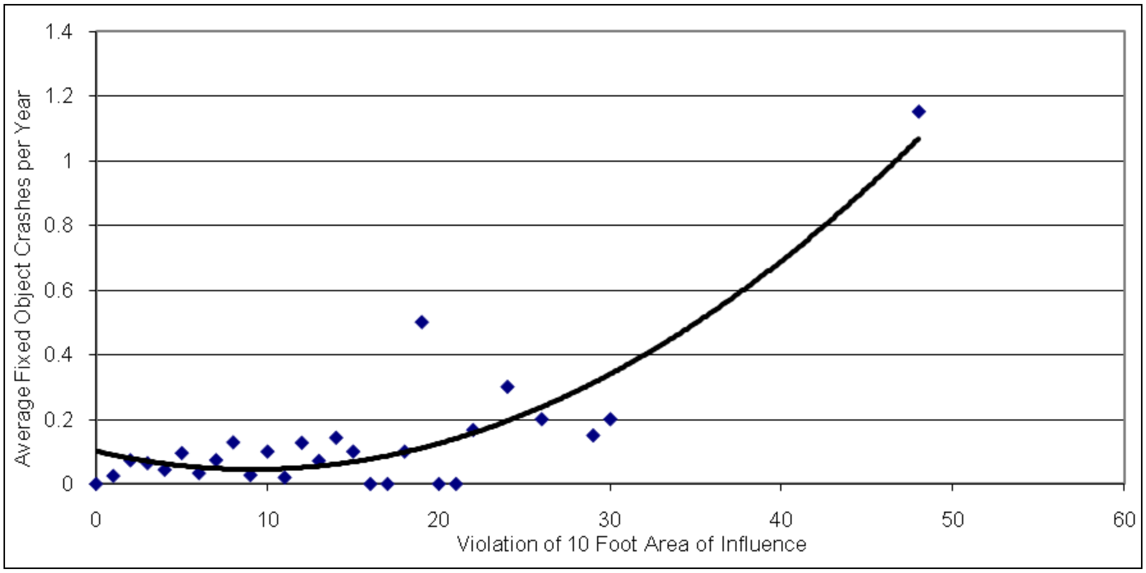

Figure 5-30. Violation of the 10 ft area of influence in block analysis

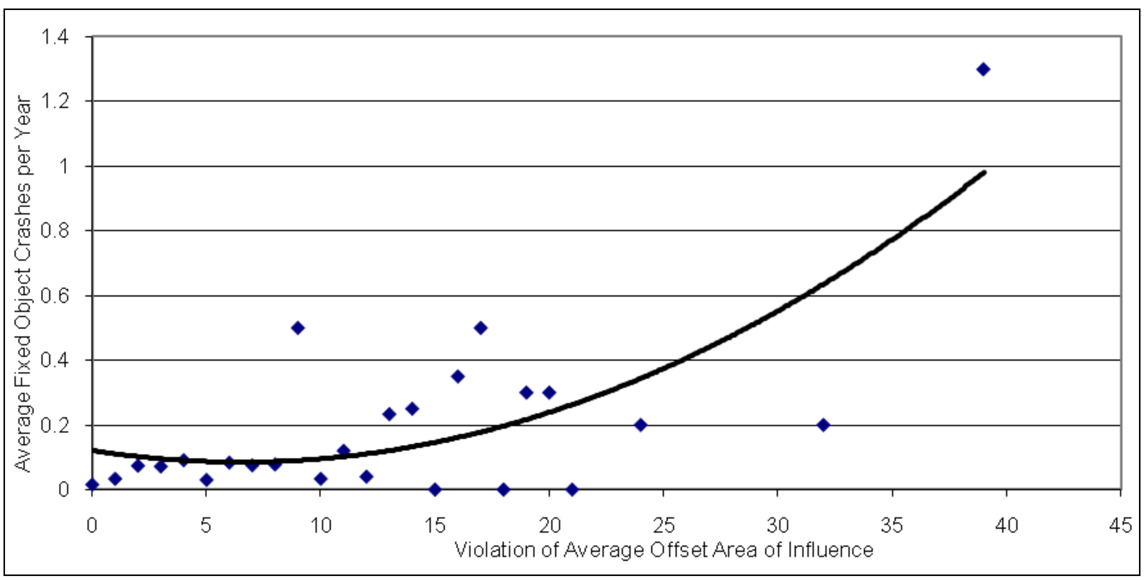

Figure 5-31. Violation of the average offset area of influence in block analysis

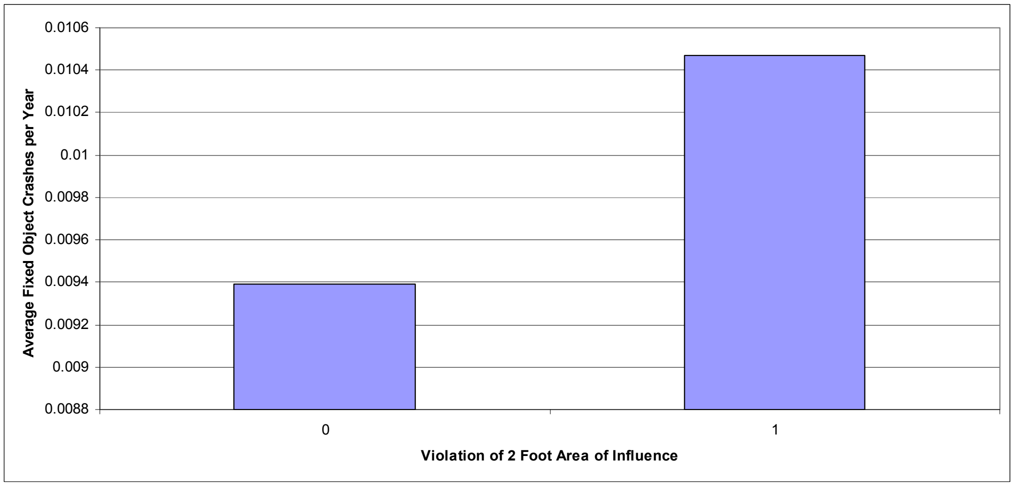

Figure 5-32. Violation of 2 ft area of influence in 15 m analysis

Table 5-2. Results of violation of 2 ft area of influence significance test

t-Test: Two-Sample Assuming Unequal Variances		
	Variable 1	*Variable 2*
Mean	0.009391771	0.01046832
Variance	0.003054061	0.002486797
Observations	1118	363
Hypothesized Mean Difference	0	
df	674	
t Stat	-0.347773523	
P(T<=t) one-tail	0.364059428	
t Critical one-tail	2.331893192	
P(T<=t) two-tail	0.728118855	
t Critical two-tail	2.583143341	

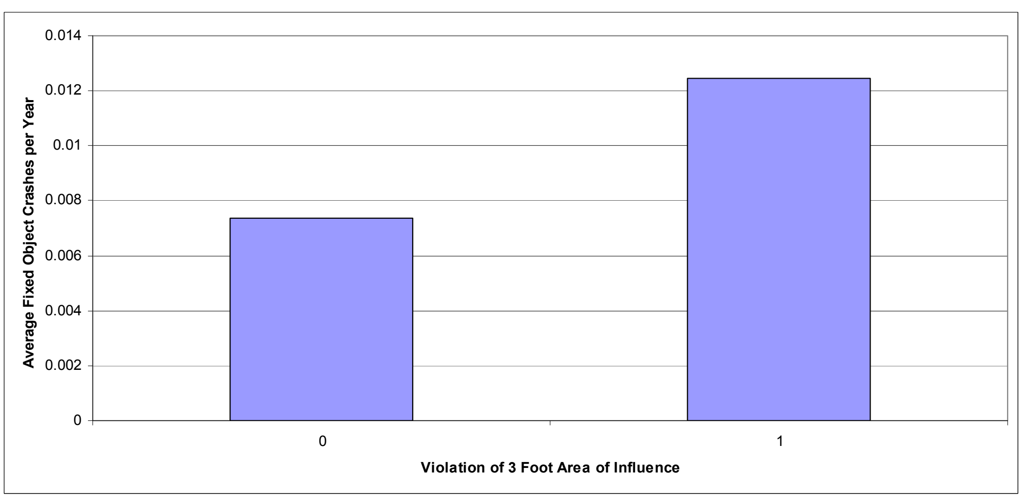

Figure 5-33. Violation of 3 ft area of influence in 15 m analysis

Table 5-3. Results of violation of 3 ft area of influence significance test

t-Test: Two-Sample Assuming Unequal Variances		
	Variable 1	*Variable 2*
Mean	0.007361963	0.012462462
Variance	0.002083327	0.003919641
Observations	815	666
Hypothesized Mean Difference	0	
df	1185	
t Stat	-1.755500252	
P(T<=t) one-tail	0.039716057	
t Critical one-tail	2.329498798	
P(T<=t) two-tail	0.079432115	
t Critical two-tail	2.579984553	

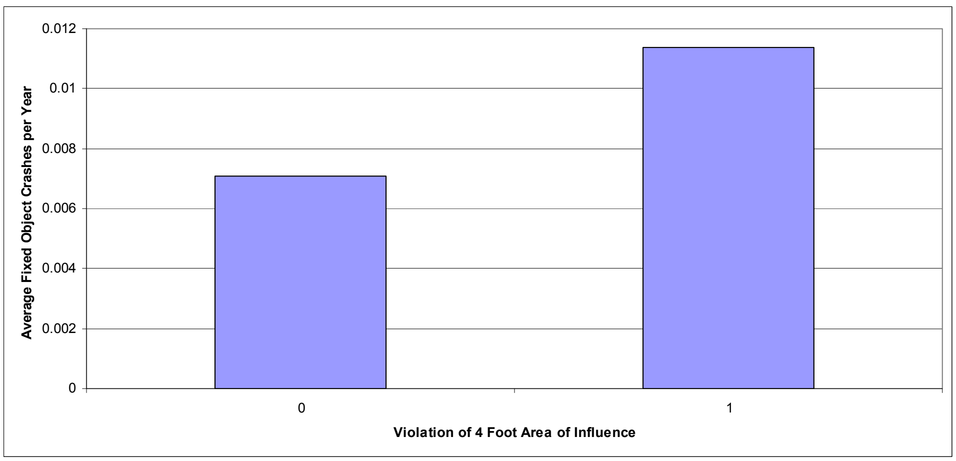

Figure 5-34. Violation of 4 ft area of influence in 15 m analysis

Table 5-4. Results of violation of 4 ft area of influence significance test

t-Test: Two-Sample Assuming Unequal Variances		
	Variable 1	*Variable 2*
Mean	0.007094595	0.01136108
Variance	0.002284607	0.003327988
Observations	592	889
Hypothesized Mean Difference	0	
df	1410	
t Stat	-1.547346961	
P(T<=t) one-tail	0.061002004	
t Critical one-tail	2.328995434	
P(T<=t) two-tail	0.122004008	
t Critical two-tail	2.57932063	

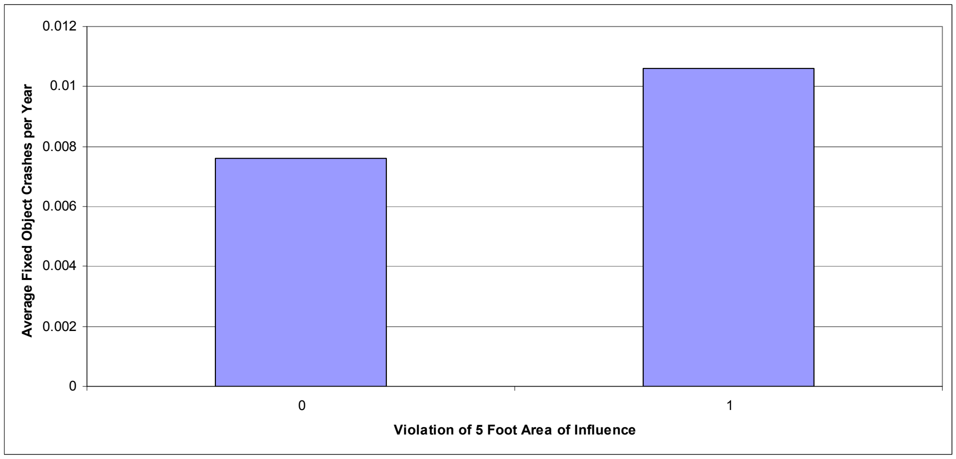

Figure 5-35. Violation of 5 ft area of influence in 15 m analysis

Table 5-5. Results of violation of 5 ft area of influence significance test

t-Test: Two-Sample Assuming Unequal Variances		
	Variable 1	*Variable 2*
Mean	0.007610994	0.010615079
Variance	0.002611442	0.003055033
Observations	473	1008
Hypothesized Mean Difference	0	
df	992	
t Stat	-1.027267192	
P(T<=t) one-tail	0.152272541	
t Critical one-tail	2.330112791	
P(T<=t) two-tail	0.304545082	
t Critical two-tail	2.580794457	

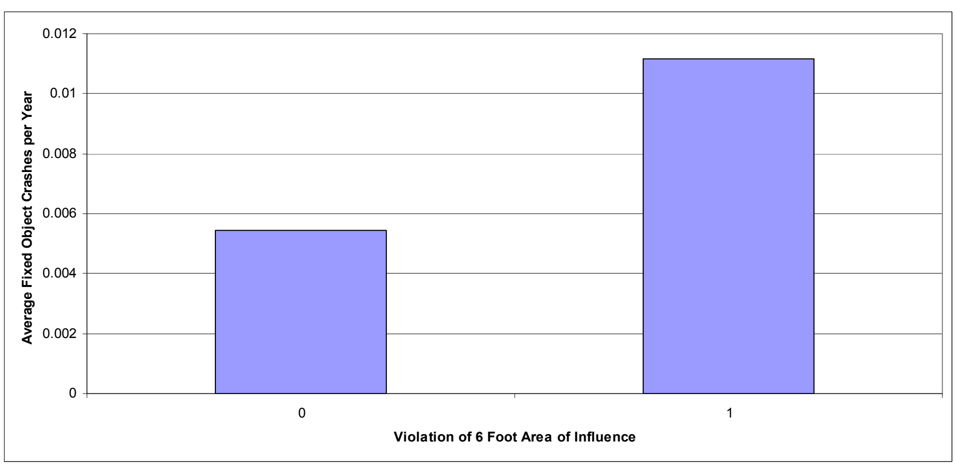

Figure 5-36. Violation of 6 ft area of influence in 15 m analysis

Table 5-6. Results of violation of 6 ft area of influence significance test

t-Test: Two-Sample Assuming Unequal Variances		
	Variable 1	*Variable 2*
Mean	0.005426357	0.011151737
Variance	0.001136281	0.003535177
Observations	387	1094
Hypothesized Mean Difference	0	
df	1193	
t Stat	-2.30540877	
P(T<=t) one-tail	0.010657301	
t Critical one-tail	2.329477641	
P(T<=t) two-tail	0.021314601	
t Critical two-tail	2.579956647	

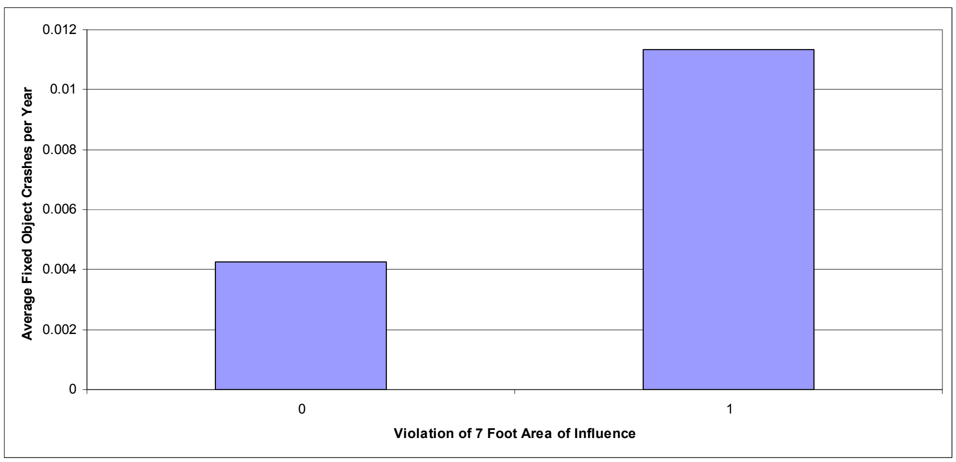

Figure 5-37. Violation of 7 ft area of influence in 15 m analysis

Table 5-7. Results of violation of 7 ft area of influence significance test

t-Test: Two-Sample Assuming Unequal Variances		
	Variable 1	*Variable 2*
Mean	0.004261364	0.011170213
Variance	0.00092196	0.003495346
Observations	352	1128
Hypothesized Mean Difference	0	
df	1165	
t Stat	-2.889261373	
P(T<=t) one-tail	0.001966493	
t Critical one-tail	2.329552963	
P(T<=t) two-tail	0.003932987	
t Critical two-tail	2.580055999	

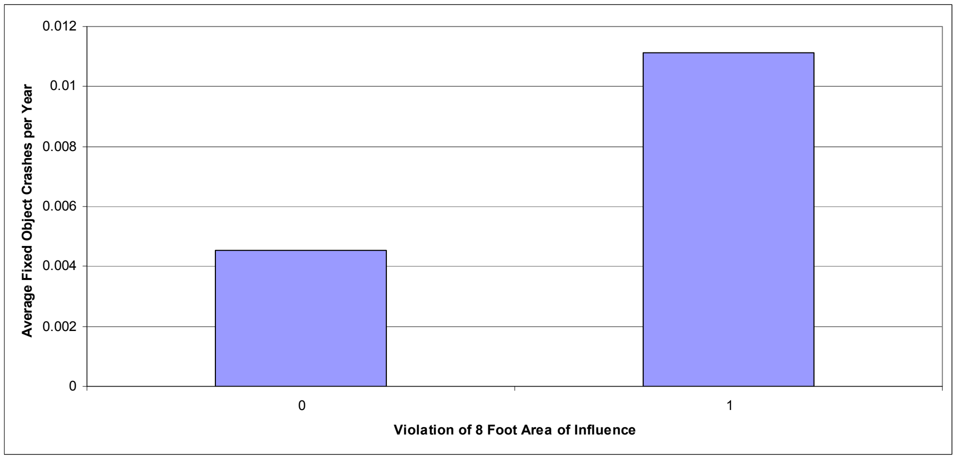

Figure 5-38. Violation of 8 ft area of influence in 15 m analysis

Table 5-8. Results of violation of 8 ft area of influence significance test

t-Test: Two-Sample Assuming Unequal Variances		
	Variable 1	*Variable 2*
Mean	0.004545455	0.011120765
Variance	0.000982316	0.00345883
Observations	330	1151
Hypothesized Mean Difference	0	
df	1029	
t Stat	-2.688444408	
P(T<=t) one-tail	0.00364727	
t Critical one-tail	2.329977211	
P(T<=t) two-tail	0.00729454	
t Critical two-tail	2.580615611	

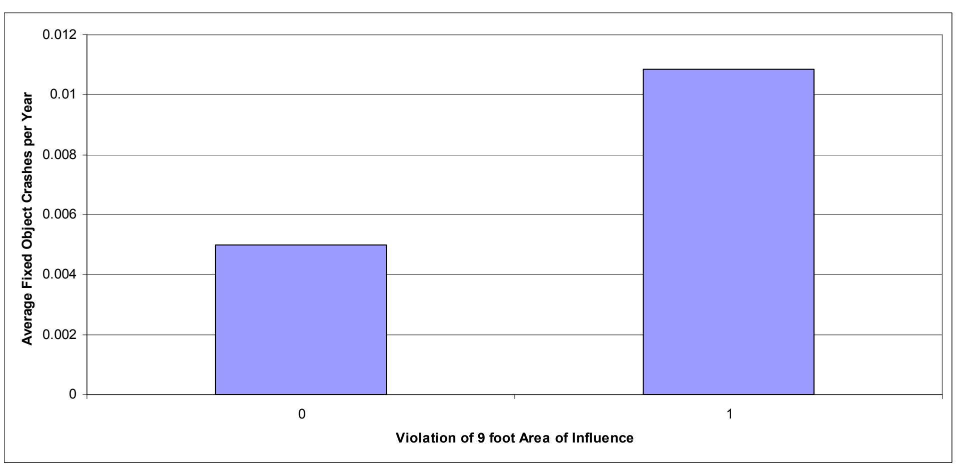

Figure 5-39. Violation of 9 ft area of influence in 15 m analysis

Table 5-9. Results of violation of 9 ft area of influence significance test

t-Test: Two-Sample Assuming Unequal Variances		
	Variable 1	*Variable 2*
Mean	0.005	0.010838273
Variance	0.001078595	0.003373958
Observations	300	1181
Hypothesized Mean Difference	0	
df	830	
t Stat	-2.298428718	
P(T<=t) one-tail	0.01089257	
t Critical one-tail	2.330849001	
P(T<=t) two-tail	0.02178514	
t Critical two-tail	2.581765668	

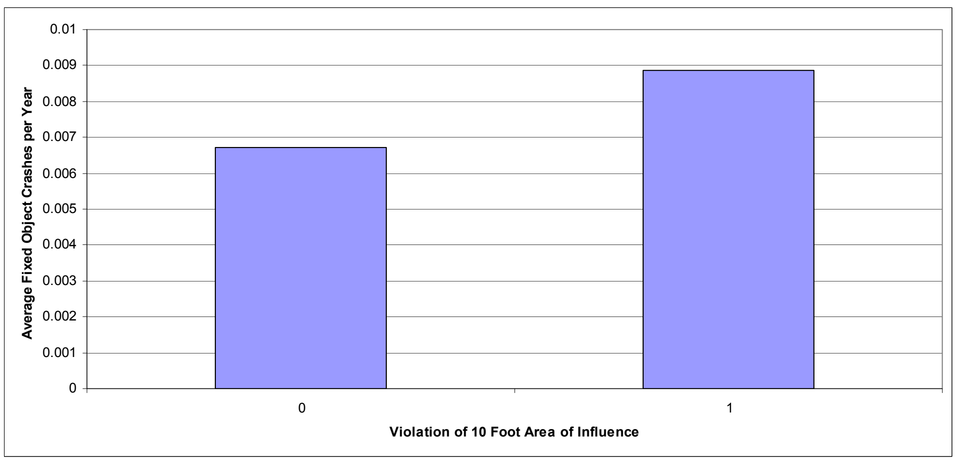

Figure 5-40. Violation of 10 ft area of influence in 15 m analysis

Table 5-10. Results of violation of 10 ft area of influence significance test

t-Test: Two-Sample Assuming Unequal Variances		
	Variable 1	*Variable 2*
Mean	0.006701031	0.008857809
Variance	0.002079216	0.002487575
Observations	194	1287
Hypothesized Mean Difference	0	
df	268	
t Stat	-0.606390459	
P(T<=t) one-tail	0.272384398	
t Critical one-tail	2.340342285	
P(T<=t) two-tail	0.544768796	
t Critical two-tail	2.594298248	

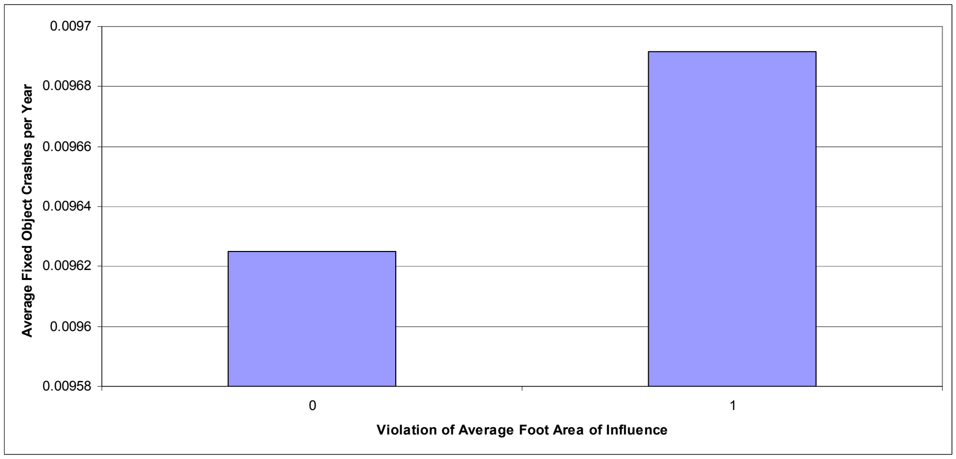

Figure 5-41. Violation of average setback area of influence in 15 m analysis

Table 5-11. Results of violation of average setback area of influence significance test

t-Test: Two-Sample Assuming Unequal Variances		
	Variable 1	*Variable 2*
Mean	0.009625	0.00969163
Variance	0.002322763	0.003611817
Observations	800	681
Hypothesized Mean Difference	0	
df	1297	
t Stat	-0.023258054	
P(T<=t) one-tail	0.490724004	
t Critical one-tail	2.329226379	
P(T<=t) two-tail	0.981448008	
t Critical two-tail	2.579625234	

5.7. Speed Limit

The speed limit of each segment, block, and 15 m section was evaluated to determine whether the speed limit was correlated to the number of fixed object crashes. Each of the analysis predictors showed a different relation between fixed object crashes and speed limit. The segment analysis showed an overall decrease in fixed object crashes as the speed limit was increased. However, there was an increase in fixed object crashes when the speed limit was between 30 mph and 35 mph. The block analysis showed a constant increase in the number of fixed object crashes as the speed limit increased. The 15 m analysis showed an overall increase in fixed object crashes as the speed limit increased. However, there was a decrease in fixed object crashes when the speed limit was between 30 mph and 35 mph.

5.7.1. Segment Analysis

In the segment analysis, the speed limit showed a relationship to the average number of fixed object crashes. Figure 5-42 illustrates the average number of fixed object crashes per year in relation to the speed limit. The figure shows that as the speed limit increased, the number of fixed object crashes decreased. This conclusion is different than the conclusions drawn from the analysis of speed limit by block and 15 m section that follow; this difference may be due to the changing characteristics of the road over the length of the segment.

5.7.2. Block Analysis

In the block analysis, the speed limit showed a relationship to the average number of fixed object crashes. Figure 5-43 illustrates the average number of fixed object crashes per year in relation to the speed limit. The figure shows that as the speed limit increased, the average number of fixed object crashes also increased. The result of this analysis is in contrast to the result of the segment analysis. However, the analysis of speed limit by block may be considered to be more significant than the segment analysis because the roadway characteristics are more likely to be consistent over the length of a block than over the length of a segment consisting of several blocks.

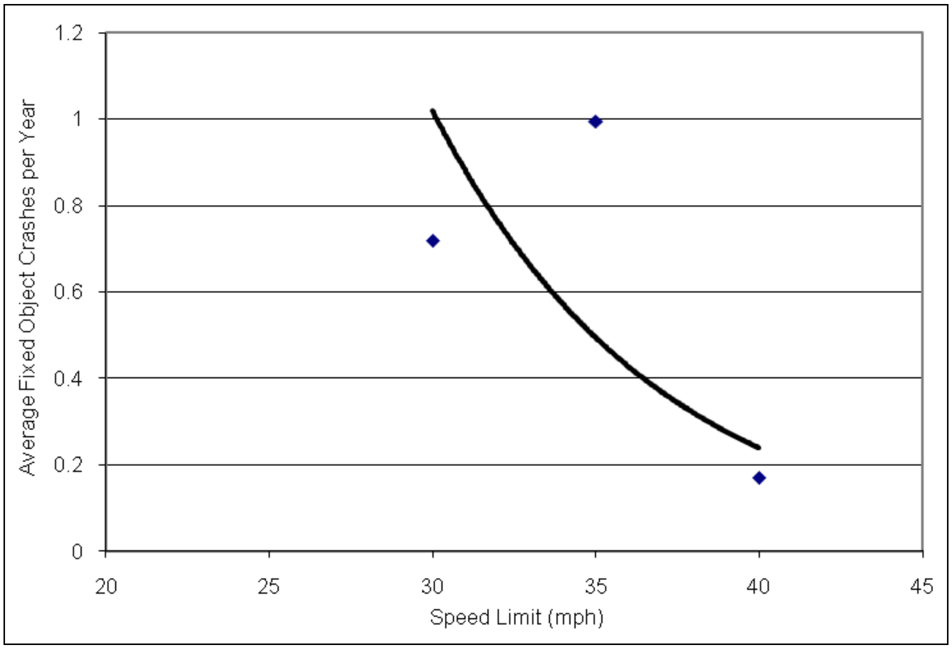

Figure 5-42. Speed limit in segment analysis

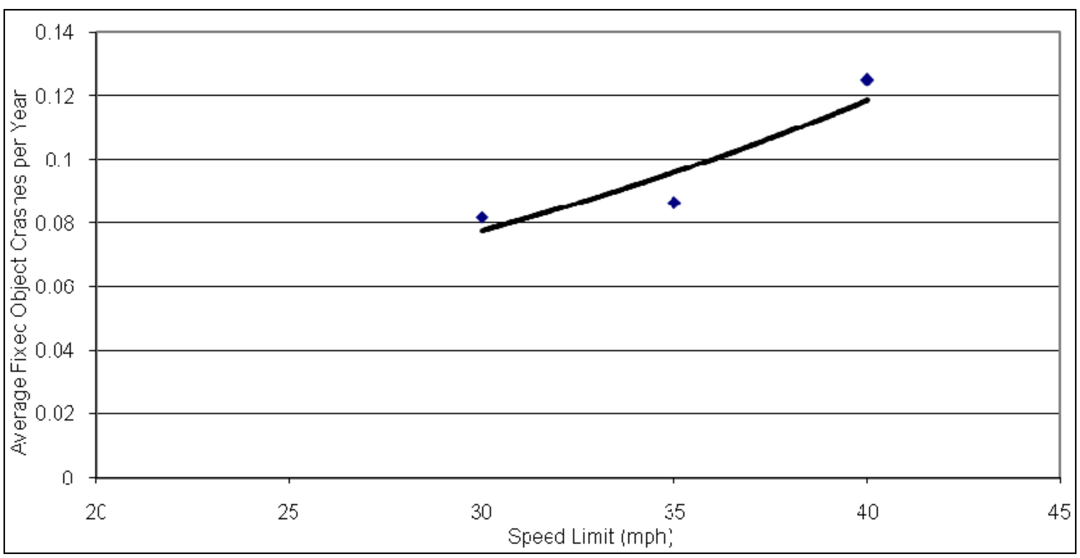

Figure 5-43. Speed limit in block analysis

5.7.3. 15 m Analysis

In the 15 m analysis, the speed limit did not show a relationship to the average number of fixed object crashes. Figure 5-44 illustrates the average number of fixed object crashes per year in relation to the speed limit. While the figure does not show a direct relationship between fixed object crashes and speed limit, the figure shows that road sections with a speed limit of 35 mph have the lowest average fixed object crash rate per year. The results of the 15 m analysis are not as convincing as the results of the block analysis, but the conclusion is the same for the two analyses: a lower speed limit results in fewer fixed object crashes.

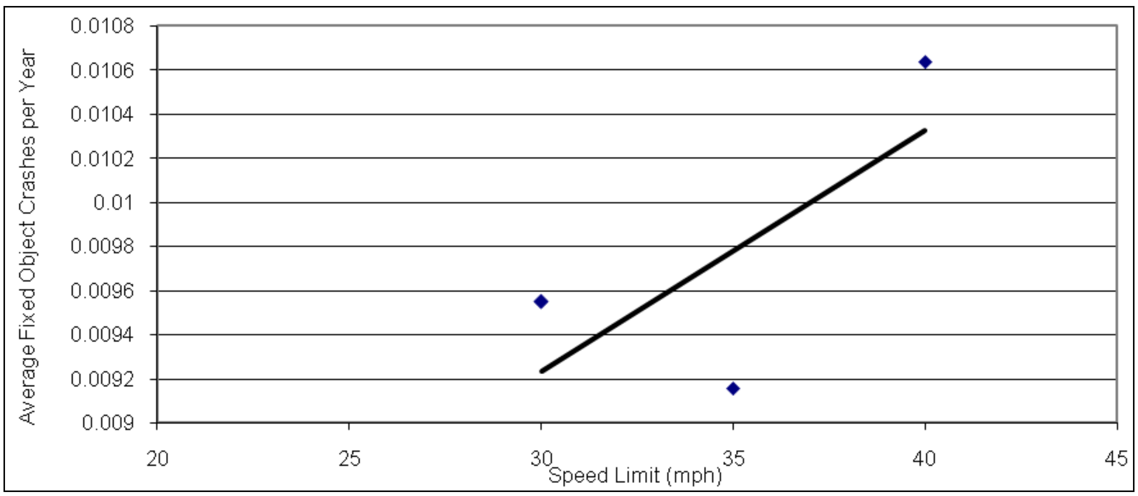

Figure 5-44. Speed limit in 15 m analysis

An increased speed limit was found to have a negative impact on safety in the block and 15 m analysis. However, an increased speed limit was found to have a positive impact on safety in the segment analysis. It can be noted that the highest and lowest correlations were found in the block analysis and segment analysis, respectively. Therefore, the outcome of the block analysis is the most significant. In addition to having the highest correlation, the block analysis features roadway sections on which the total physical characteristics are likely to be consistent; consistency is more likely over a block than over several blocks. The consistency of the total physical characteristics throughout the block makes it easier to isolate the speed limit as the only changing variable, which thus makes speed limit more significant in block analysis than in segment analysis.

5.8. Fixed Object Density

The fixed object density was evaluated as the number of fixed object per linear mile, as measured along the centerline of the roadway. In summary, none of the three analyses showed any consistent relationship between fixed object density and the number of fixed object crashes.

5.8.1. Segment Analysis

In the segment analysis, the fixed object density did not show a relationship to the average number of fixed object crashes. Figure 5-45 illustrates the average number of fixed object crashes per year in relation to the fixed object density. The figure does not show a direct relationship between fixed object crashes and fixed object density. The analysis was performed again without an outlying point, which had a density of 355 fixed objects per mile, to determine the effect of the outlier. The result, shown in Figure 5-46, does not indicate a direct relationship between fixed object density and fixed object crashes.

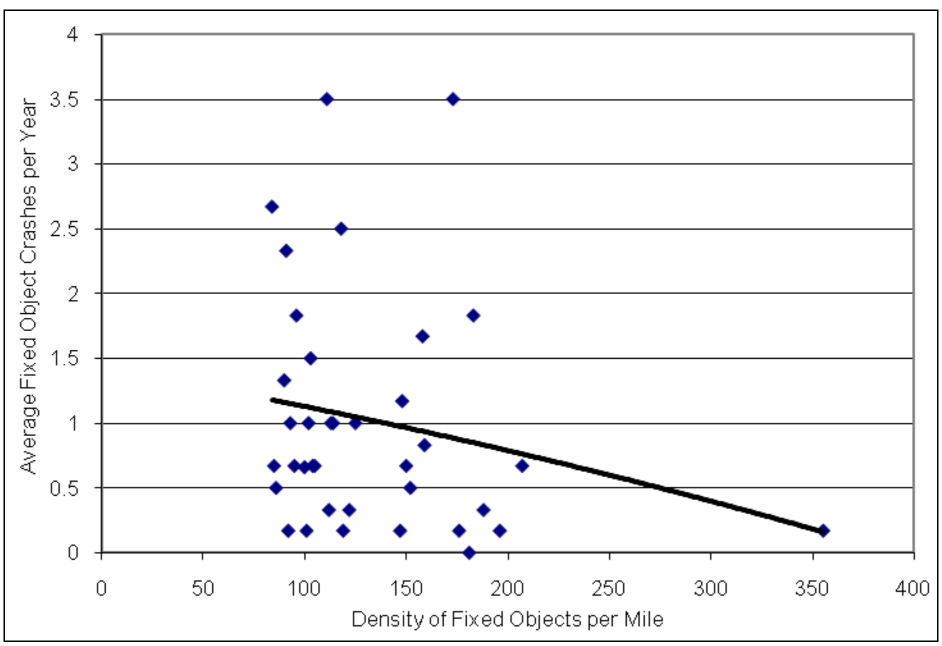

Figure 5-45. Fixed object density in segment analysis

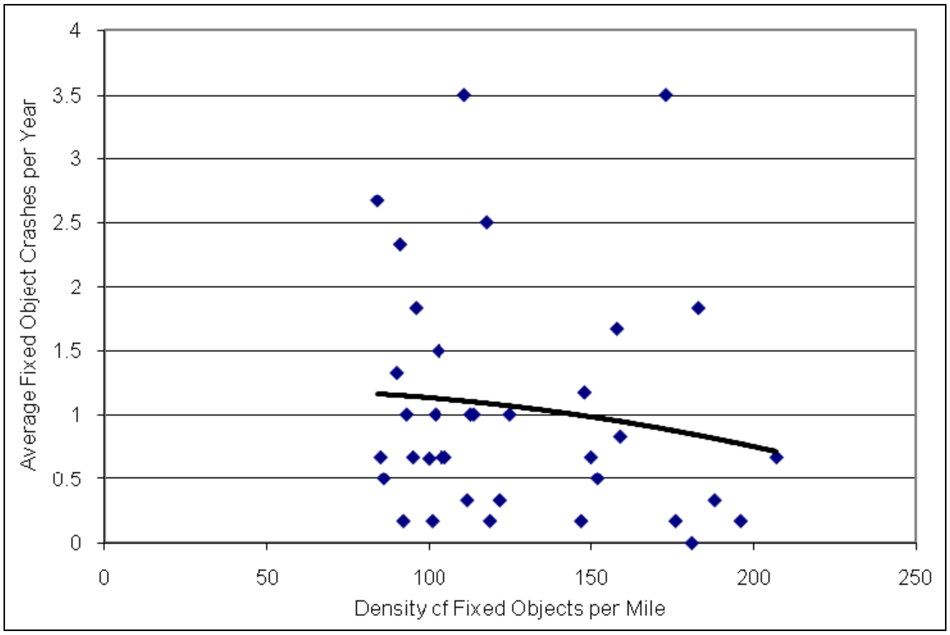

Figure 5-46. Fixed object density in segment analysis, with outlier removed

5.8.2. Block Analysis

In the block analysis, the fixed object density did not show a relationship to the average number of fixed object crashes. Figure 5-47 illustrates the average number of fixed object crashes per year in relation to the fixed object density. The figure does not show a relationship between the two variables.

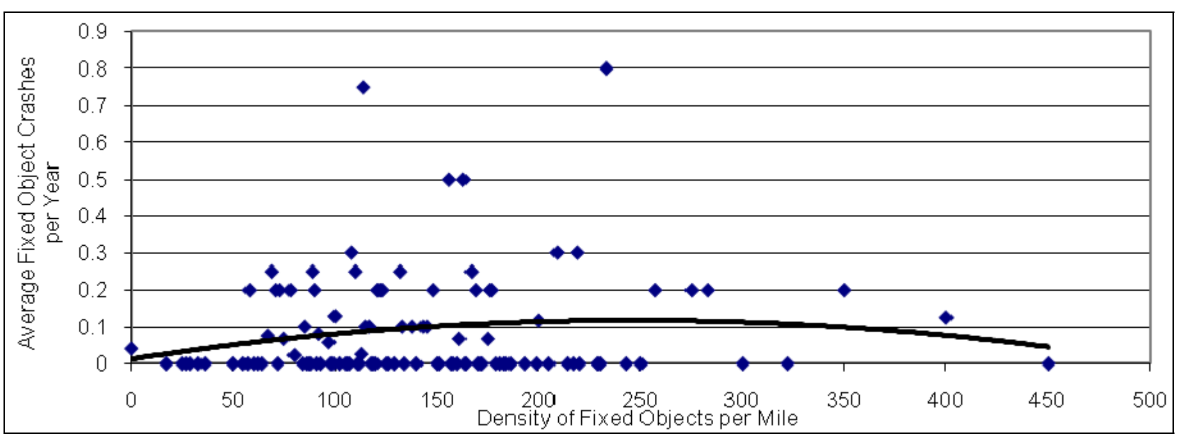

Figure 5-47. Density in block analysis

5.8.3. 15 m Analysis

In the 15 m analysis, the fixed object density did not show a relationship to the average number of fixed object crashes. Figure 5-48 illustrates the average number of fixed object crashes per year in relation to the fixed object density. The figure does not show a direct relationship between the two variables.

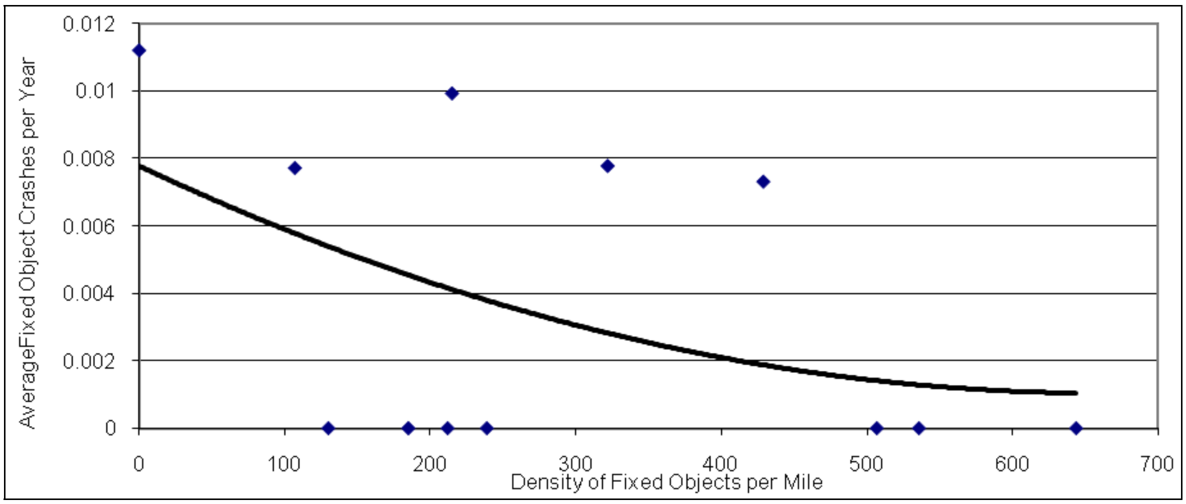

Figure 5-48. Density in 15 m analysis

5.9. Cumulative Percent Crashes

To determine where a majority of the fixed object crashes occurred, a cumulative percent analysis was conducted for each of the three sections (segment, block, and 15 m) for each of the three setback measurements (minimum, average, and 15th percentile). According to this analysis, a 5 ft clear zone for fixed objects would be the most effective for preventing fixed object crashes. Of the 53 predictors described in this section, 43 show a highly linear relationship between setback distance and the number of fixed object crashes within 5 ft of the pavement edge. According to Figures 5-49 through 5-102, widening the clear zone beyond 5 ft will only have a marginal rate of return, and thus a larger clear zone would not be an economically efficient design requirement. The cumulative percent analysis also found that as the speed limit or ADT increased, the setback distance where 90% of fixed object crashes occur only increased by one or 2 ft on average. It is also worth noting that when the segment, block, and 15 m analyses were carried out after dividing the data by speed limit or ADT, the setback distance where 90% of fixed object crashes occur decreased in all situations.

5.9.1. Segment Analysis

The segment analysis, shown in Figures 5-49 through 5-51, indicates varying distances where 90% of fixed object crashes occur. The minimum setback and 15th percentile setback measurements showed that 90% of fixed object crashes occur within approximately 5 ft of the pavement edge, while the average measurement showed that 90% of fixed object crashes occur within approximately 10 ft of the pavement edge. The minimum setback measurement also shows a highly linear relationship within the first 2 ft of the pavement edge, and the 15th percentile measurement shows a highly linear relationship within the first 3 ft of the pavement edge.

The same analysis was completed for each speed limit, shown in Figures 5-52 through 5-60. At a 30 mph speed limit, the setback distance where 90% of fixed object crashes occur for the minimum, average, and 15th percentile setback measurements were 2 ft, 7 ft, and 5 ft, respectively. At a 35 mph speed limit, the setback distance where 90% of fixed object crashes occur for the minimum, average, and 15th percentile setback measurements were 2 ft, 9 ft, and 4 ft, respectively. At a 40 mph speed limit, there were only two observations, and thus a significant conclusion cannot be made.

The same setback measurement analysis was done for the ADT rates of 1,500–6,000 and over 6,000, shown in Figures 5-61 through 5-66. At an ADT of 1,500–6,000, the setback distance where 90% of fixed object crashes occur for the minimum, average, and 15th percentile setback measurements were 1.2 ft, 6 ft, and 3 ft, respectively. At an ADT of over 6,000, the setback distance where 90% of fixed object crashes occur for the minimum, average, and 15th percentile setback measurements were 2 ft, 10 ft, and 3 ft, respectively.

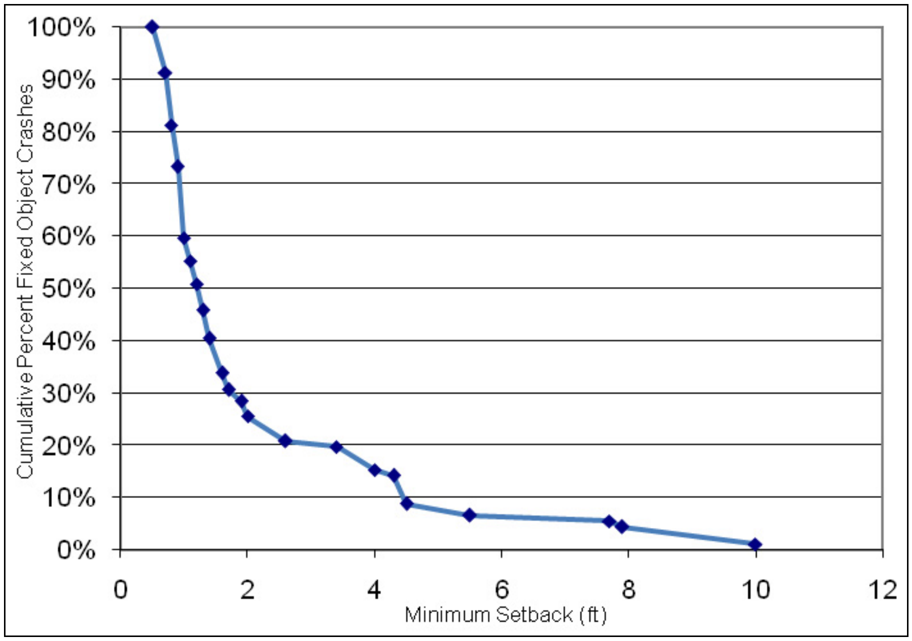

Figure 5-49. Cumulative percent minimum setback in segment analysis

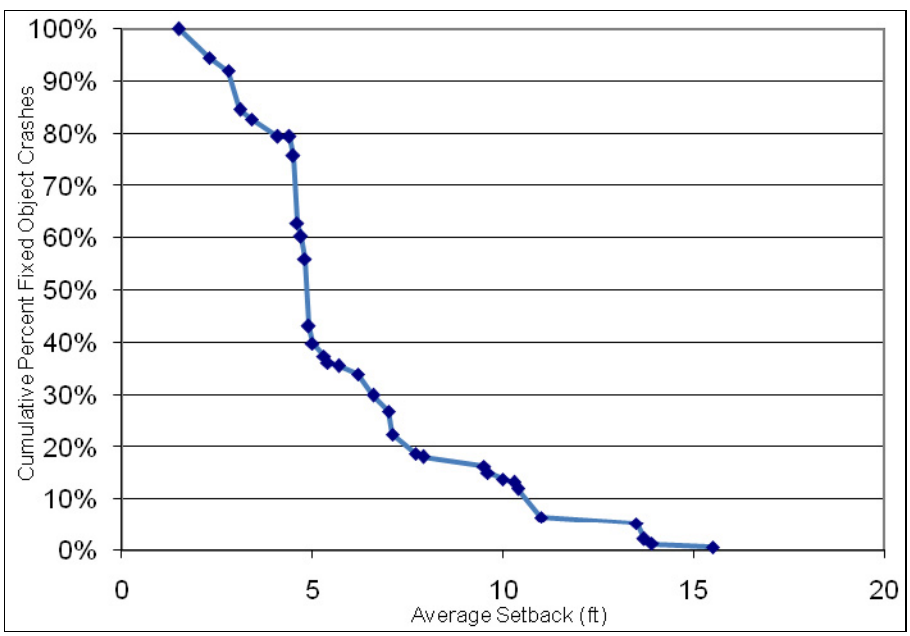

Figure 5-50. Cumulative percent average setback in segment analysis

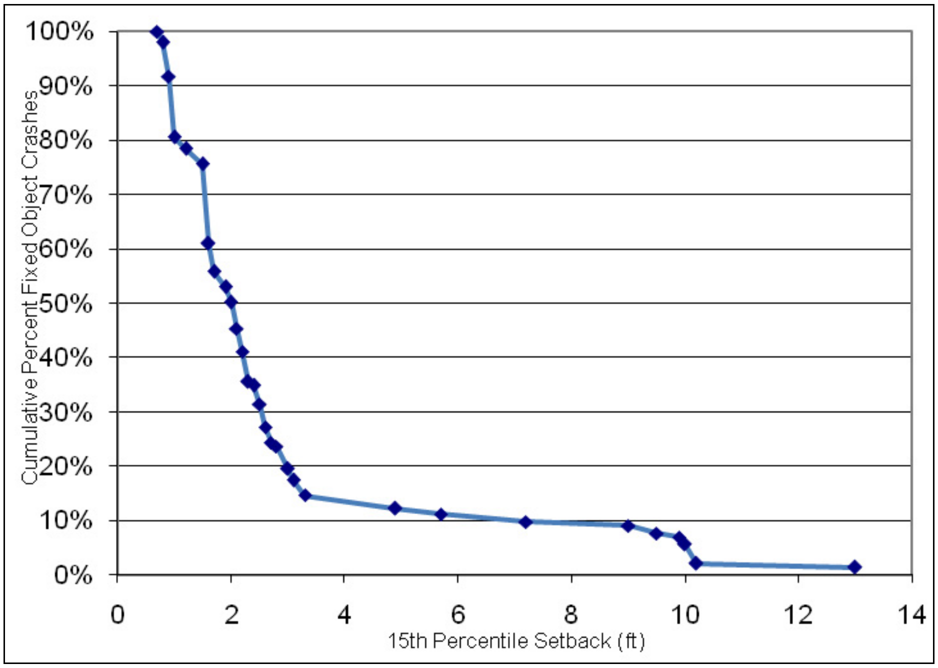

Figure 5-51. Cumulative percent 15th percentile setback in segment analysis

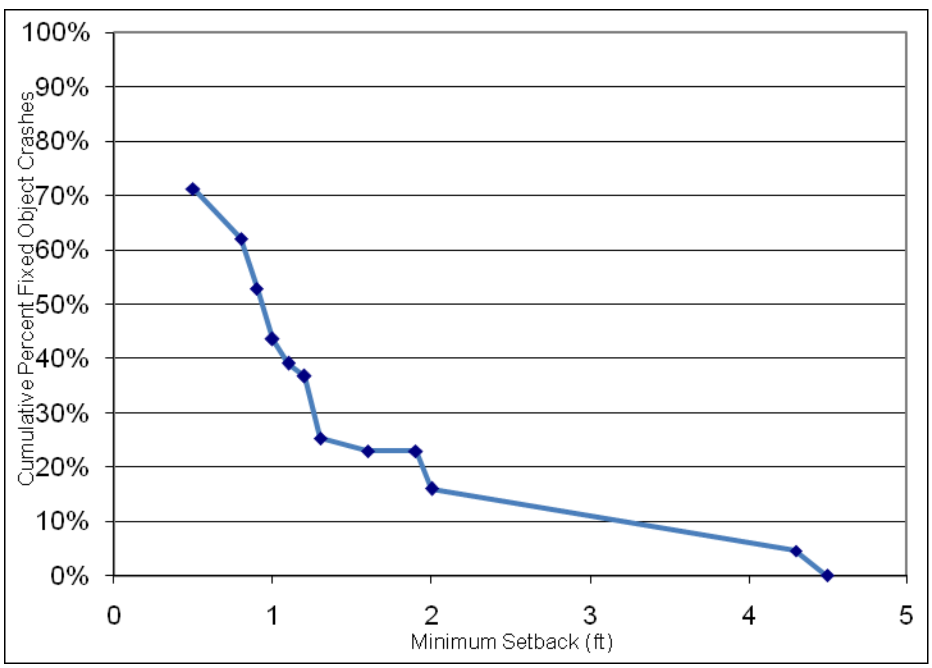

Figure 5-52. Cumulative percent minimum setback in segment analysis at 30 mph

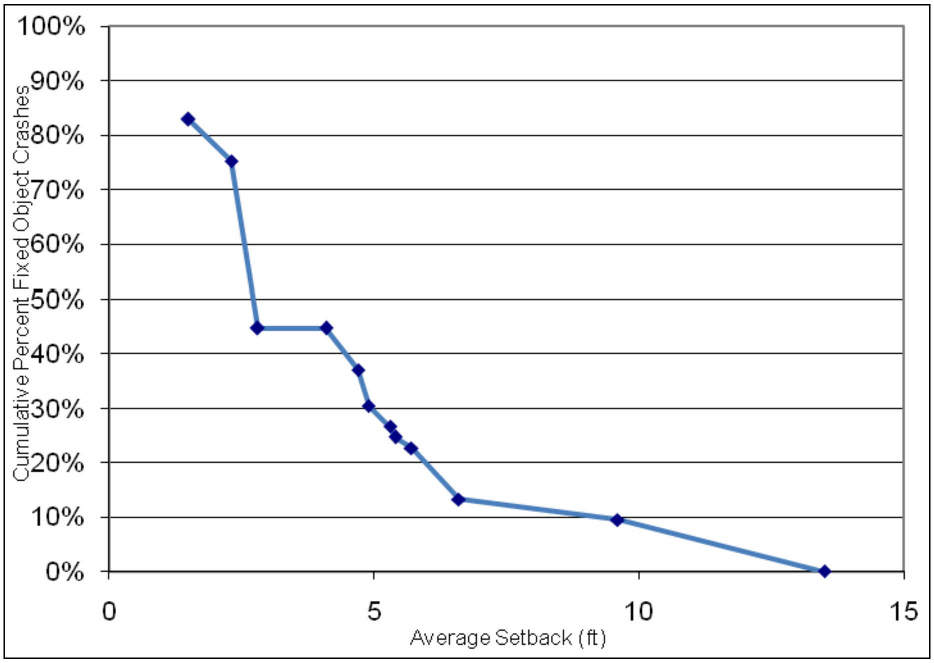

Figure 5-53. Cumulative percent average setback in segment analysis at 30 mph

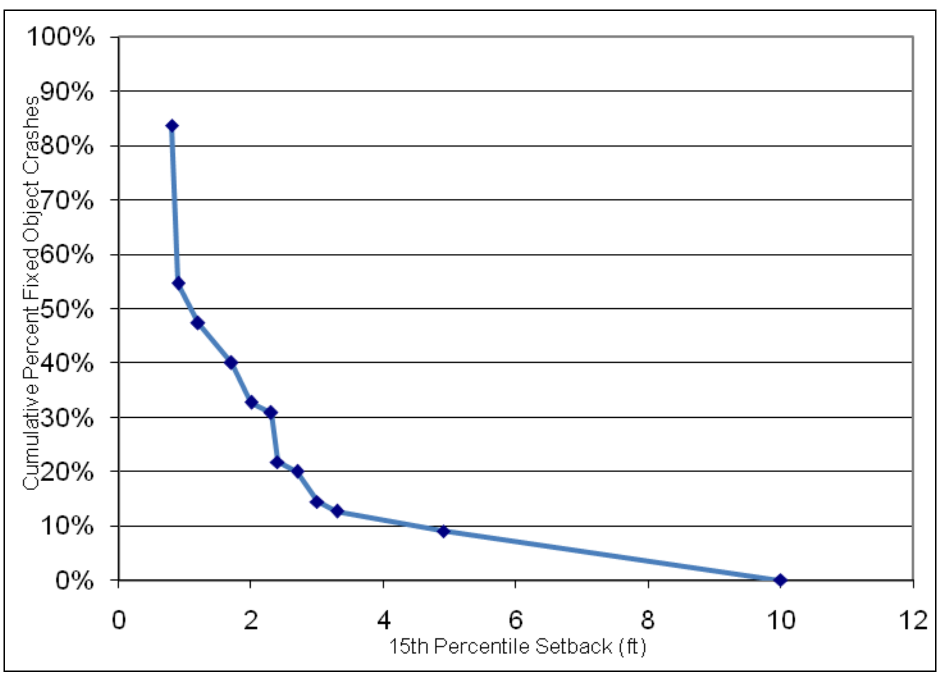

Figure 5-54. Cumulative percent 15th percentile setback in segment analysis at 30 mph

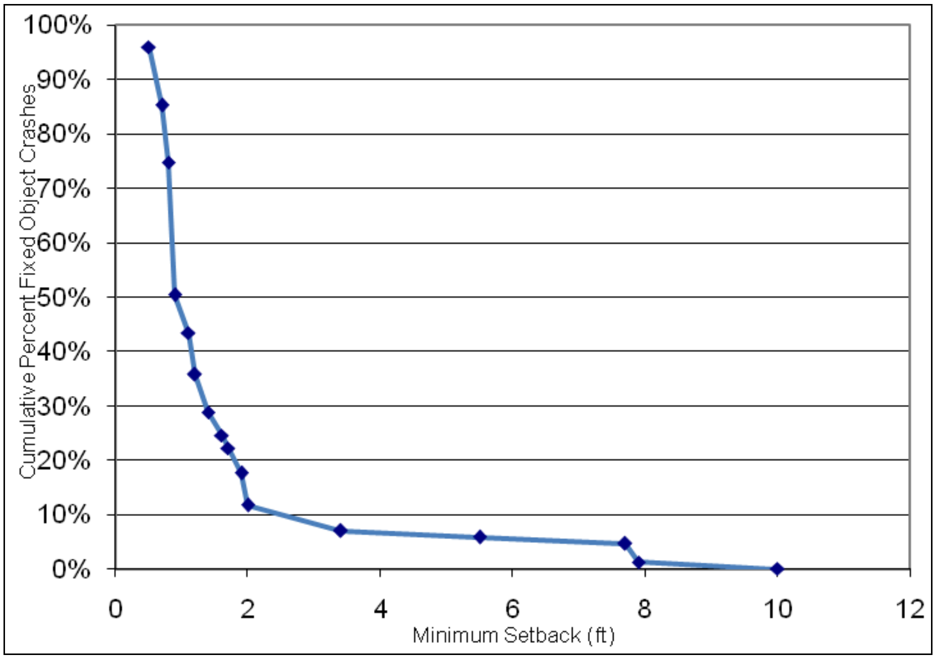

Figure 5-55. Cumulative percent minimum setback in segment analysis at 35 mph

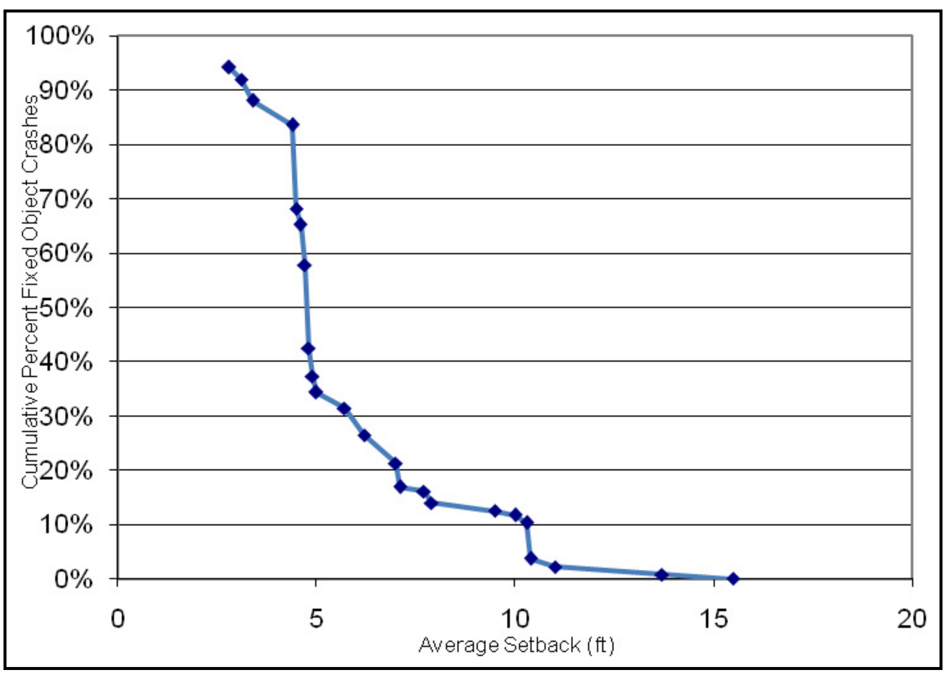

Figure 5-56. Cumulative percent average setback in segment analysis at 35 mph

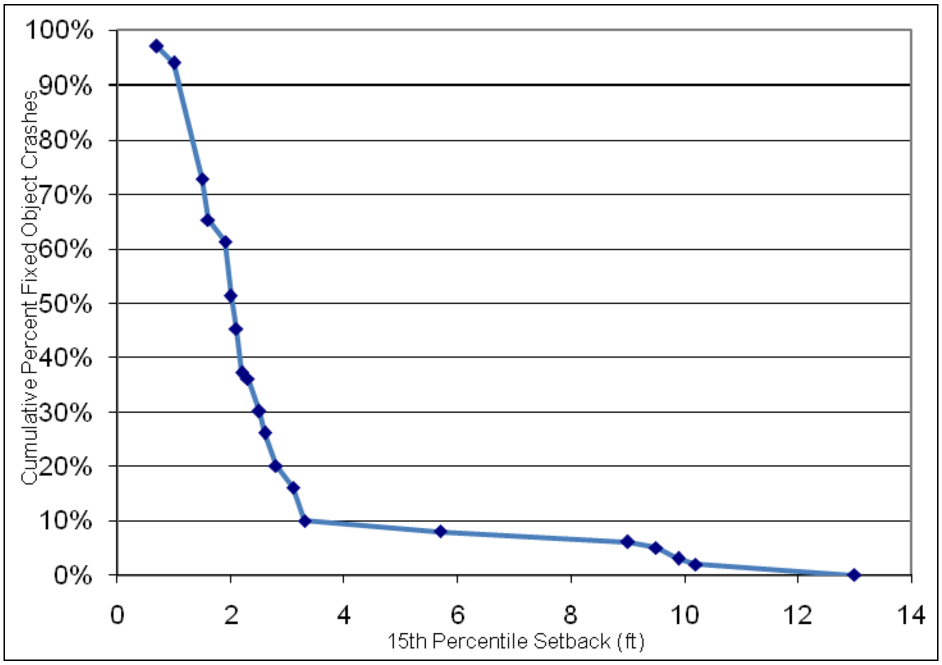

Figure 5-57. Cumulative percent 15th percentile setback in segment analysis at 35 mph

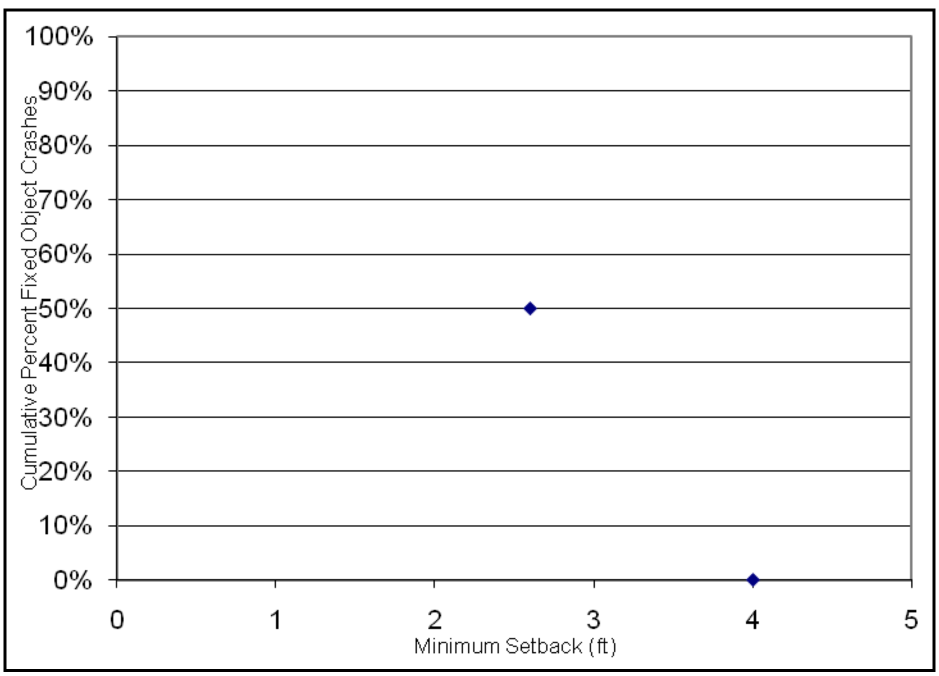

Figure 5-58. Cumulative percent minimum setback in segment analysis at 40 mph

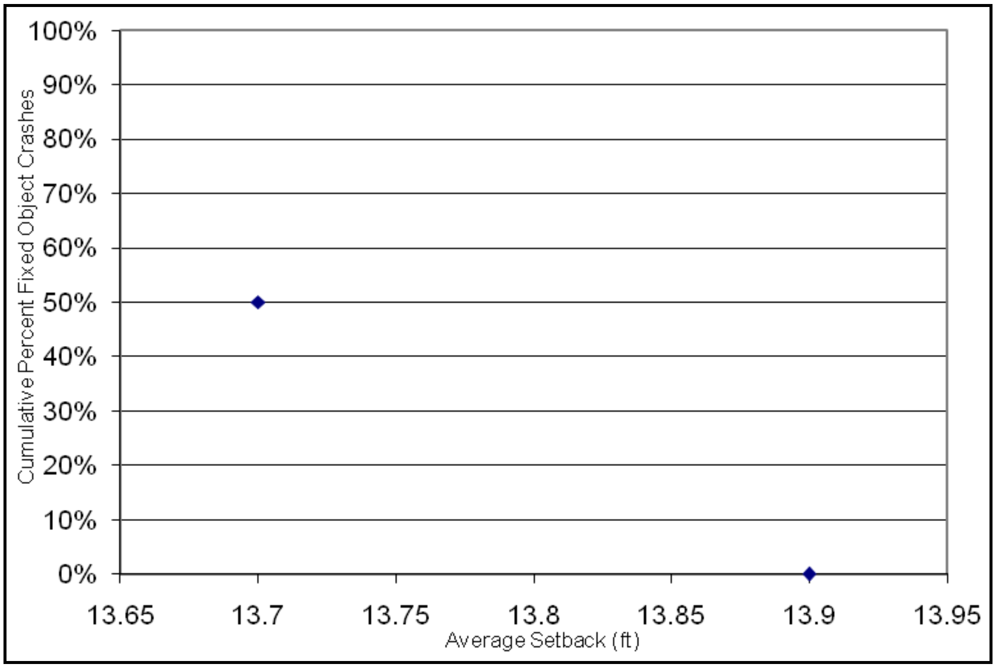

Figure 5-59. Cumulative percent average setback in segment analysis at 40 mph

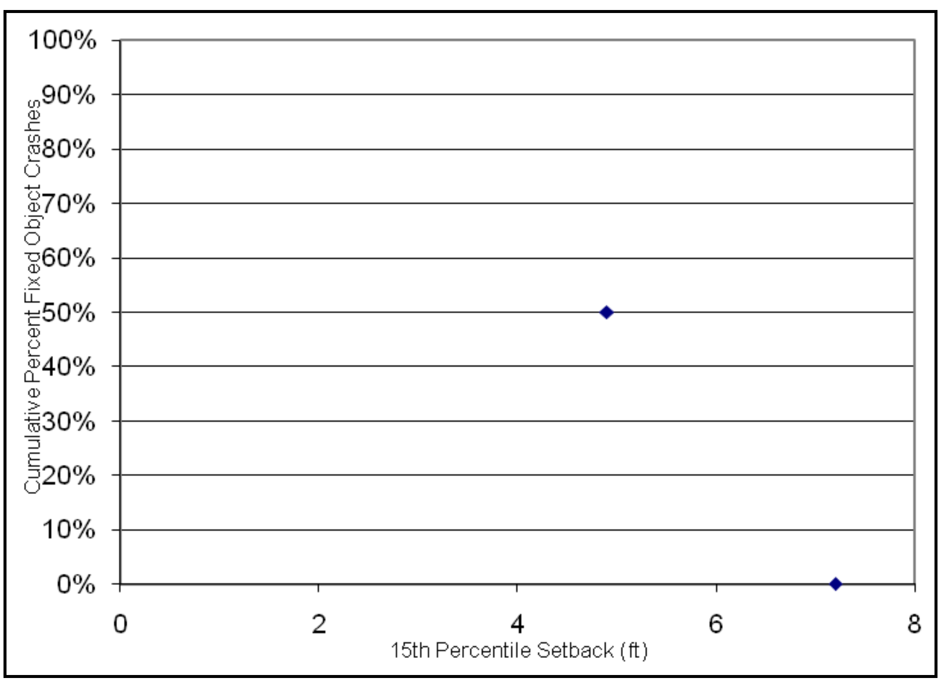

Figure 5-60. Cumulative percent 15th percentile setback in segment analysis at 40 mph

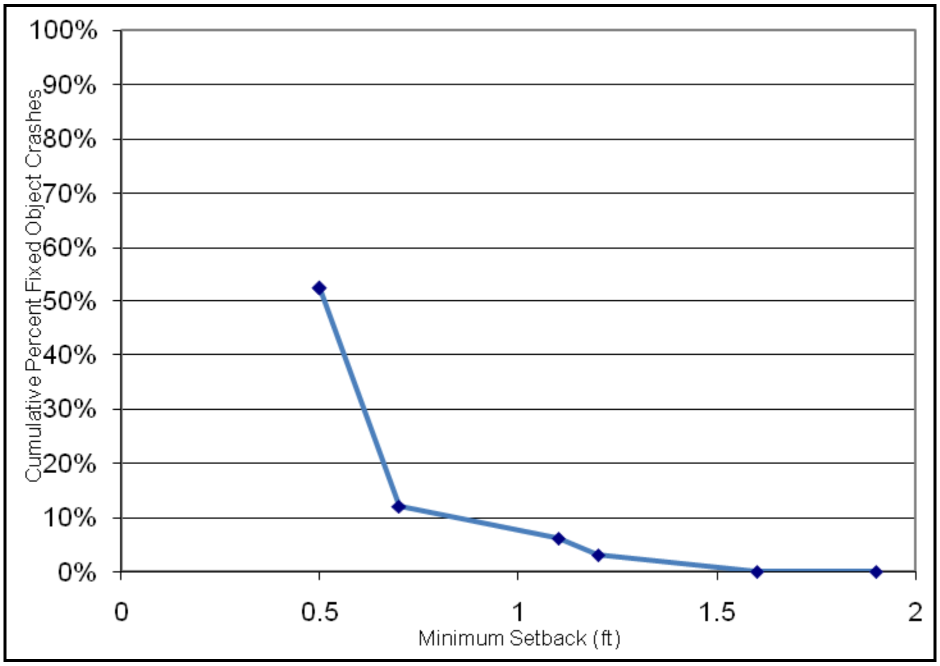

Figure 5-61. Cumulative percent minimum setback in segment analysis at ADT 1,500–6,000

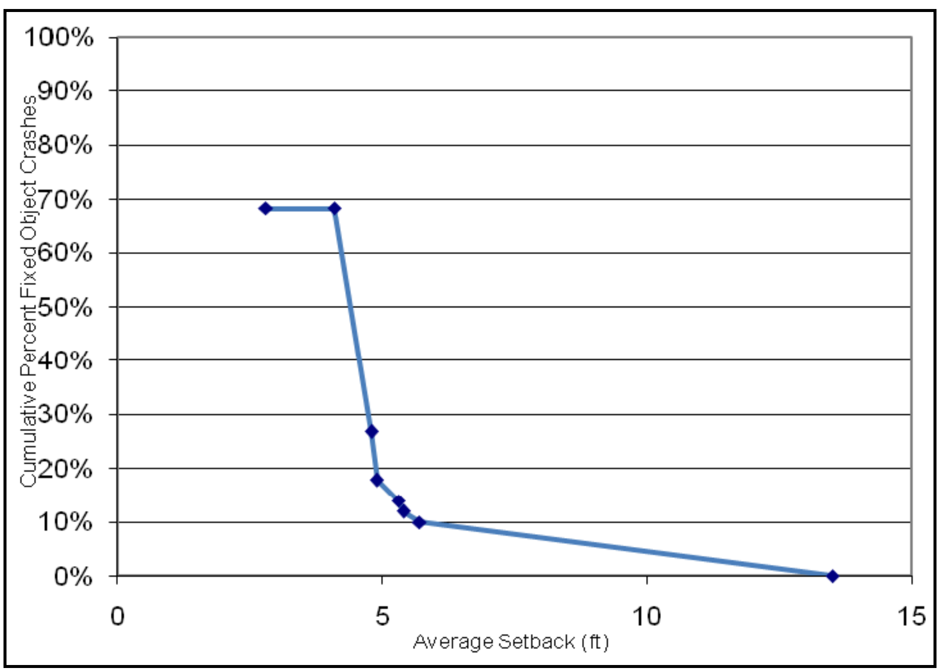

Figure 5-62. Cumulative percent average setback in segment analysis at ADT 1,500–6,000

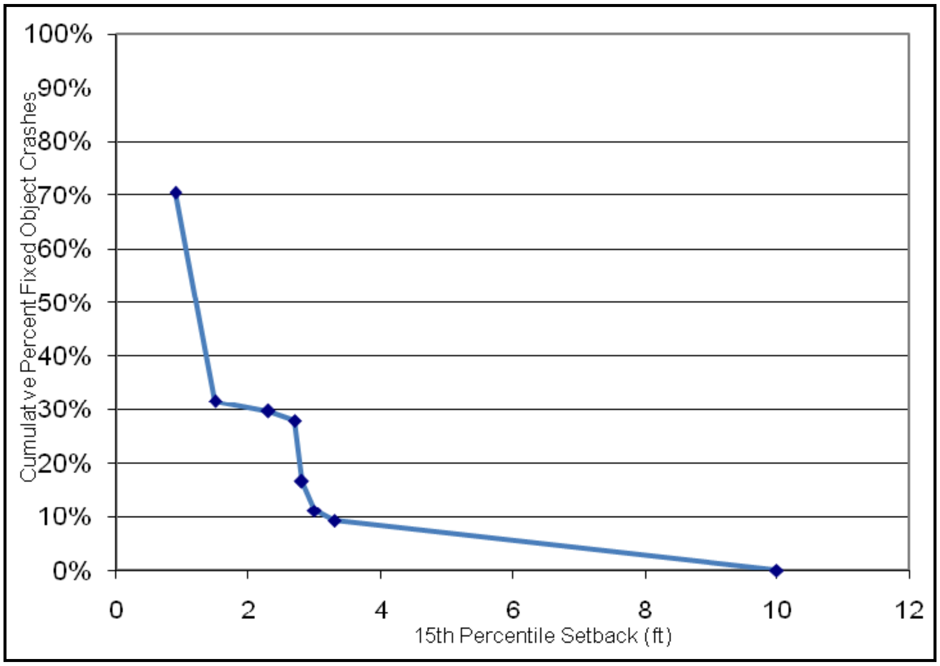

Figure 5-63. Cumulative percent 15th percentile setback in segment analysis at ADT 1,500–6,000

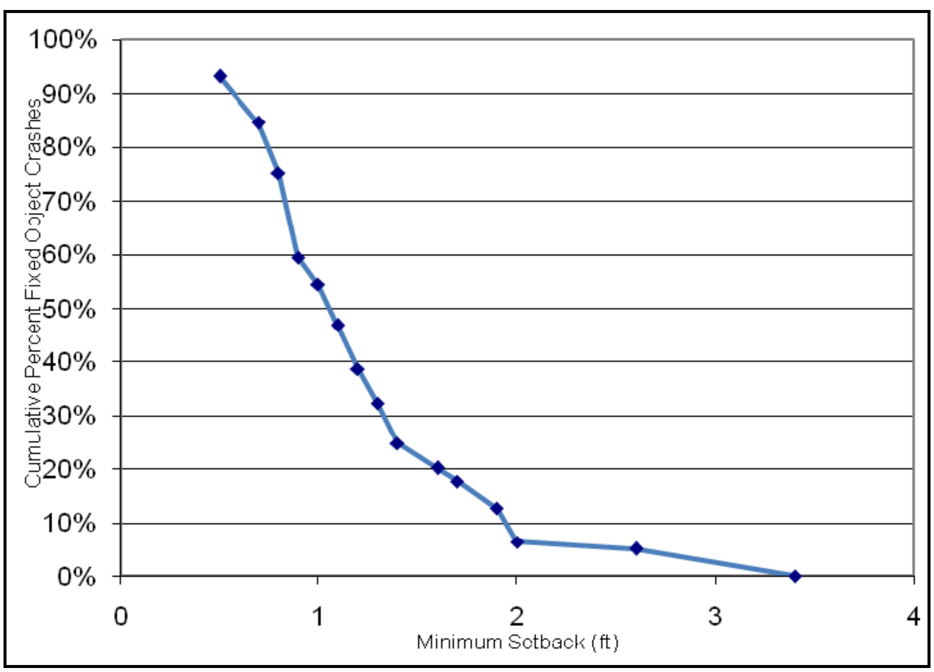

Figure 5-64. Cumulative percent minimum setback in segment analysis at ADT over 6,000

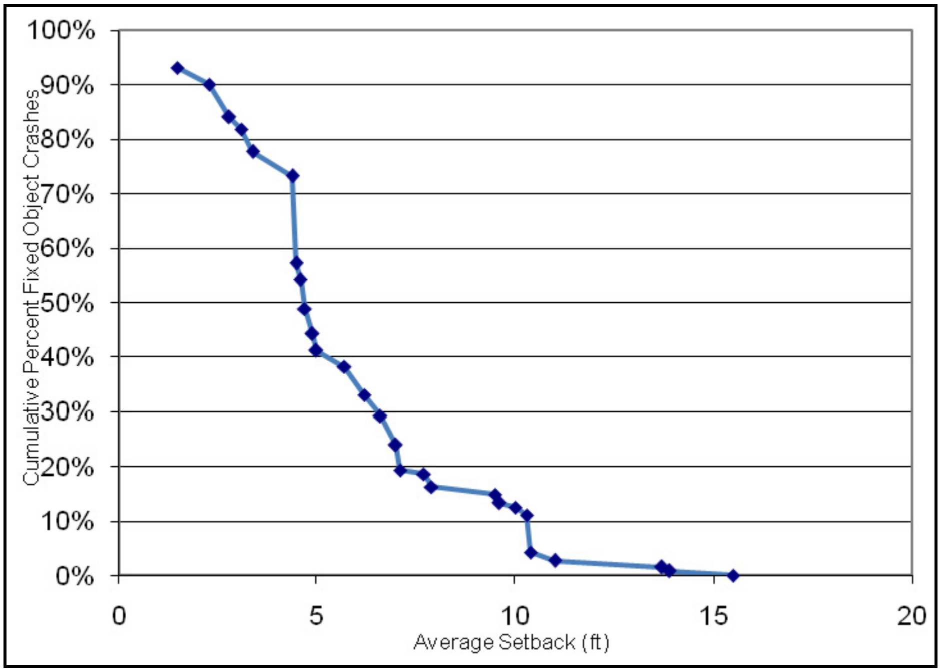

Figure 5-65. Cumulative percent average setback in segment analysis at ADT over 6,000

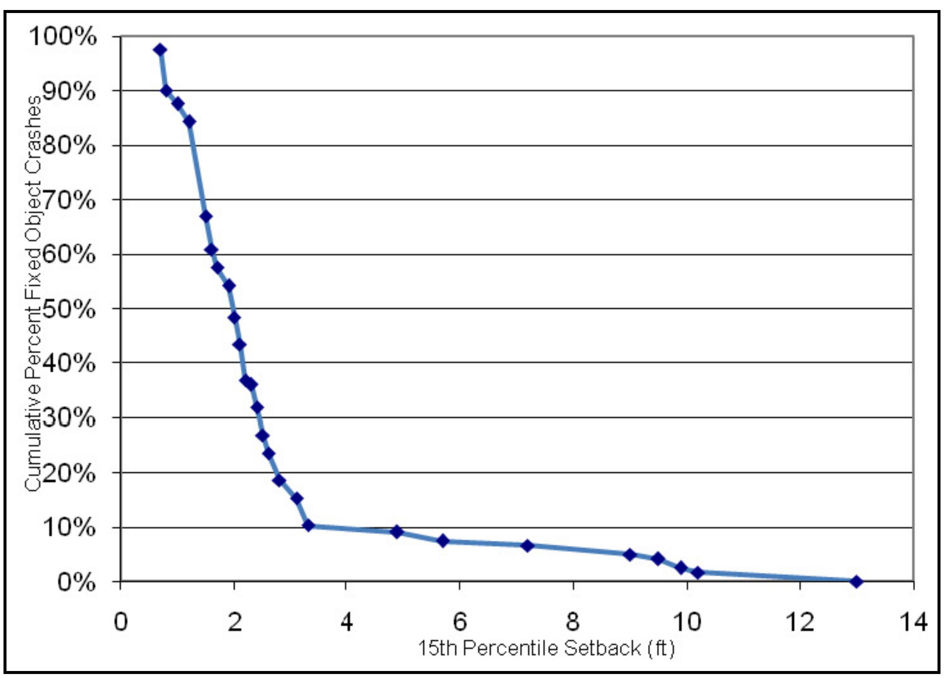

Figure 5-66. Cumulative percent 15th percentile setback in segment analysis at ADT

over 6,000

5.9.2. Block Analysis

The block analysis, shown in Figures 5-67 through 5-69, indicates varying distances where 90% of fixed object crashes occur. The minimum setback measurement showed that 90% of fixed object crashes occur within approximately 7 ft of the pavement edge. The average setback measurement showed that 90% of fixed object crashes occur within approximately 14 ft of the pavement edge, and the 15th percentile measurement showed that 90% of fixed object crashes occur within approximately 3 ft of the pavement edge. The minimum and 15th percentile setback measurements also show a highly linear relationship within the first 3 ft of the pavement edge. The average setback measurement shows a highly linear relationship within the first 5 ft from the pavement edge.

The same analysis was done for each speed limit, as shown in Figures 5-70 through 5-78. At a 30 mph speed limit, the setback distance where a majority of fixed object crashes occurred for the minimum, average, and 15th percentile setback measurements were 3 ft, 12 ft, and 3 ft, respectively. At a 35 mph speed limit, the setback distance where a majority of fixed object crashes occurred for the minimum, average, and 15th percentile setback measurements were 4 ft, 12 ft, and 4 ft, respectively. At a 40 mph speed limit, there were only two observations, and thus it is not significant to make a conclusion for this speed limit.

The same analysis was done again for the ADT ranges of 1,500–6,000 and over 6,000, shown in Figures 5-79 through 5-84. At an ADT of 1,500–6,000, the setback distance where a majority of fixed object crashes occurred for the minimum, average, and 15th percentile setback measurements were 4 ft, 12 ft, and 5 ft, respectively. At an ADT of over 6,000, the setback distance where a majority of fixed object crashes occurred for the minimum, average, and 15th percentile setback measurements were 5 ft, 14 ft, and 12 ft, respectively.

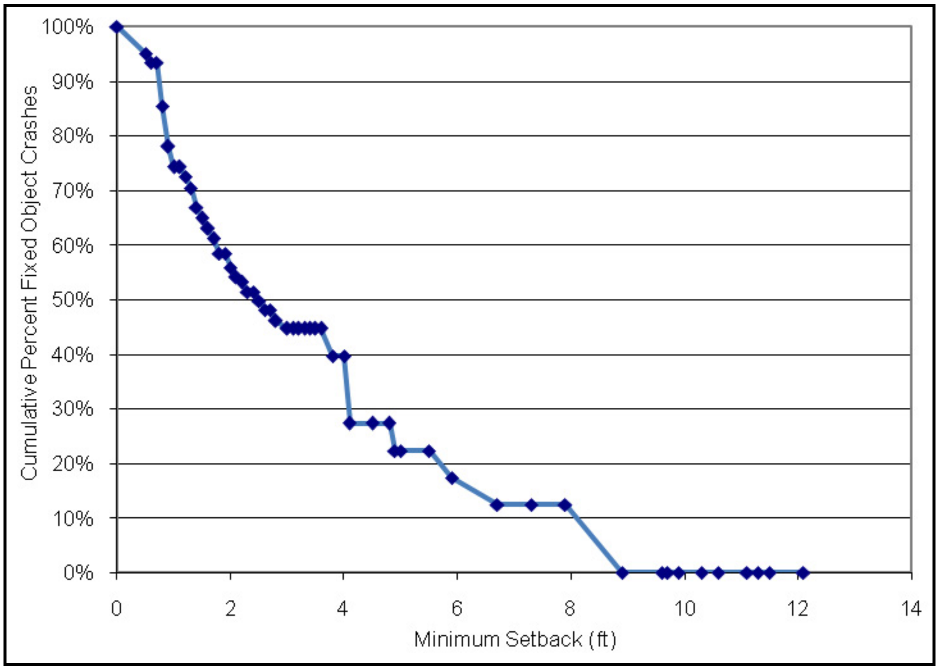

Figure 5-67. Cumulative percent minimum setback in block analysis

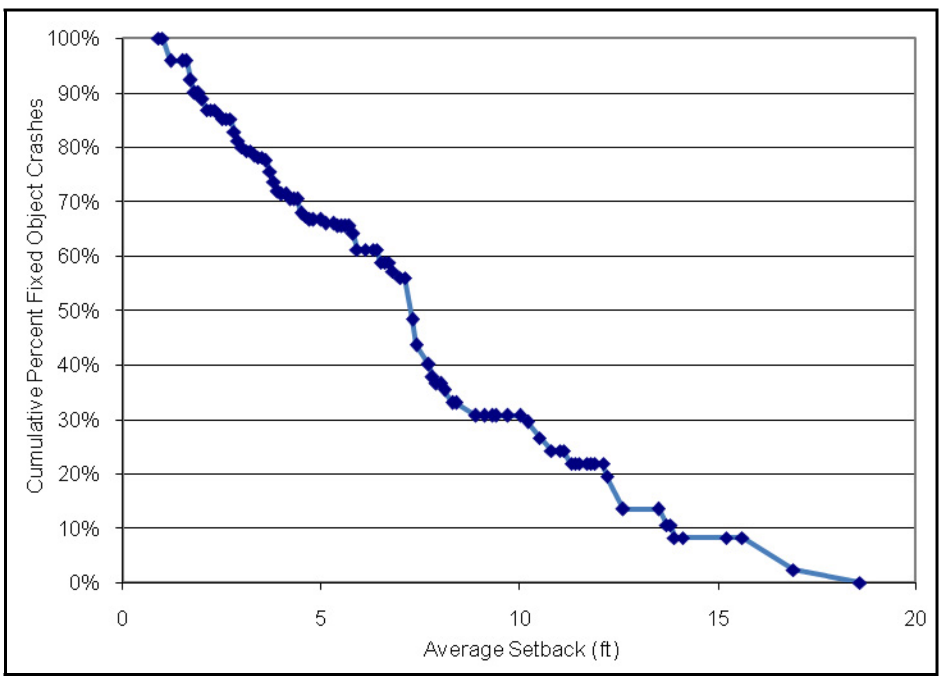

Figure 5-68. Cumulative percent average setback in block analysis

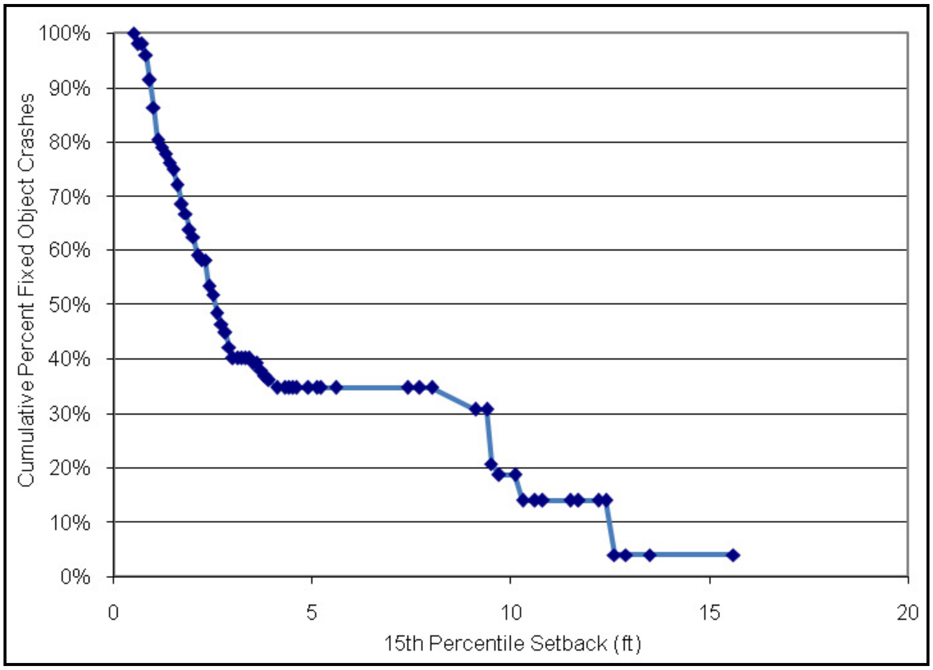

Figure 5-69. Cumulative percent 15th percentile setback in block analysis

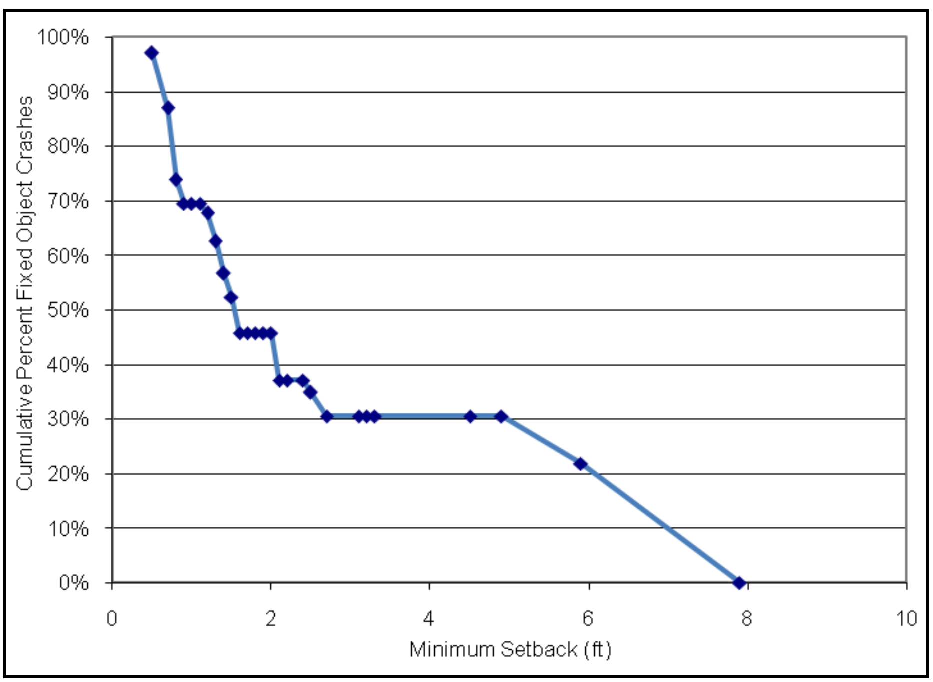

Figure 5-70. Cumulative percent minimum setback in block analysis at 30 mph

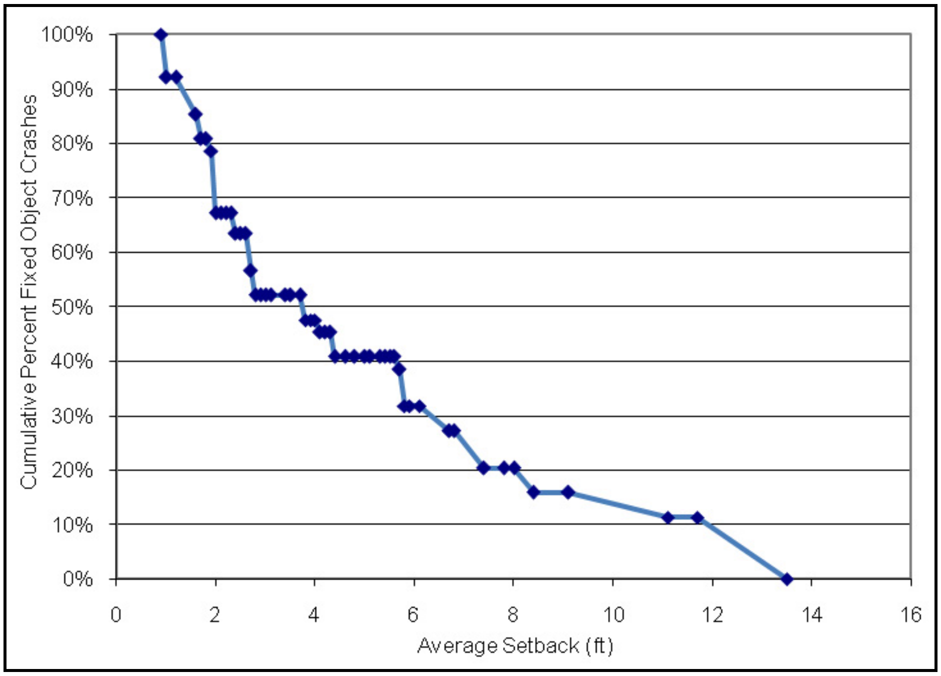

Figure 5-71. Cumulative percent average setback in block analysis at 30 mph

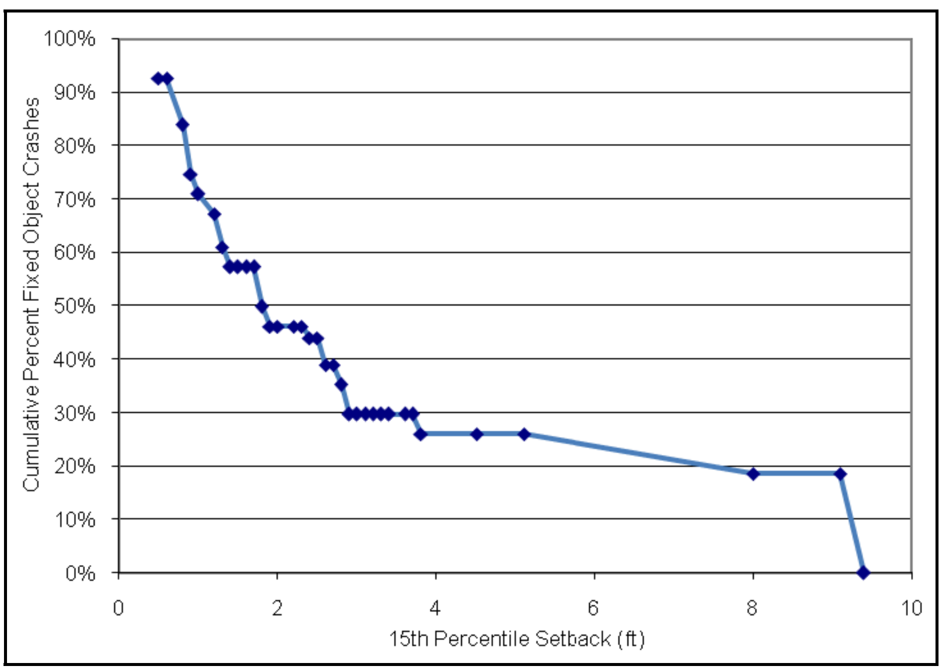

Figure 5-72. Cumulative percent 15th percentile setback in block analysis at 30 mph

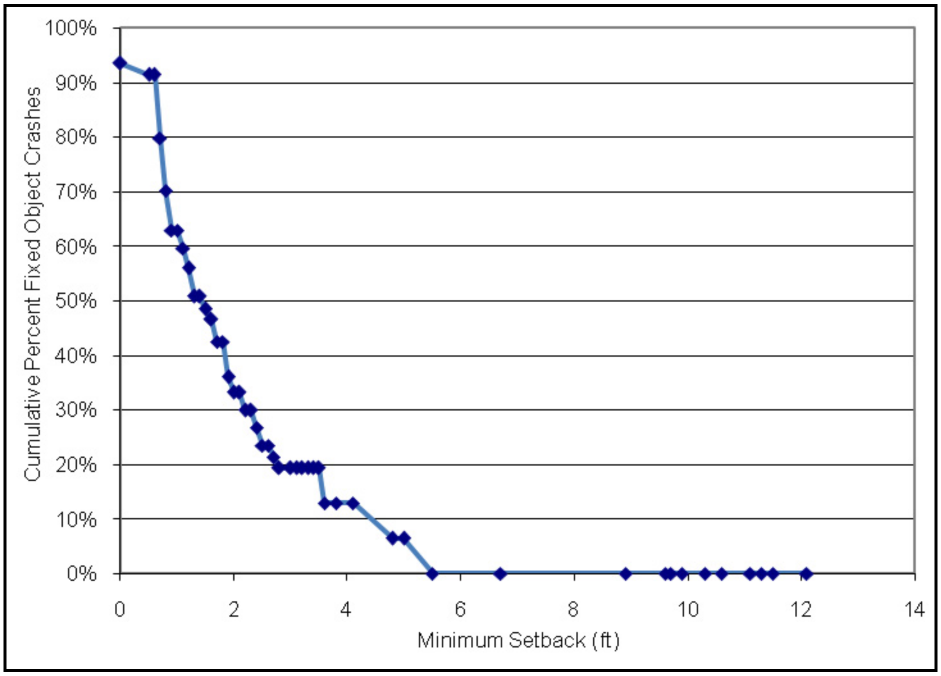

Figure 5-73. Cumulative percent minimum setback in block analysis at 35 mph

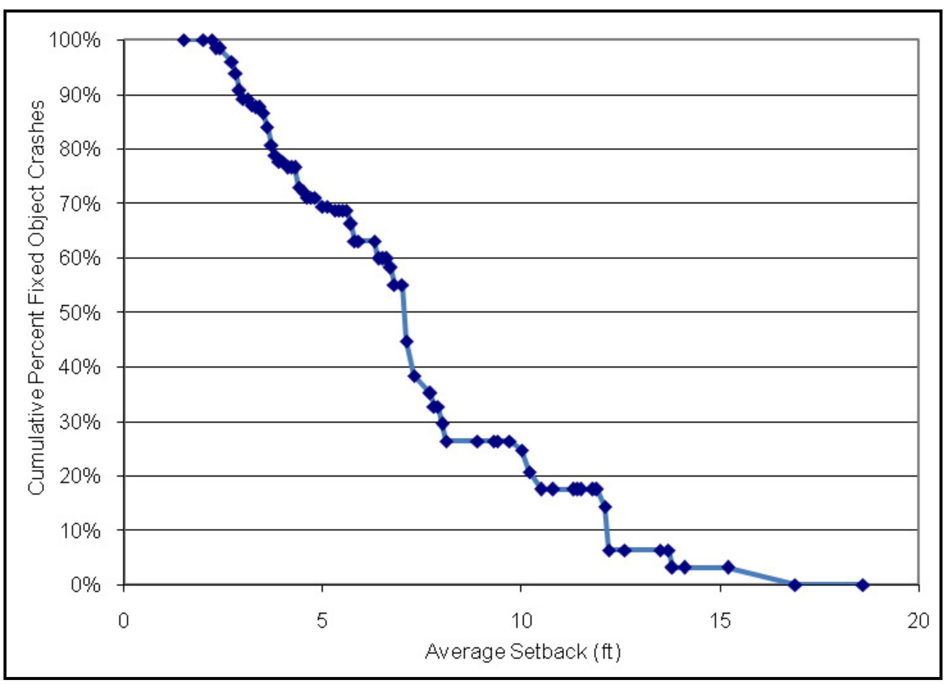

Figure 5-74. Cumulative percent average setback in block analysis at 35 mph

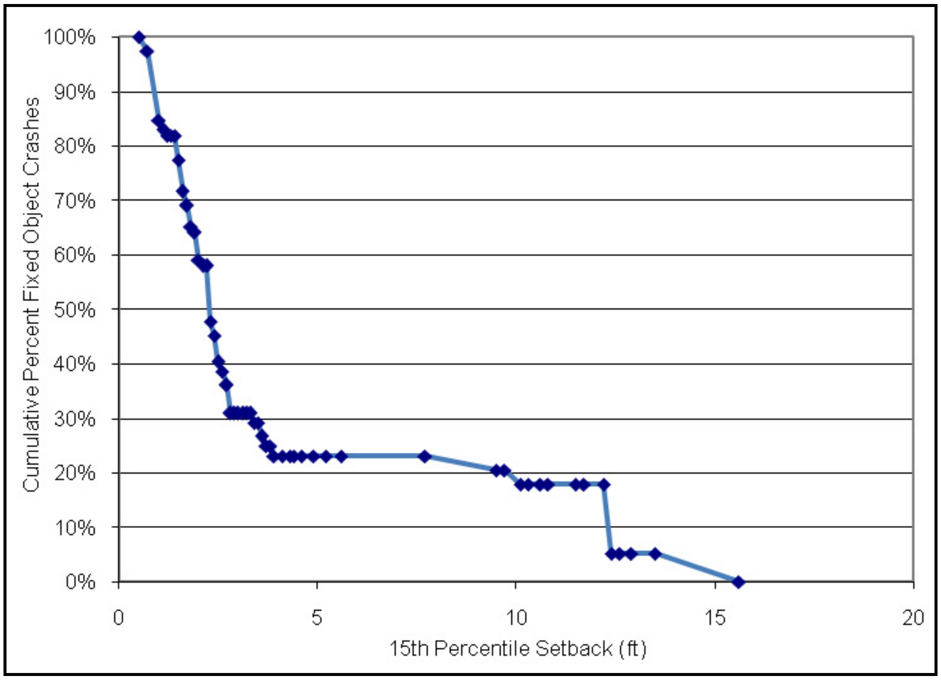

Figure 5-75. Cumulative percent 15th percentile setback in block analysis at 35 mph

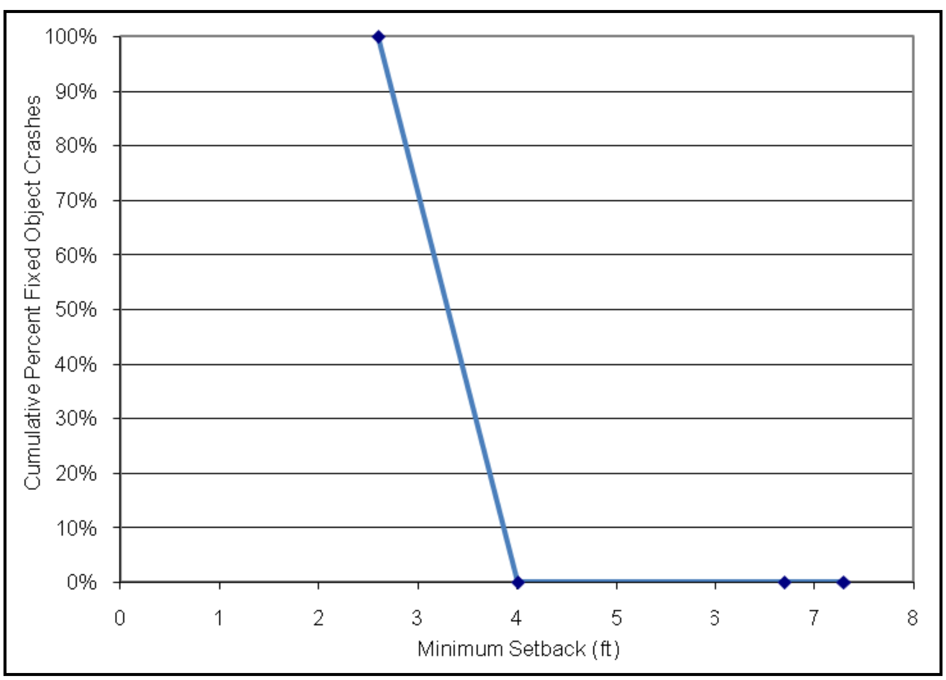

Figure 5-76. Cumulative percent minimum setback in block analysis at 40 mph

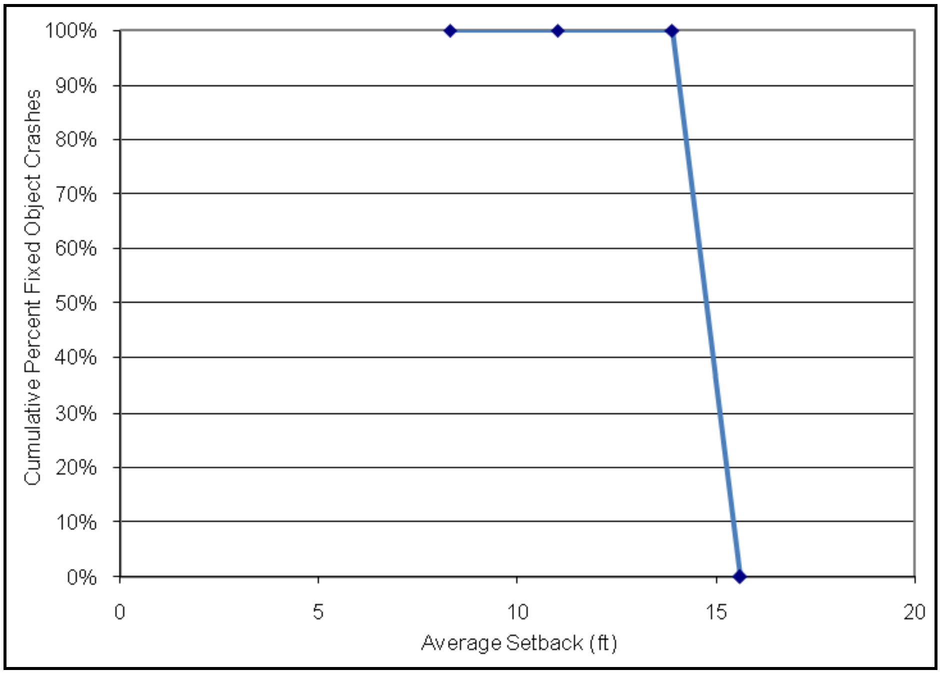

Figure 5-77. Cumulative percent average setback in block analysis at 40 mph

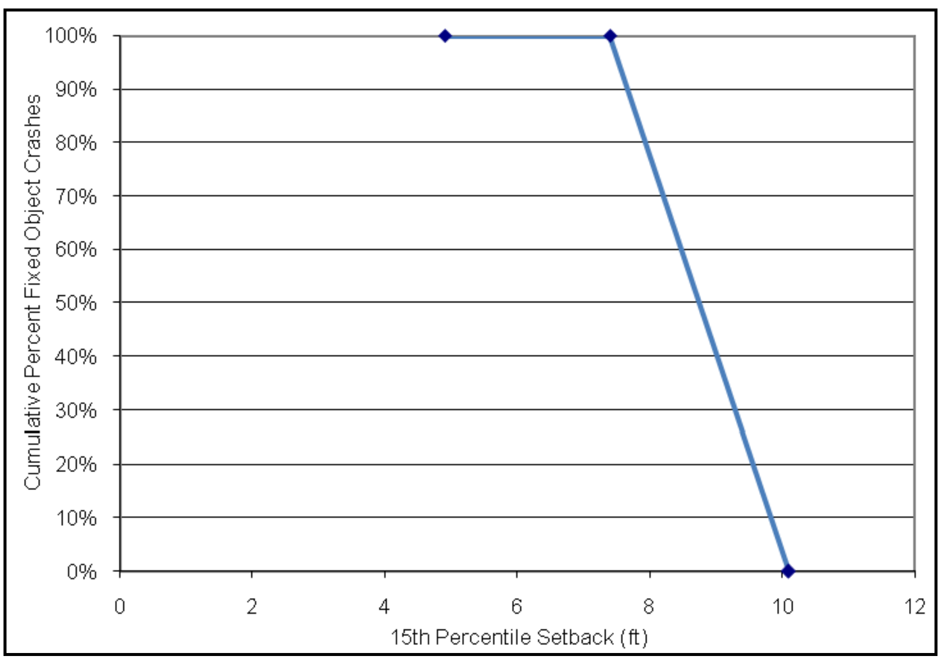

Figure 5-78. Cumulative percent 15th percentile setback in block analysis at 40 mph

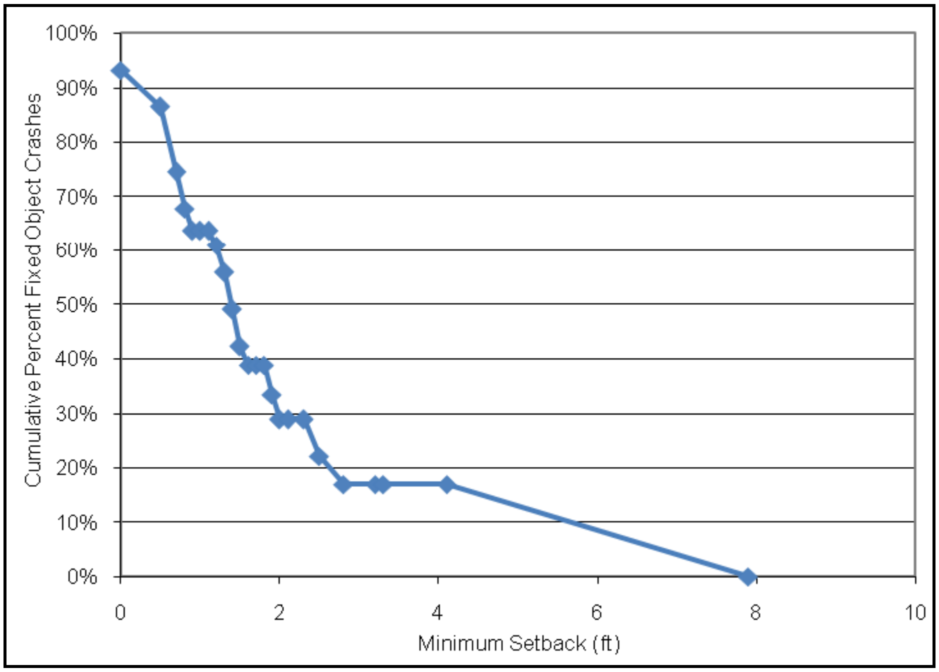

Figure 5-79. Cumulative percent minimum setback in block analysis at ADT 1,500–6,000

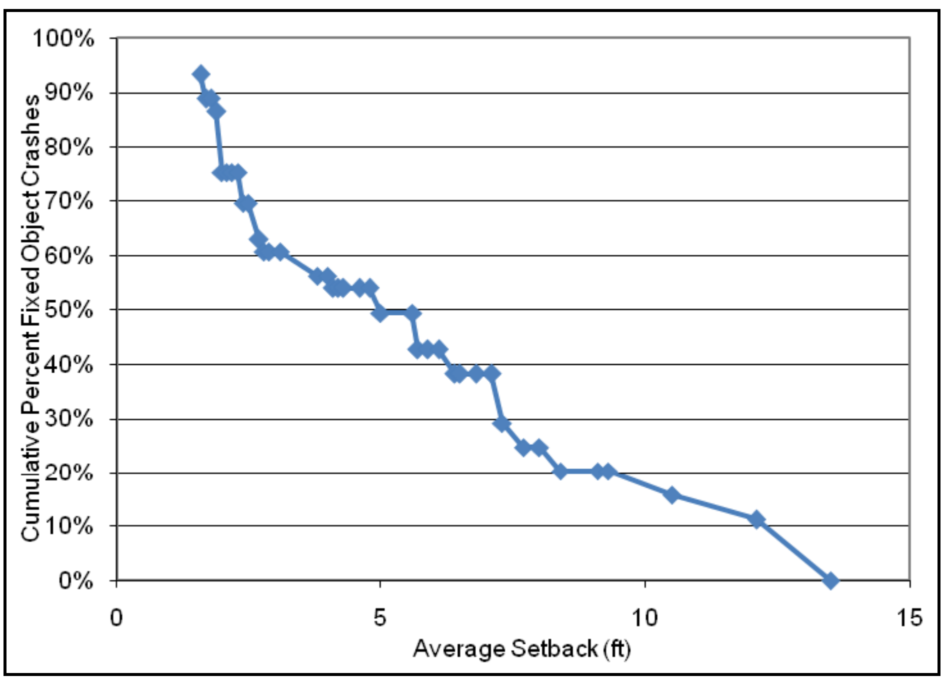

Figure 5-80. Cumulative percent average setback in block analysis at ADT 1,500–6,000

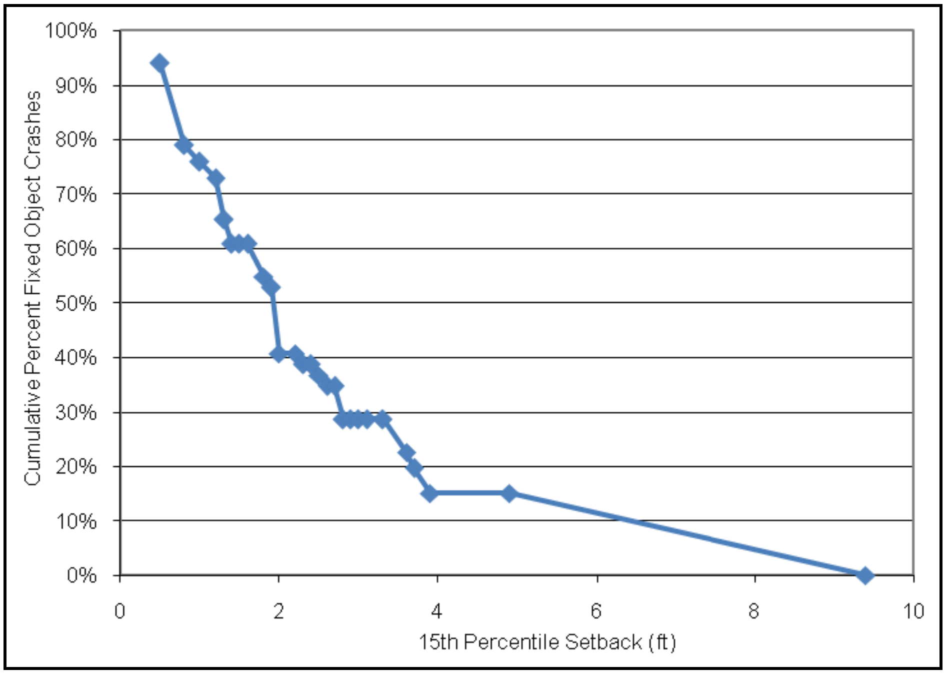

Figure 5-81. Cumulative percent 15th percentile setback in block analysis at ADT 1,500–6,000

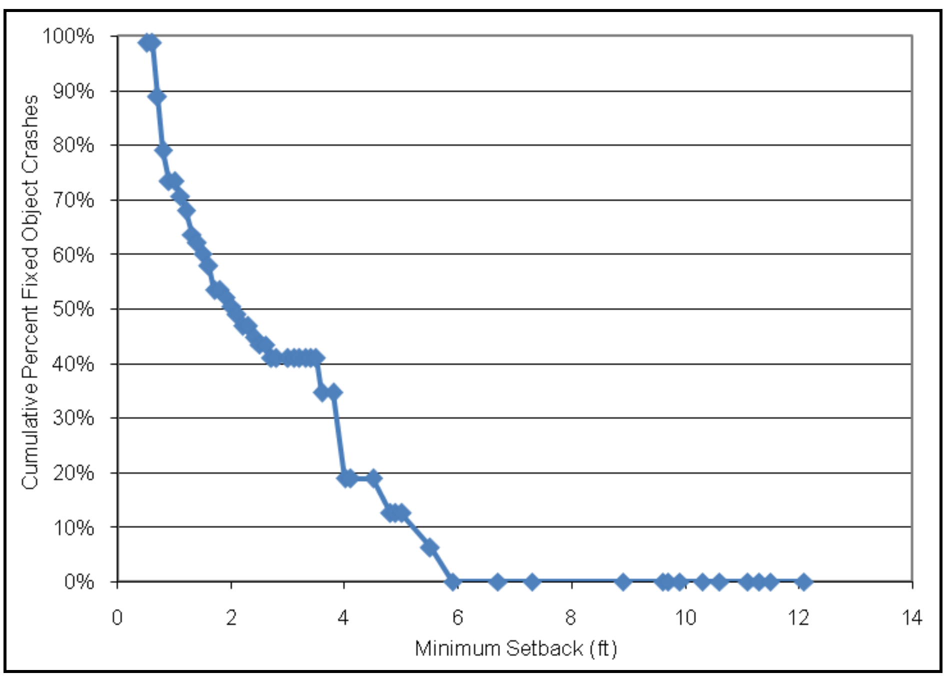

Figure 5-82. Cumulative percent minimum setback in block analysis at ADT 6,000

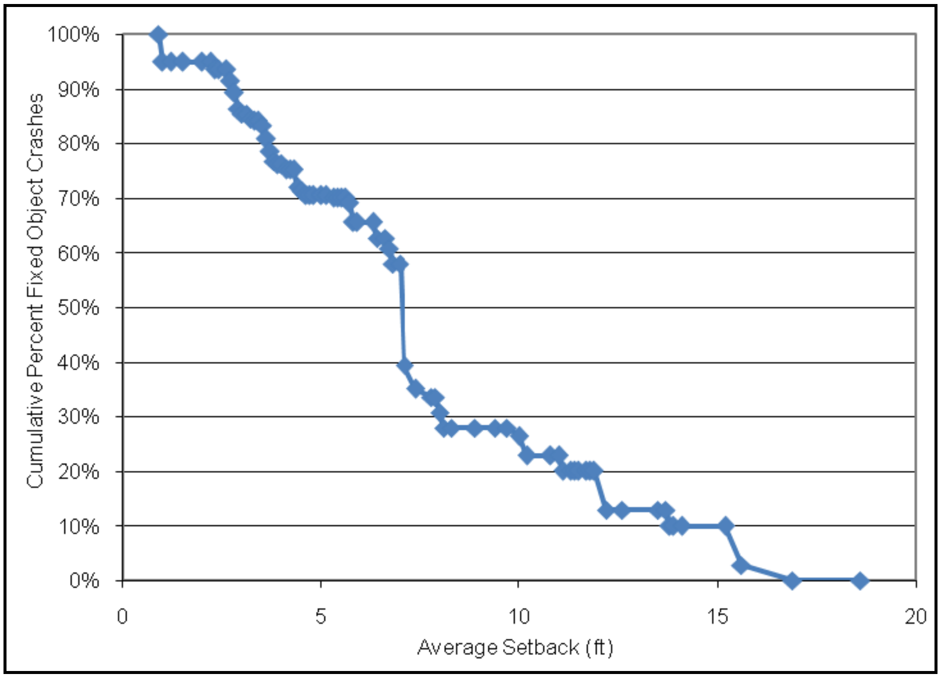

Figure 5-83. Cumulative percent average setback in block analysis at ADT 6,000

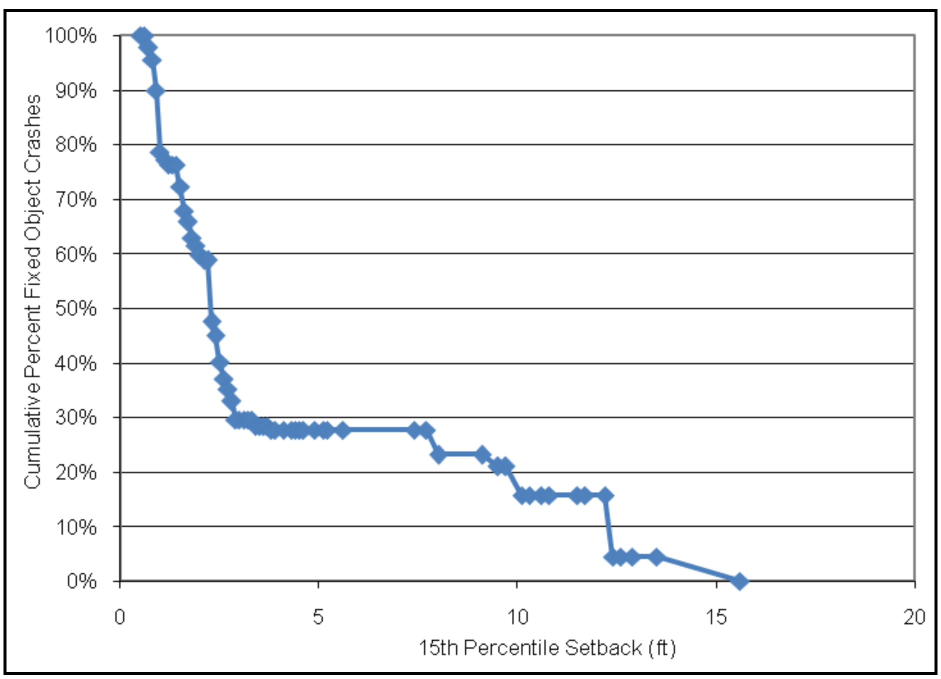

Figure 5-84. Cumulative percent 15th percentile setback in block analysis at ADT 6,000

5.9.3. 15 m Analysis

The 15 m analysis, shown in Figures 5-85 through 5-87, indicates the most consistent set of distances where 90% of fixed object crashes occur. The minimum setback, average setback, and 15th percentile setback measurement showed that 90% of fixed object crashes occur within approximately 20 ft of the pavement edge. These figures also show a highly linear trend within 5 ft of the pavement edge. This linear trend over the first 5 ft of setback suggests that the greatest crash reduction benefit will be achieved by placing fixed objects at an offset of 5 ft from the edge of the pavement.

The same analysis was completed for each speed limit, shown in Figures 5-88 through 5-96. At a 30 mph speed limit, the setback distances where a majority of fixed object crashes occurred for the minimum, average, and 15th percentile setback measurements were all 4 ft. At a 35 mph speed limit, the setback distance where a majority of fixed object crashes occurred for the minimum, average, and 15th percentile setback measurements were all 5 ft. At a 40 mph speed limit, there were only a few observations, and thus it is not significant to make a conclusion.

The same analysis was completed again for the ADT ranges of 1,500–6,000 and over 6,000, shown in Figures 5-97 through 5-102. At an ADT of 1,500–6,000, the setback distances where a majority of fixed object crashes occurred for the minimum, average, and 15th percentile setback measurements were 10 ft, 11 ft, and 10 ft, respectively. At an ADT of over 6,000 the setback distance where a majority of fixed object crashes occurred for the minimum, average, and 15th percentile setback measurements were at 12 ft, 18 ft, and 12 ft, respectively.

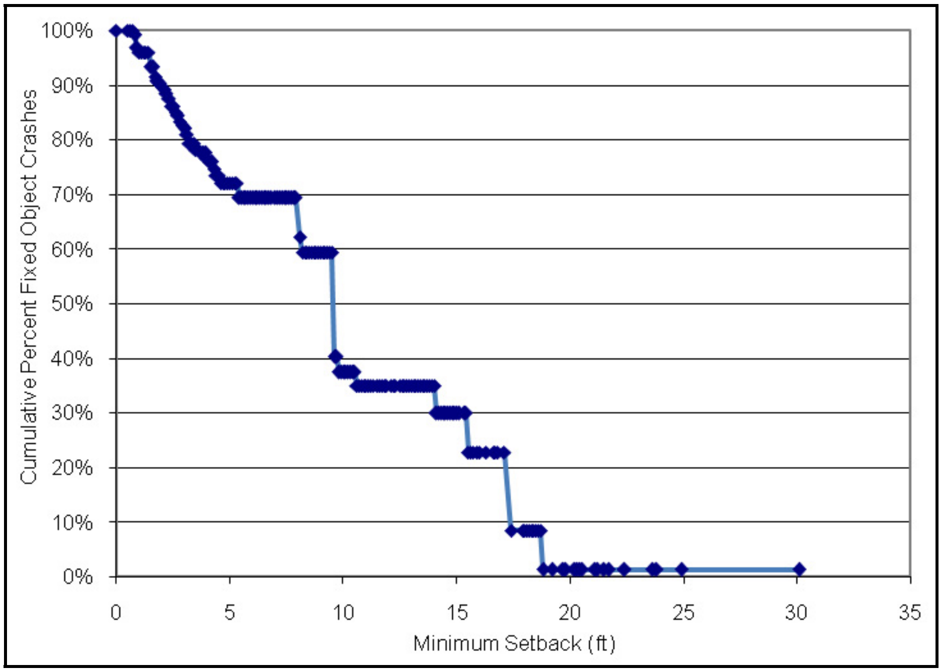

Figure 5-85. Cumulative percent minimum setback in 15 m analysis

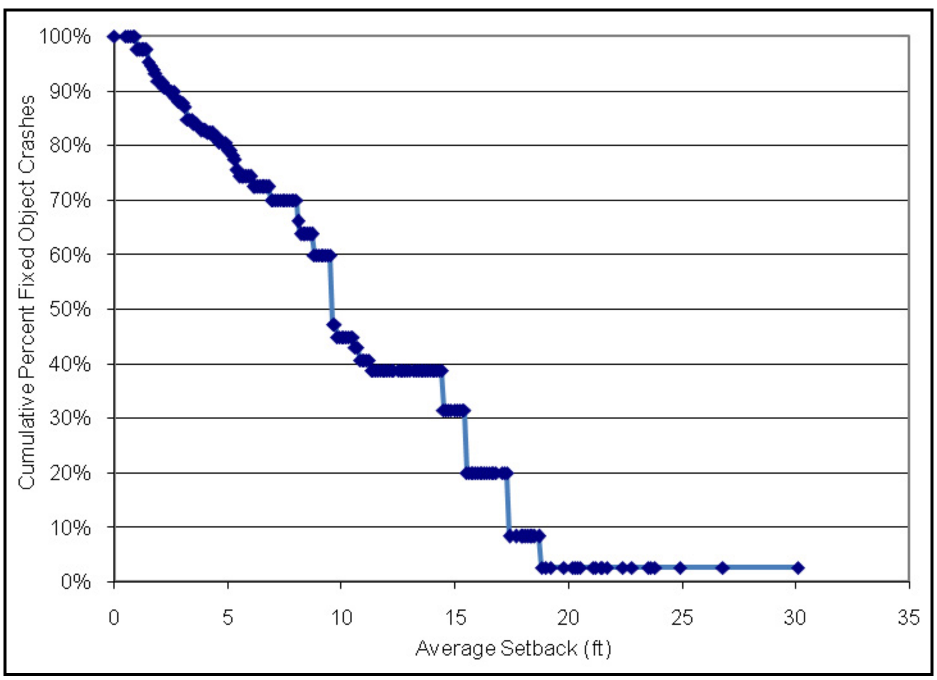

Figure 5-86. Cumulative percent average setback in 15 m analysis

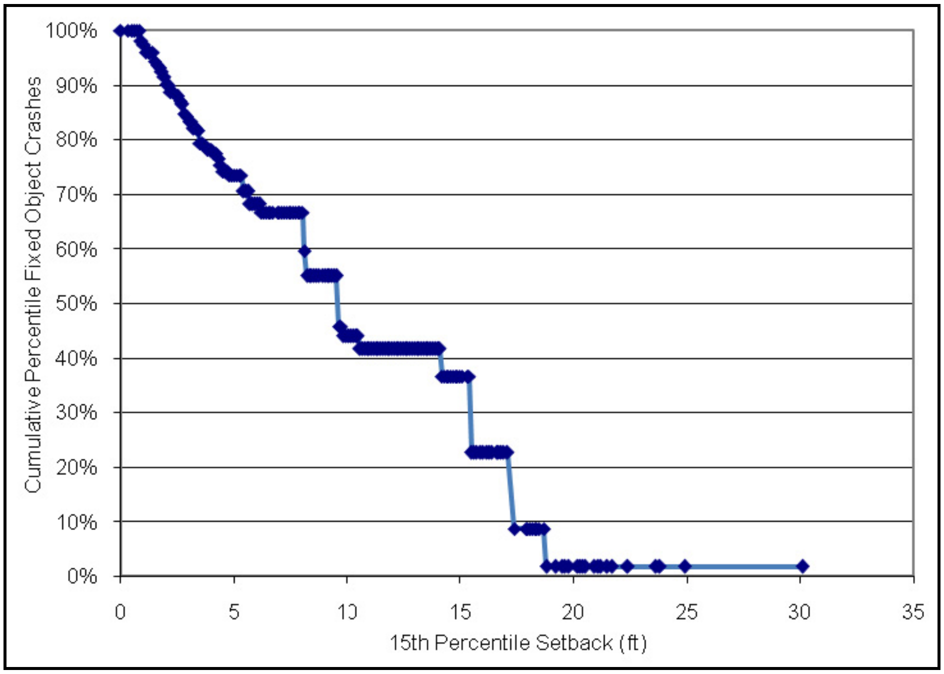

Figure 5-87. Cumulative percent 15th percentile setback in 15 m analysis

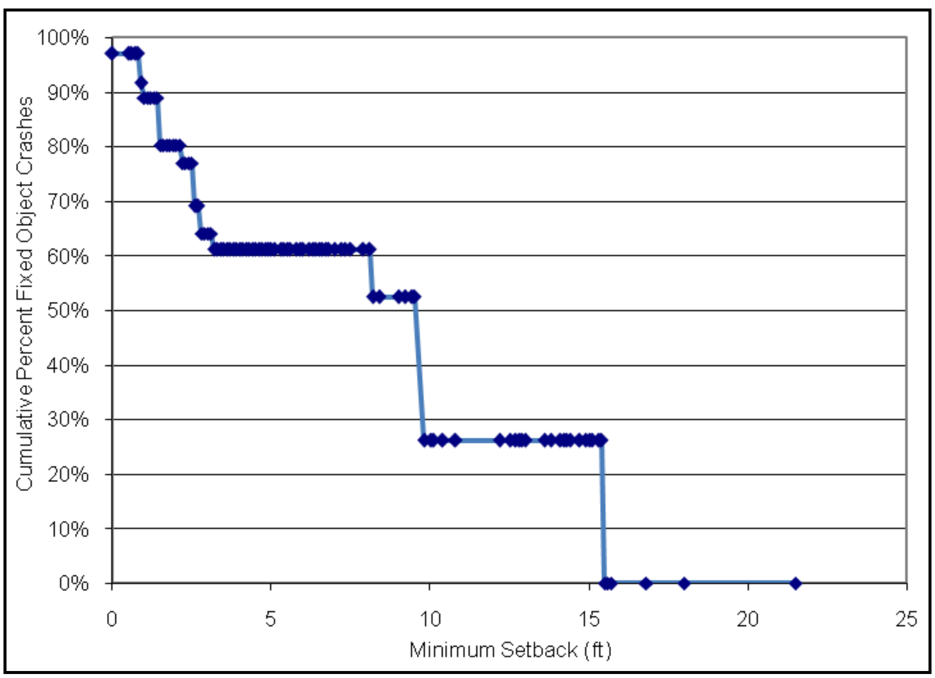

Figure 5-88. Cumulative percent minimum setback in 15 m analysis at 30 mph

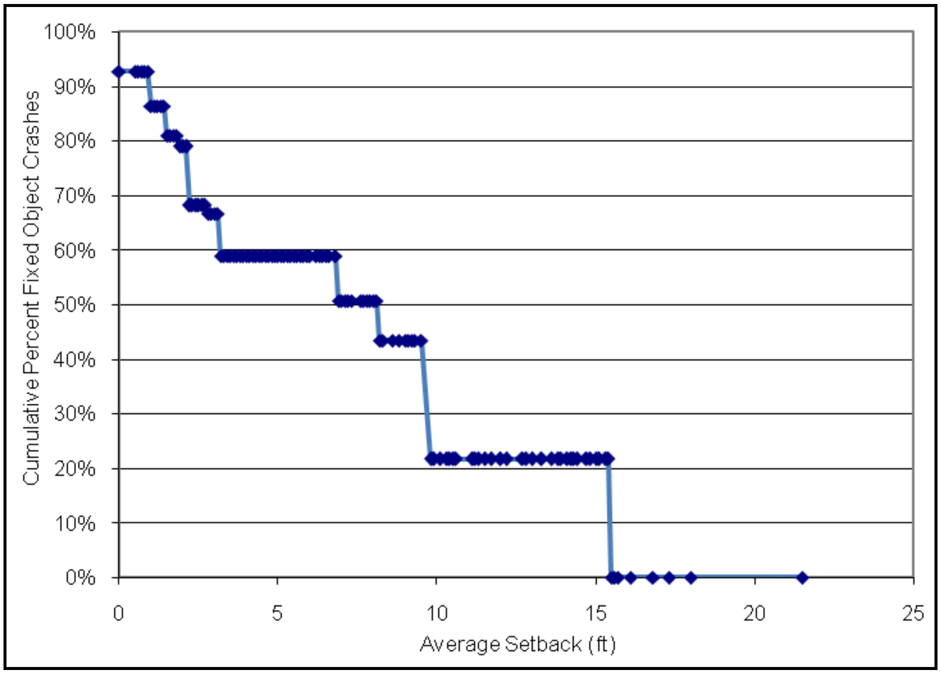

Figure 5-89. Cumulative percent average setback in 15 m analysis at 30 mph

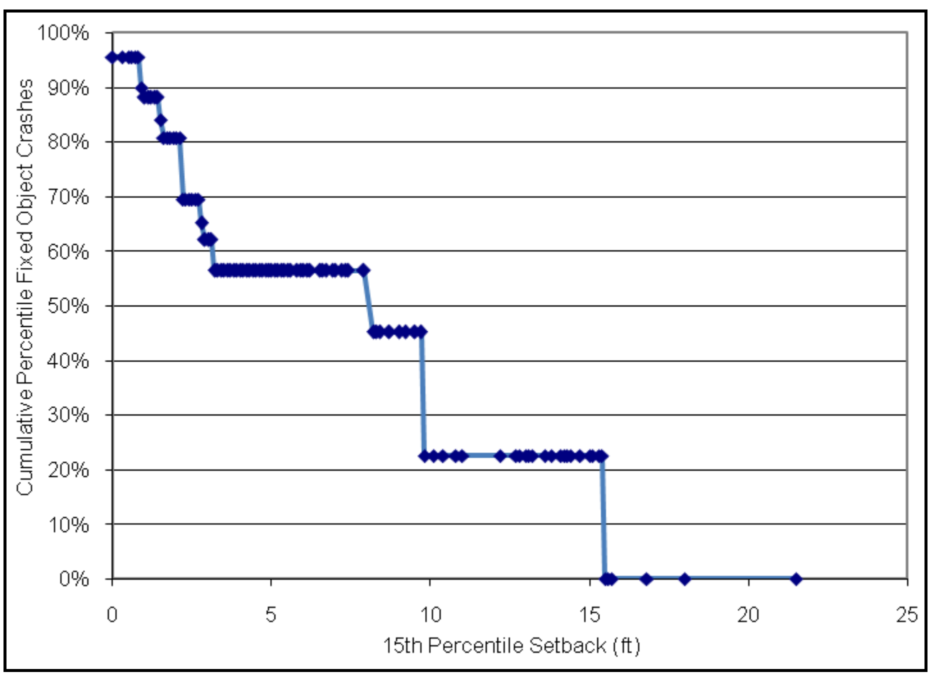

Figure 5-90. Cumulative percent 15th percentile setback in 15 m analysis at 30 mph

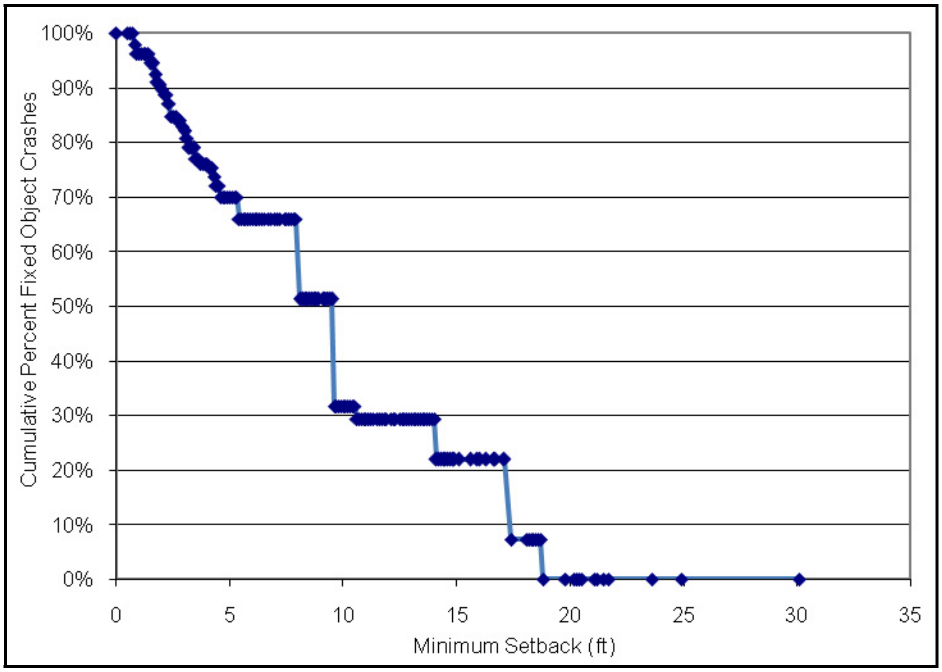

Figure 5-91. Cumulative percent minimum setback in 15 m analysis at 35 mph

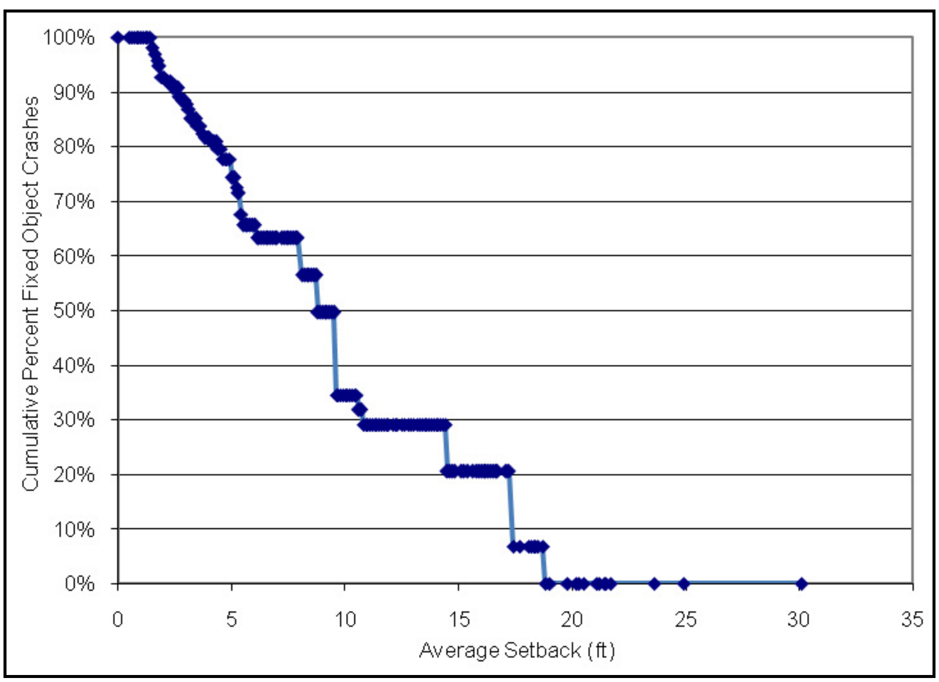

Figure 5-92. Cumulative percent average setback in 15 m analysis at 35 mph

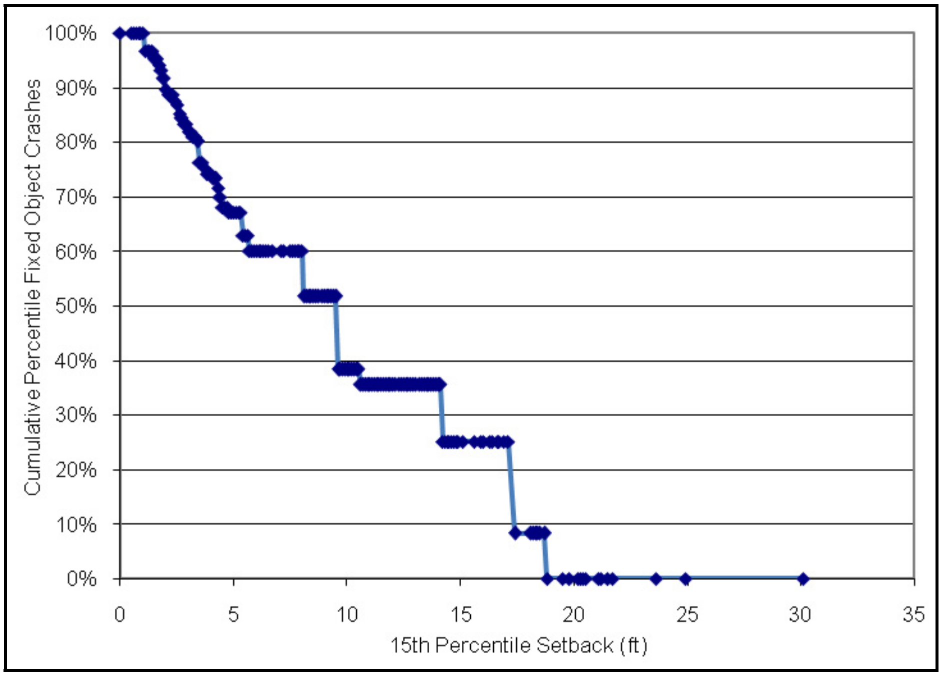

Figure 5-93. Cumulative percent 15th percentile setback in 15 m analysis at 35 mph

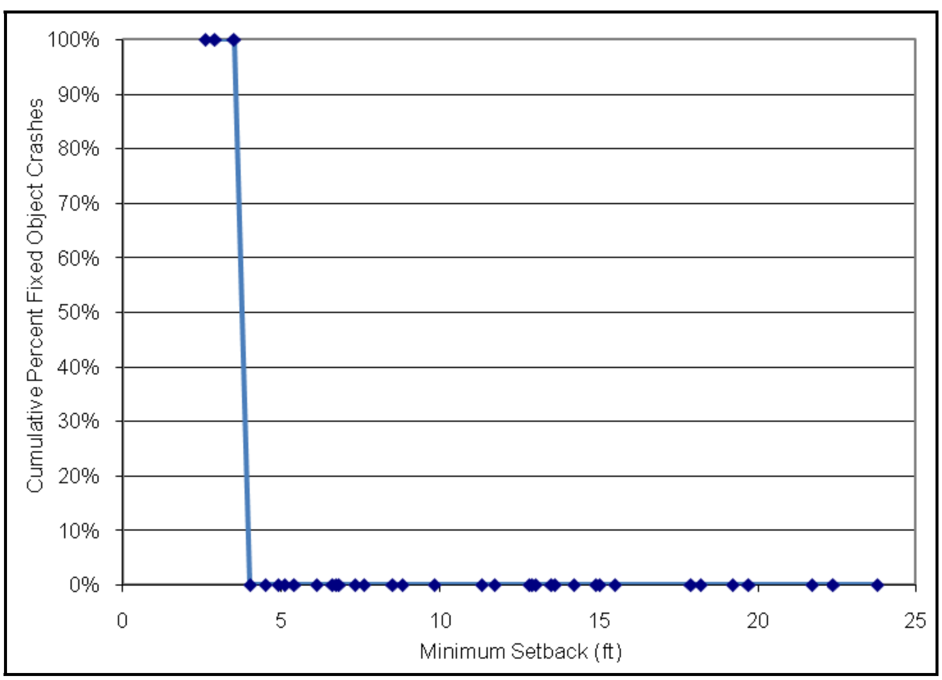

Figure 5-94. Cumulative percent minimum setback in 15 m analysis at 40 mph

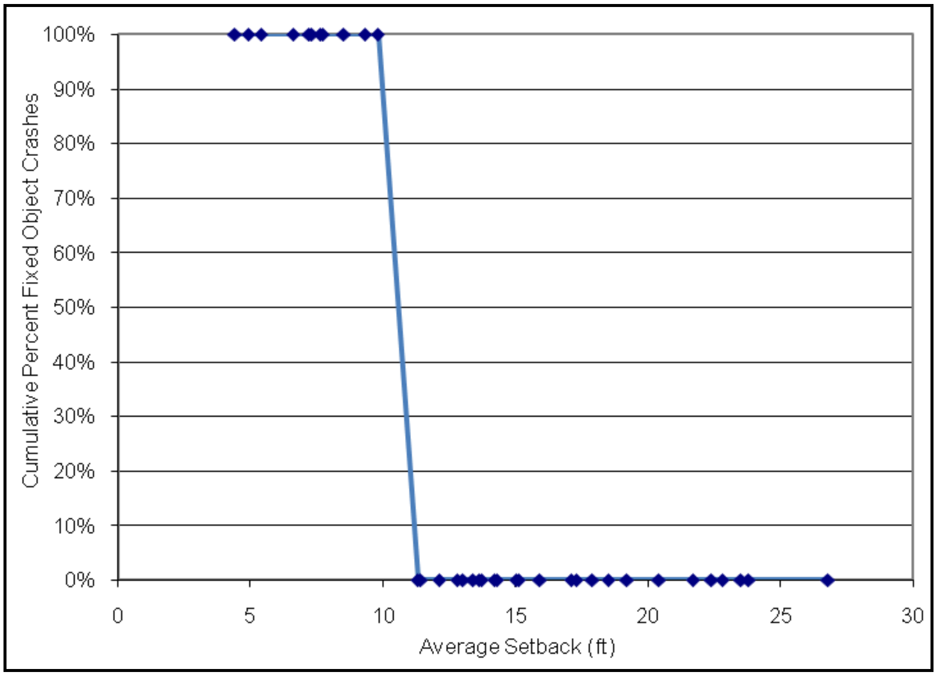

Figure 5-95. Cumulative percent average setback in 15 m analysis at 40 mph

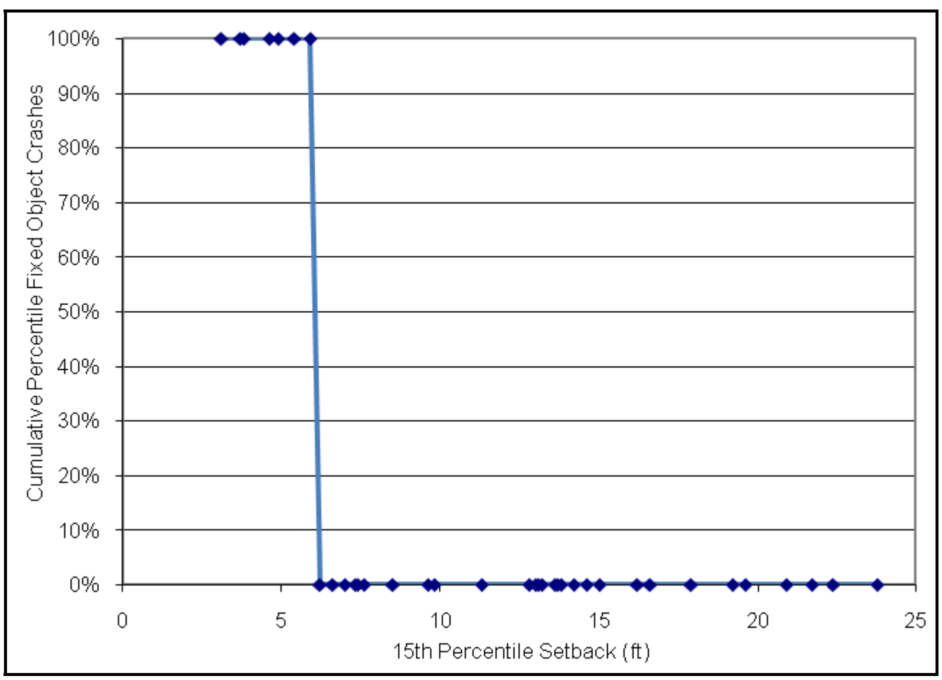

Figure 5-96. Cumulative percent 15th percentile setback in 15 m analysis at 40 mph

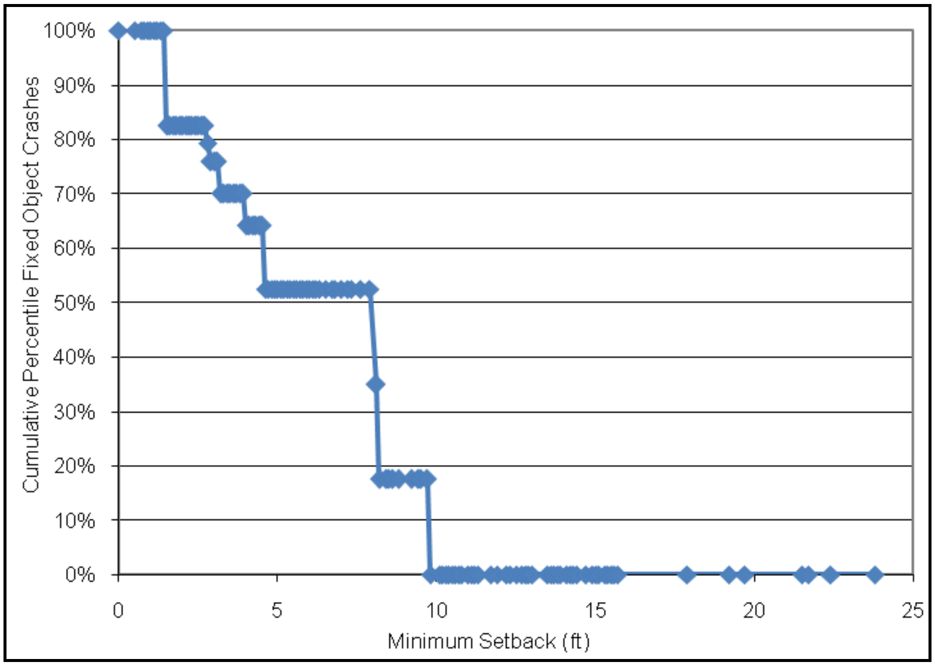

Figure 5-97. Cumulative percent minimum setback in 15 m analysis at ADT of 1,500–6,000

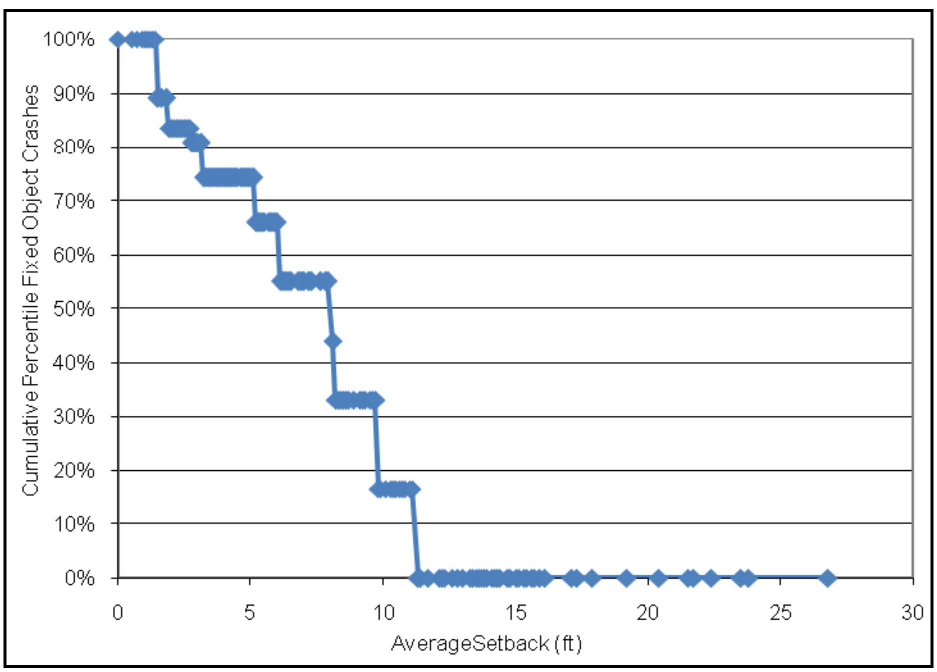

Figure 5-98. Cumulative percent average setback in 15 m analysis at ADT of 1,500–6,000

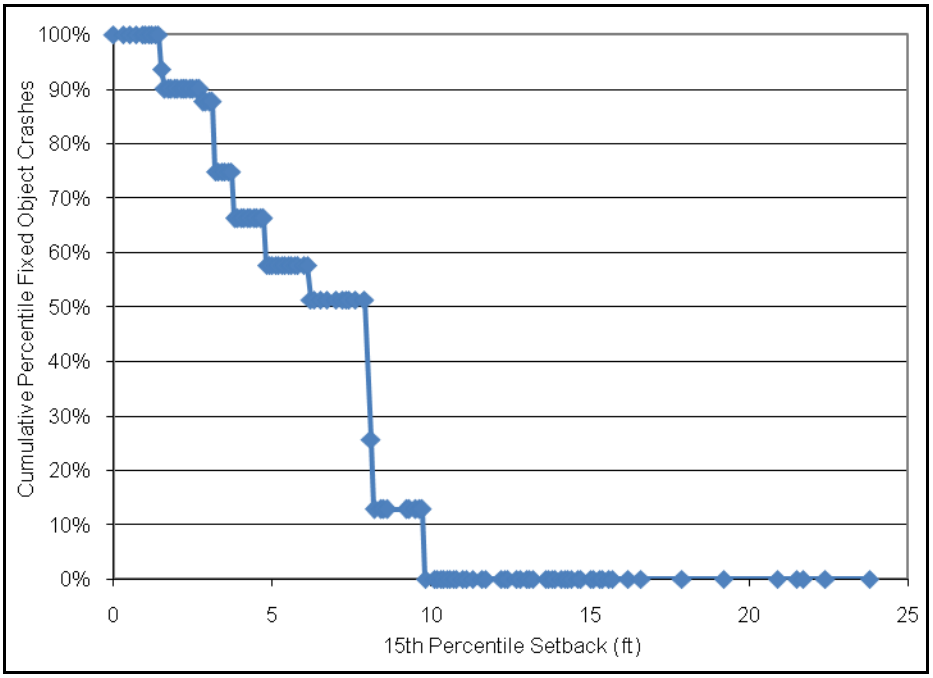

Figure 5-99. Cumulative percent 15th percentile setback in 15 m analysis at ADT of 1,500–6,000

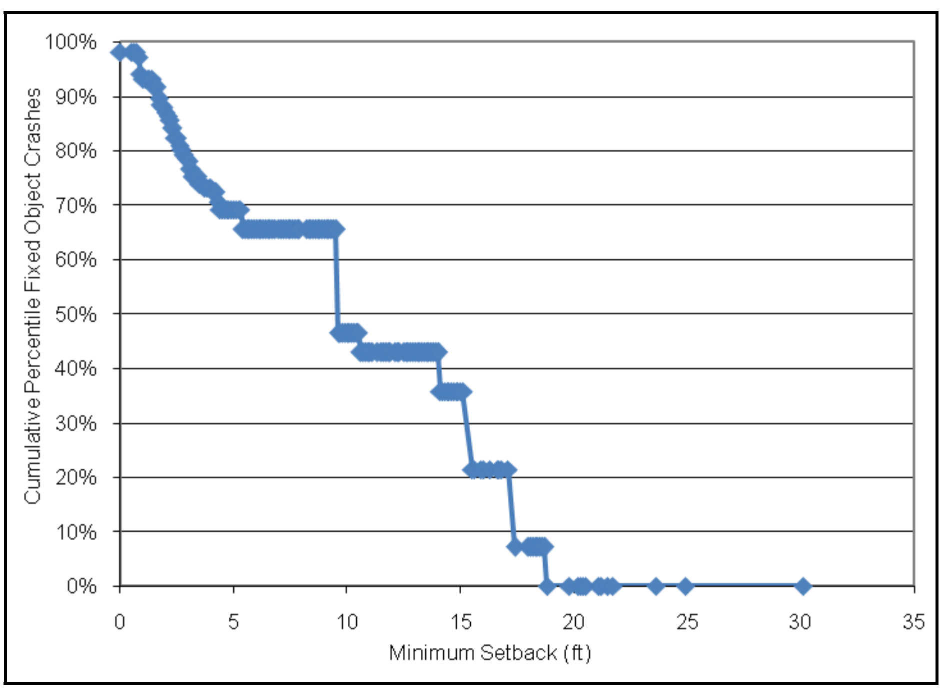

Figure 5-100. Cumulative percent minimum setback in 15 m analysis at ADT of 6,000

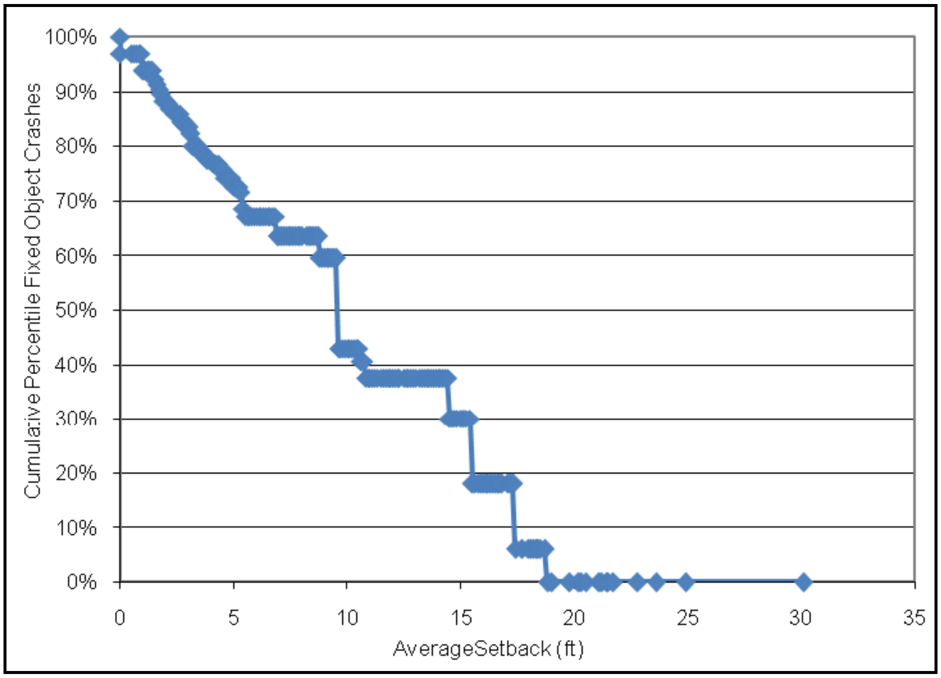

Figure 5-101. Cumulative percent average setback in 15 m analysis at ADT of 6,000

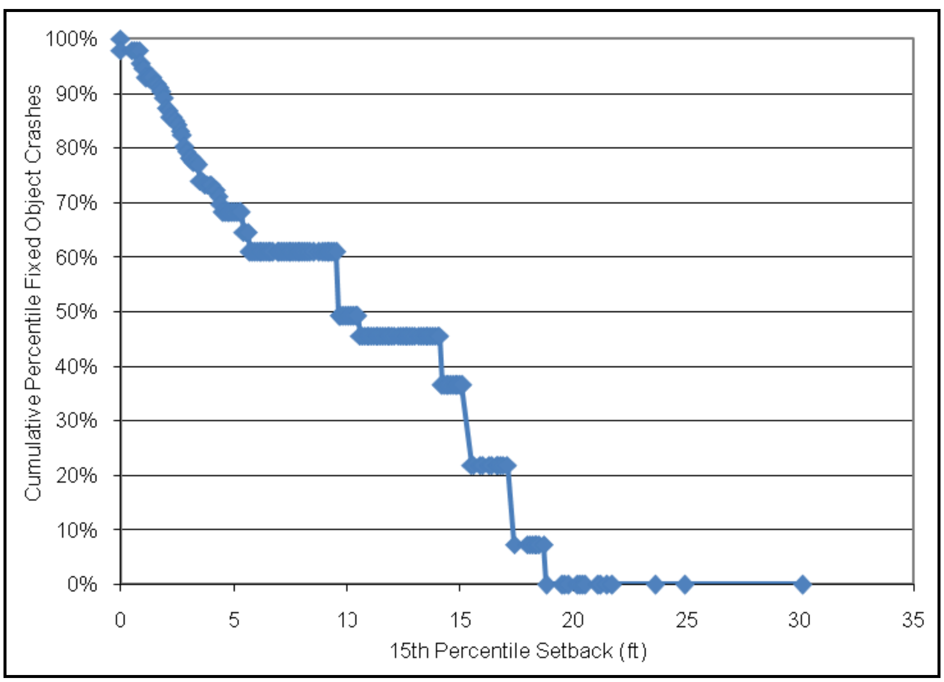

Figure 5-102. Cumulative percent 15th percentile setback in 15 m analysis at ADT of 6,000

5.10. Cumulative Percent Cost

To determine where a majority of the fixed object crash costs occurred, a cumulative percent analysis was conducted for each of the three sections (segment, block, and 15 m) for each of the three setback measurements (minimum, average, and 15th percentile). According to this analysis, a 3 ft clear zone for fixed objects would be the most cost-effective. Of the 44 predictors described in this section, 34 have a highly linear relationship between setback distance and the number of fixed object crashes within 3 ft of the pavement edge. According to Figures 5-103 through 5-147, widening the clear zone beyond 3 ft will only have a marginal rate of return and thus would not be an economically efficient design requirement. The cumulative percent analysis also found that as the speed limit or ADT increases, the setback distance where 90% of fixed object crashes occur only increases by 1 or 2 ft on average. It is also worth noting that when the segment, block, and 15 m analyses were carried out after dividing the data according to speed limit or ADT, the setback distance where 90% of fixed object crashes occur decreased in all situations.

5.10.1. Segment Analysis

The segment analysis, shown in Figures 5-103 through 5-105, indicates varying distances where 90% of fixed object crash costs occur. The minimum setback measurement showed that 90% of fixed object crash costs occur within the first 4 ft of the pavement edge. The average setback measurement showed that 90% of fixed object crash costs occur within the first 9 ft of the pavement edge. The 15th percentile setback measurement showed that 90% of fixed object crash costs occur within the first 5 ft of the pavement edge. None of these measurements showed a significant linear correlation between the cost and the setback.

The same analysis was completed for each speed limit, shown in Figures 5-106 through 5-111. At a 30 mph speed limit, the setback distance where 90% of fixed object crash costs occurred for the minimum, average, and 15th percentile setback measurements were 1.5 ft, 6 ft, and 2 ft, respectively. At a 35 mph speed limit, the setback distance where 90% of fixed object crash costs occurred for the minimum, average, and 15th percentile setback measurements were 2 ft, 10 ft, and 3 ft, respectively. At a 40 mph speed limit, there were only two observations, and thus significant conclusions cannot be made.

The same analysis was done again for the ADT ranges of 1,500–6,000 and over 6,000, shown in Figures 5-112 through 5-117. At an ADT of 1,500–6,000, the setback distance where 90% of fixed object crash costs occurred for the minimum, average, and 15th percentile setback measurements were 1 ft, 5 ft, and 3 ft, respectively. At an ADT of over 6,000, the setback distance where 90% of fixed object crash costs occurred for the minimum, average, and 15th percentile setback measurements were 4 ft, 9 ft, and 3 ft, respectively.

5.10.2. Block Analysis

The block analysis, shown in Figures 5-118 through 5-120, indicates varying distances where 90% of fixed object crash costs occur. The minimum setback measurement showed that 90% of fixed object crash costs occur within the first 5 ft of the pavement edge. The average setback measurement showed that 90% of fixed object crash costs occur within the first 15 ft of the pavement edge. The 15th percentile setback measurement showed that 90% of fixed object crash costs occur within the first 7 ft of the pavement edge. None of these analyses show a significant linear correlation between the crash costs and setback distance.

The same analysis was completed for each speed limit, shown in Figures 5-121 through 5-126. At a 30 mph speed limit, the setback distance where 90% of fixed object crash costs occurred for the minimum, average, and 15th percentile setback measurements were 3 ft, 8 ft, and 3 ft, respectively. At a 35 mph speed limit, the setback distance where 90% of fixed object crash cost occurred for the minimum, average, and 15th percentile setback measurements were 3 ft, 12 ft, and 4 ft, respectively. At a 40 mph speed limit, there were only a few observations, and thus significant conclusions cannot be drawn.

The same analysis was again completed for the ADT ranges of 1,500–6,000 and over 6,000, shown in Figures 5-127 through 5-132. At an ADT of 1,500–6,000, the setback distance where 90% of fixed object crash cost occurred for the minimum, average, and 15th percentile setback measurements were 4 ft, 7 ft, and 4 ft, respectively. At an ADT of over 6,000, the setback distance where 90% of fixed object crash costs occurred for the minimum, average, and 15th percentile setback measurements were 4 ft, 13 ft, and 4 ft, respectively.

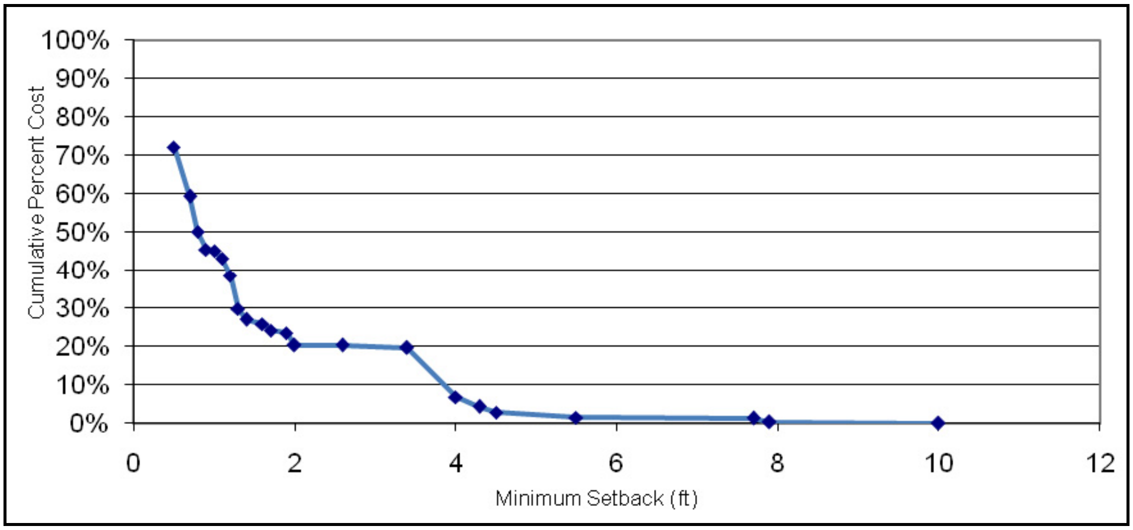

Figure 5-103. Cumulative cost minimum setback in segment analysis

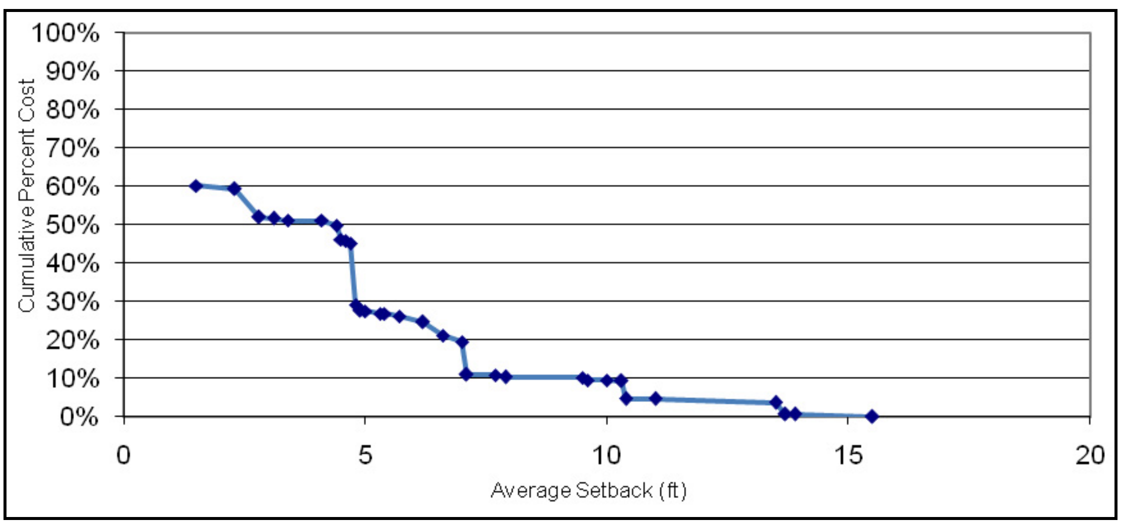

Figure 5-104. Cumulative cost average setback in segment analysis

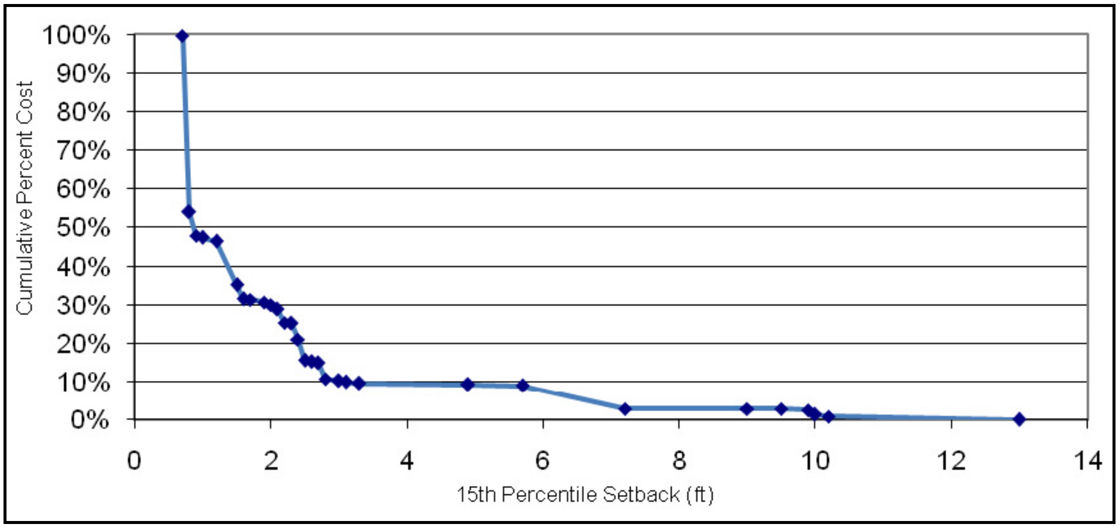

Figure 5-105. Cumulative cost 15th percentile setback in segment analysis

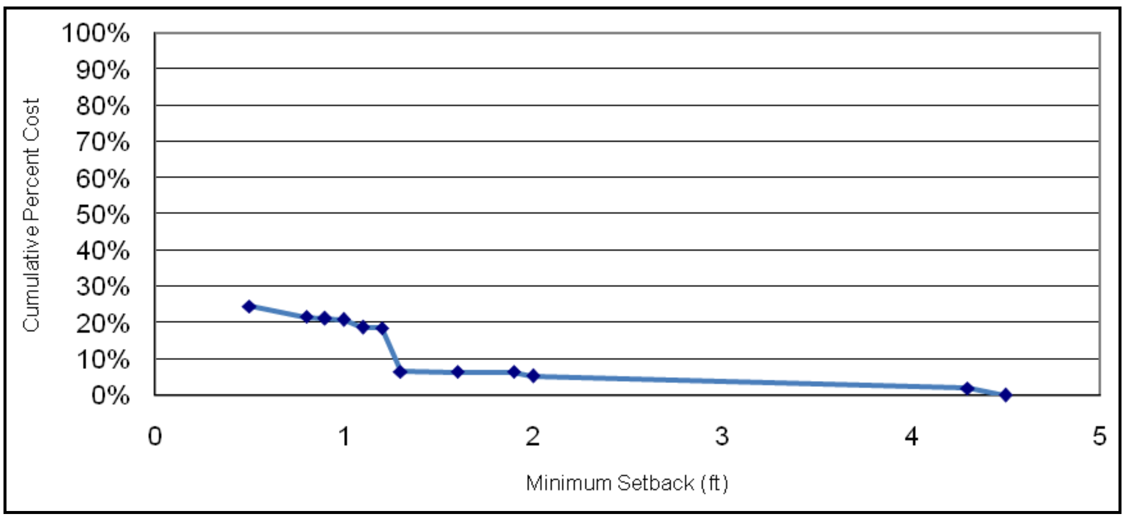

Figure 5-106. Cumulative cost minimum setback in segment analysis at 30 mph

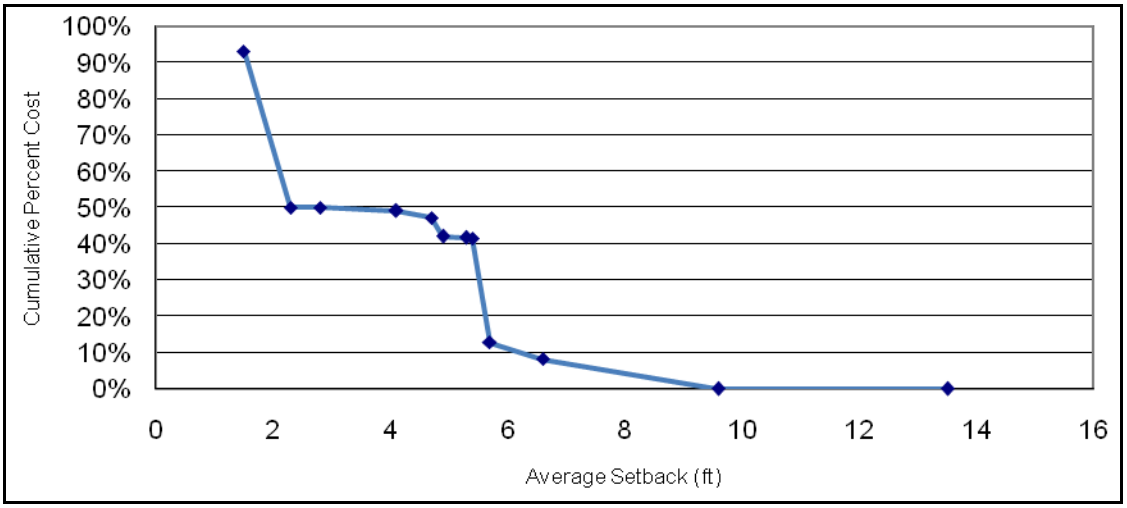

Figure 5-107. Cumulative cost average setback in segment analysis at 30 mph

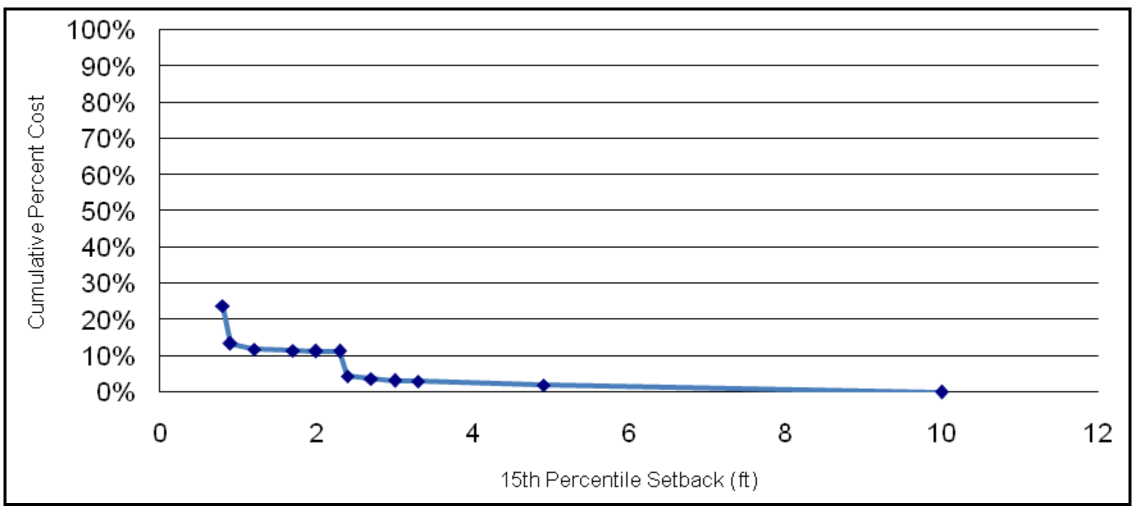

Figure 5-108. Cumulative cost 15th percentile setback in segment analysis at 30 mph

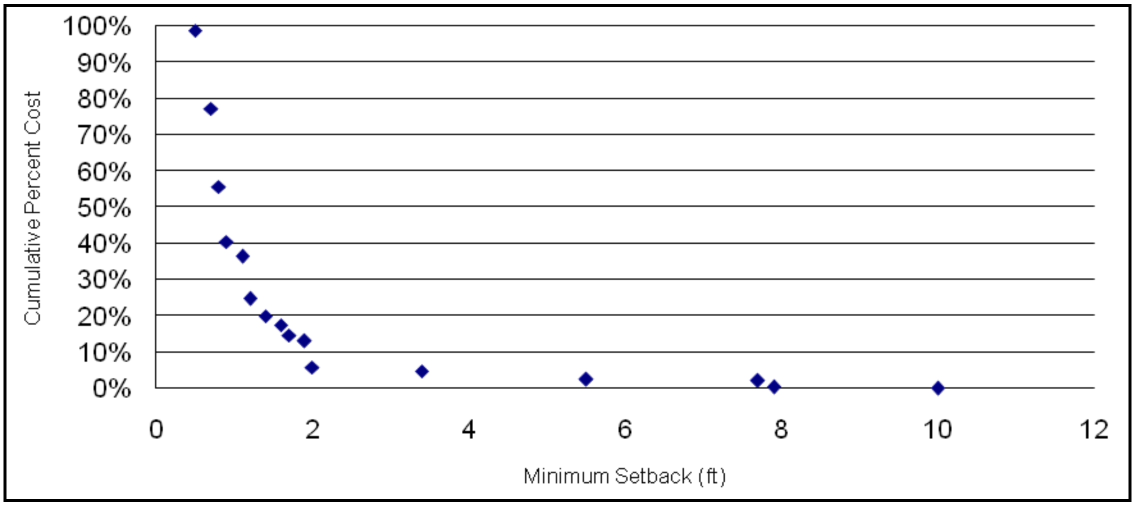

Figure 5-109. Cumulative cost minimum setback in segment analysis at 35 mph

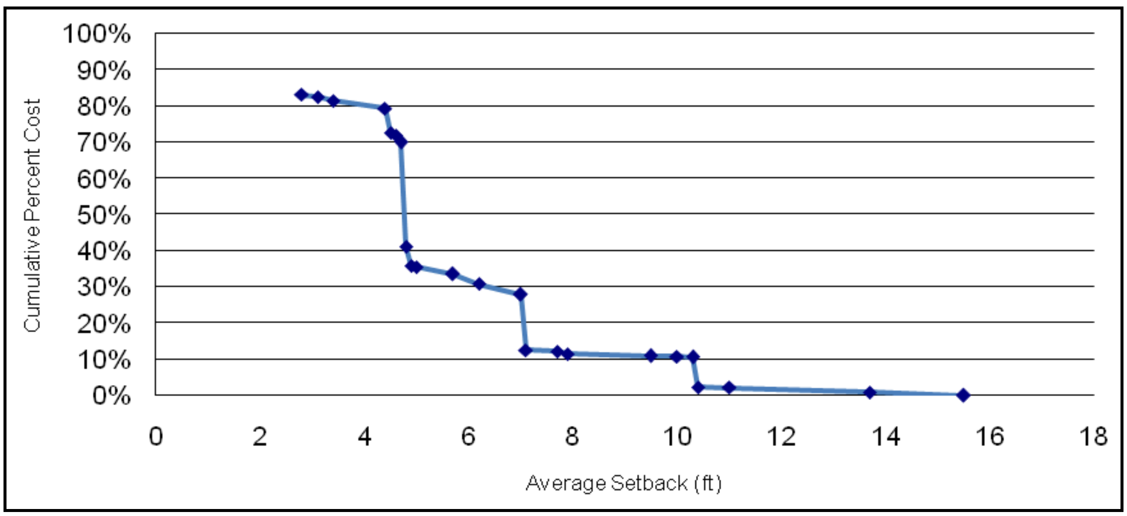

Figure 5-110. Cumulative cost average setback in segment analysis at 35 mph

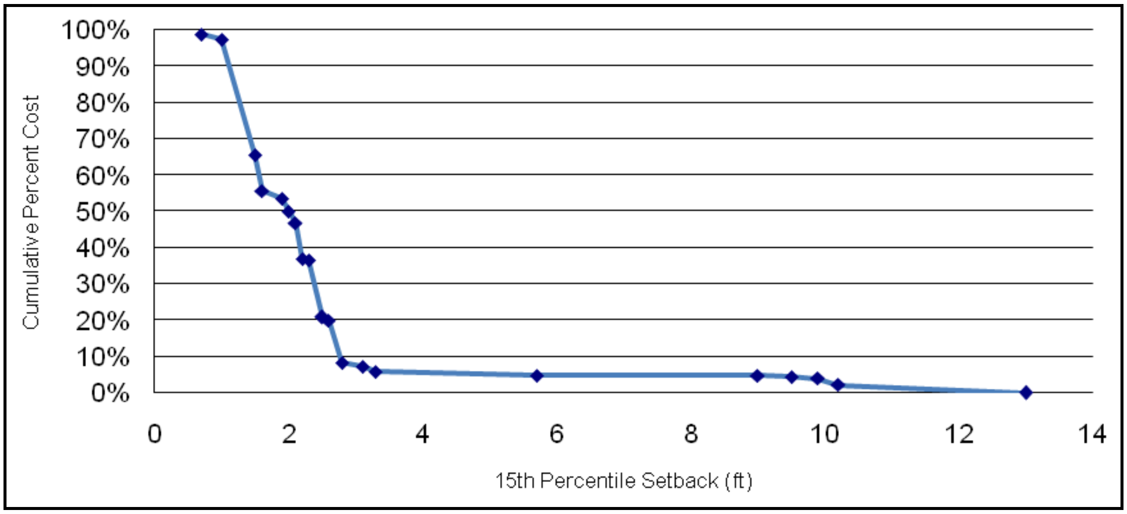

Figure 5-111. Cumulative cost 15th percentile setback in segment analysis at 35 mph

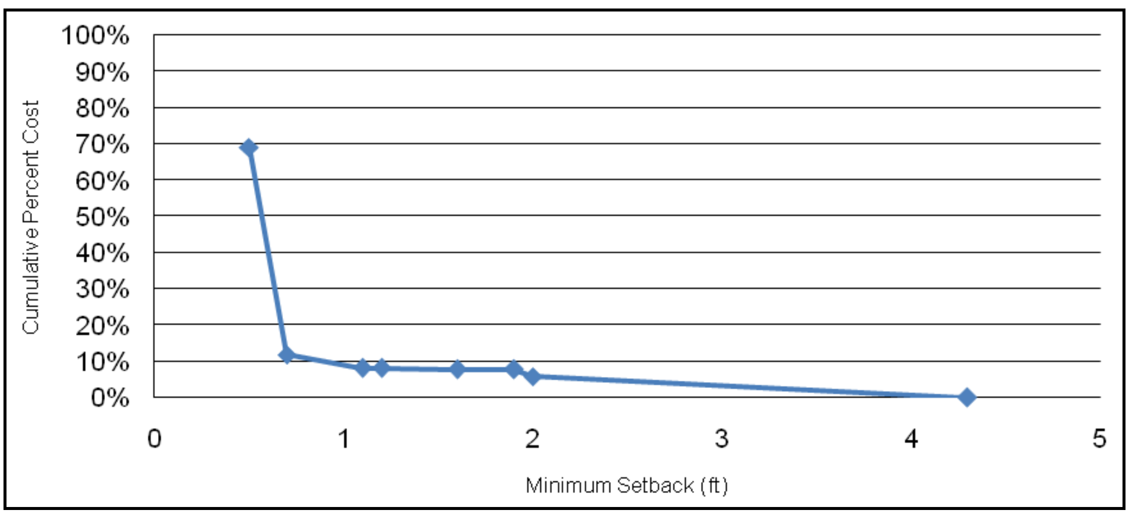

Figure 5-112. Cumulative cost minimum setback in segment analysis with a 1,500–6,000 ADT

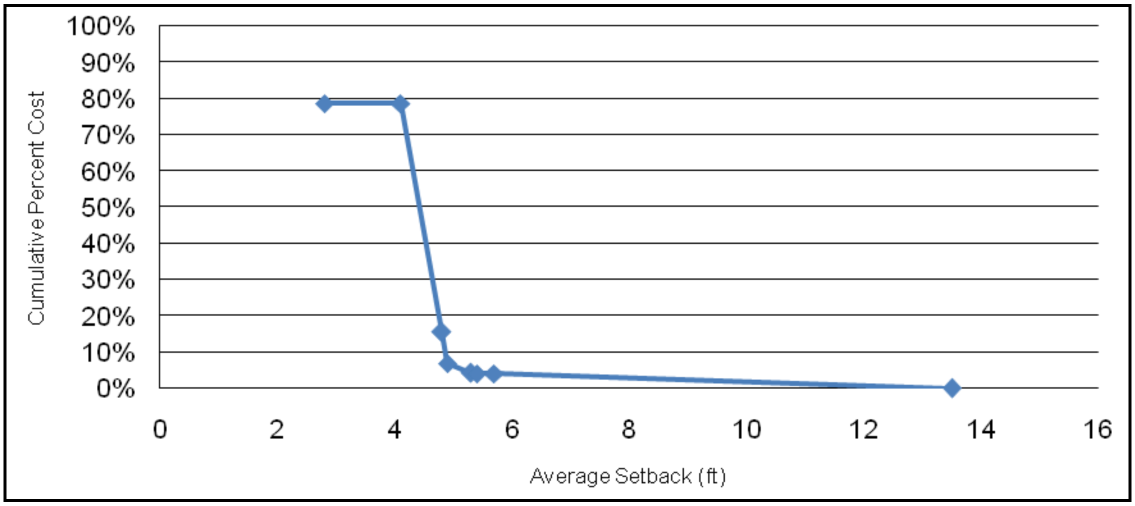

Figure 5-113. Cumulative cost average setback in segment analysis with a 1,500–6,000 ADT

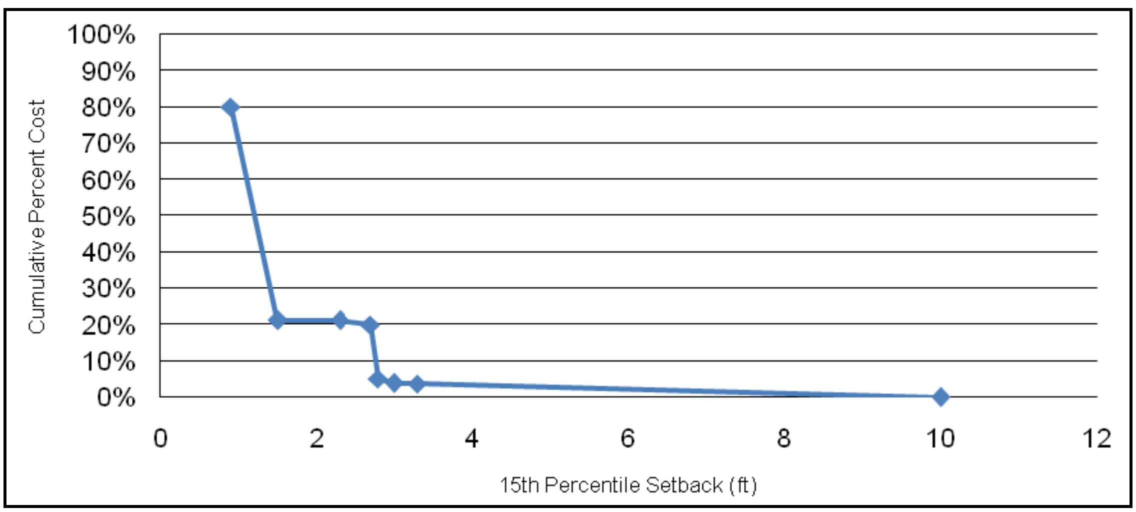

Figure 5-114. Cumulative cost 15th percentile setback in segment analysis with a 1,500–6,000 ADT

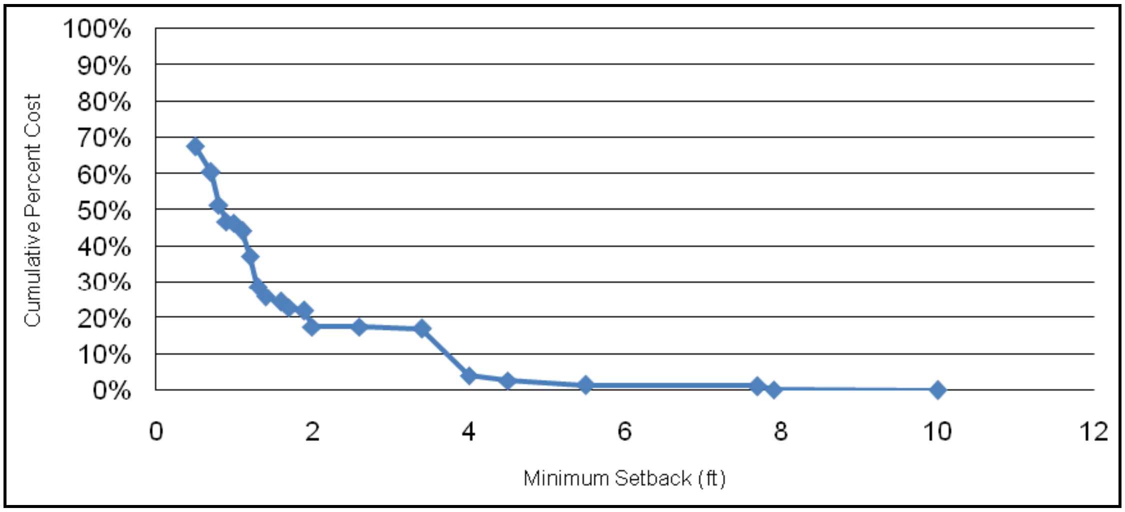

Figure 5-115. Cumulative cost minimum setback in segment analysis with over 6,000 ADT

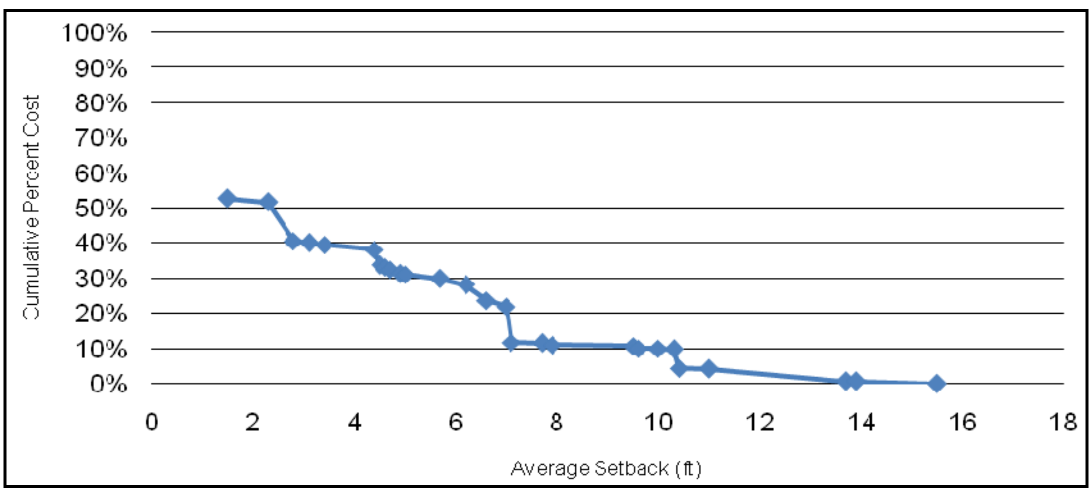

Figure 5-116. Cumulative cost average setback in segment analysis with over 6,000 ADT

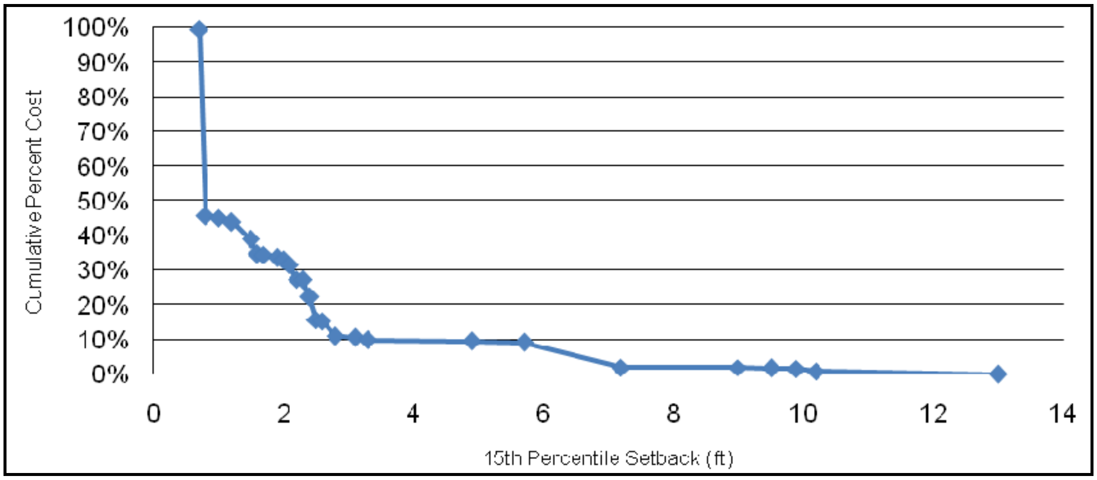

Figure 5-117. Cumulative cost 15th percentile setback in segment analysis with over 6,000 ADT

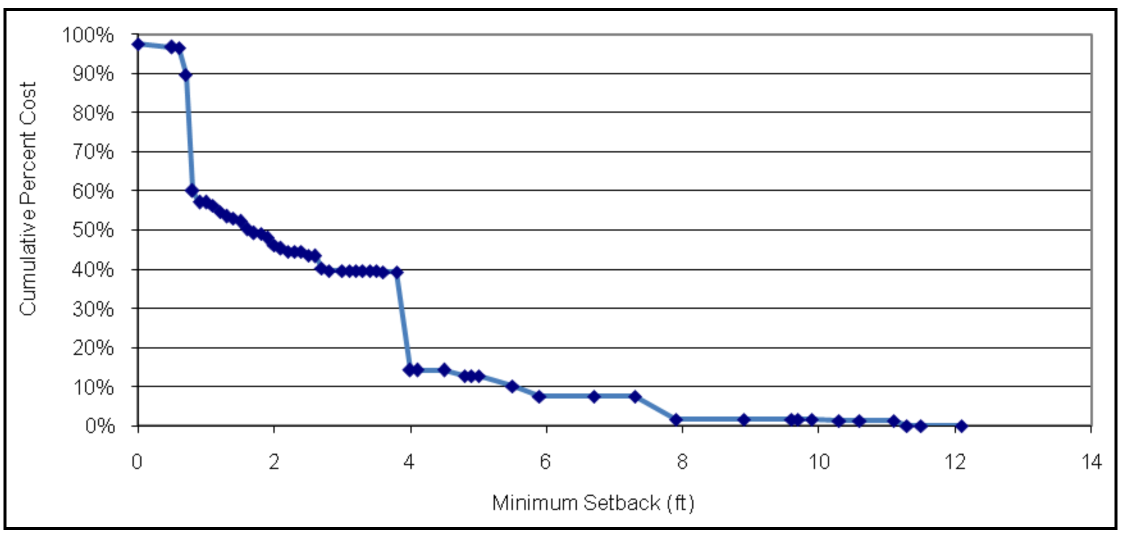

Figure 5-118. Cumulative cost minimum setback in block analysis

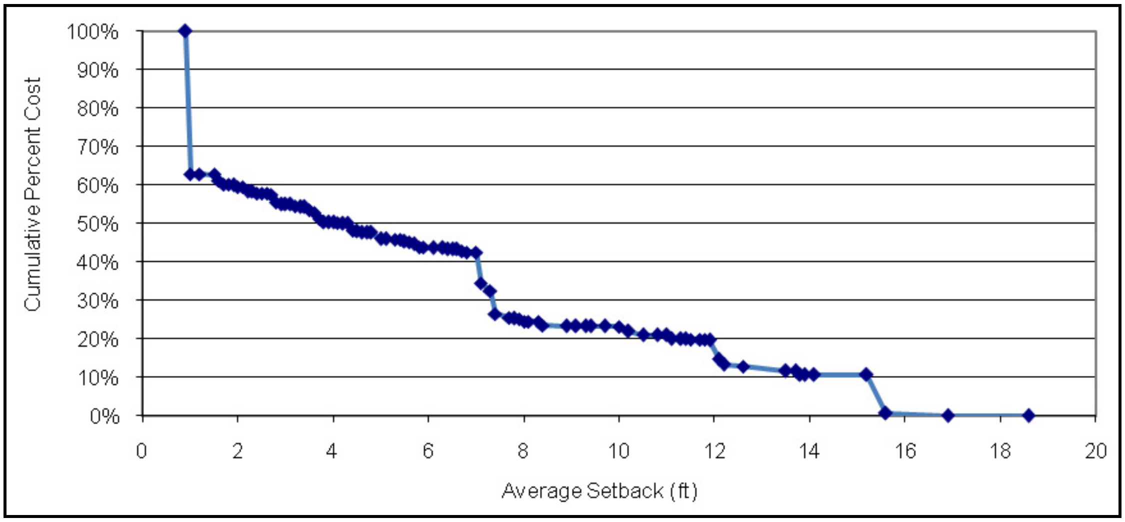

Figure 5-119. Cumulative cost average setback in block analysis

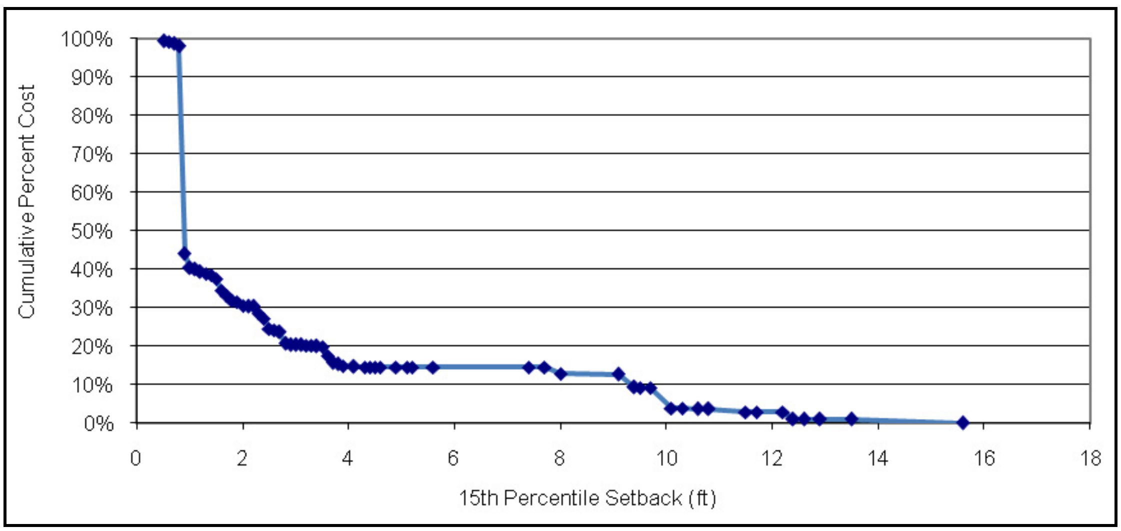

Figure 5-120. Cumulative cost 15th percentile setback in block analysis

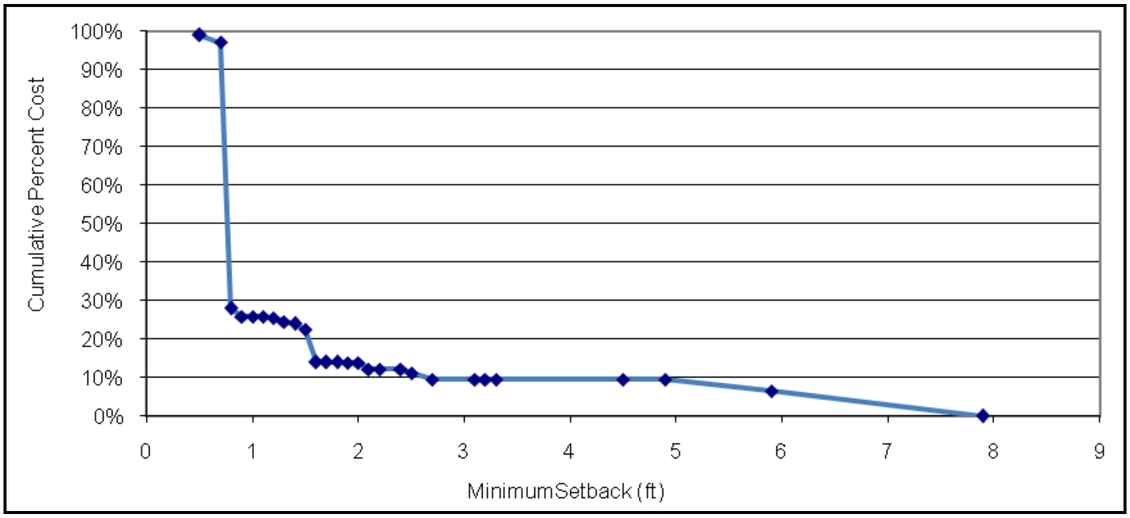

Figure 5-121. Cumulative cost minimum setback in block analysis at 30 mph

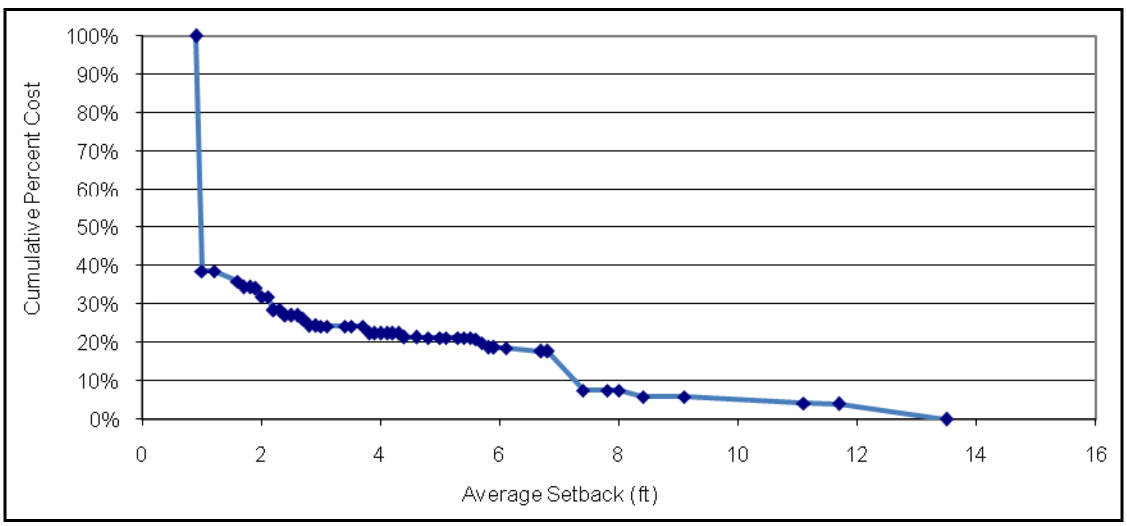

Figure 5-122. Cumulative cost average setback in block analysis at 30 mph

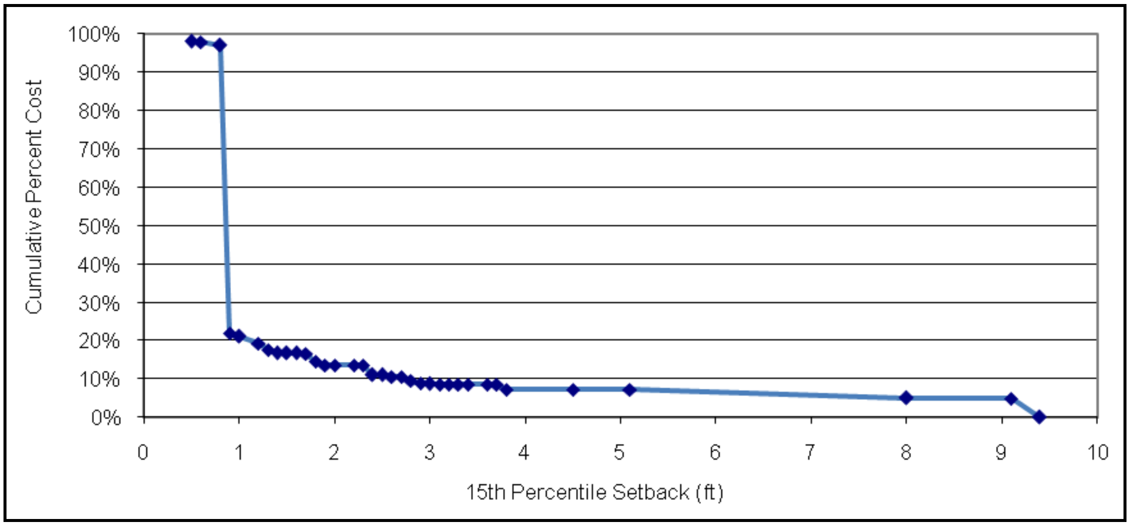

Figure 5-123. Cumulative cost 15th percentile setback in block analysis at 30 mph

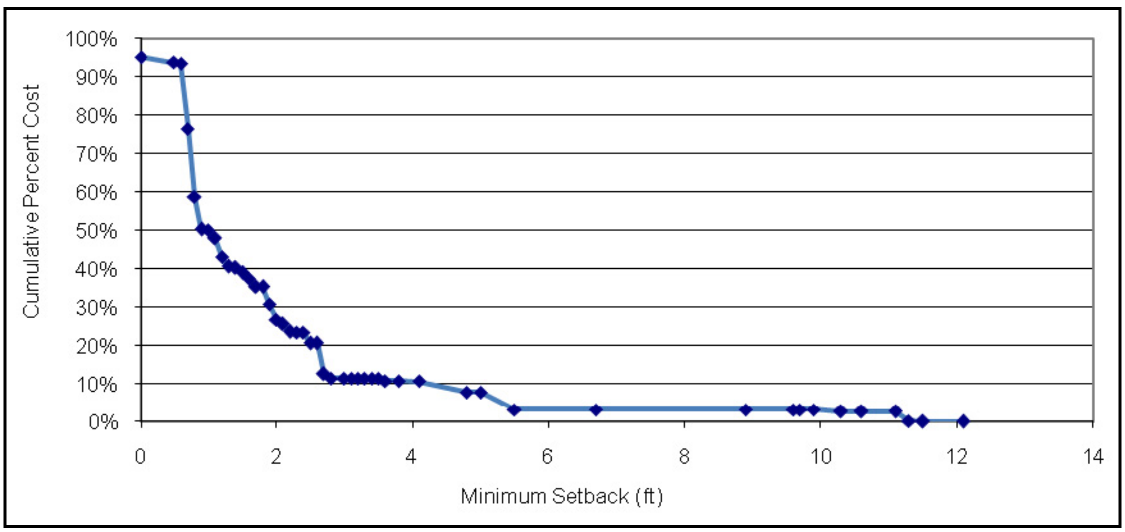

Figure 5-124. Cumulative cost minimum setback in block analysis at 35 mph

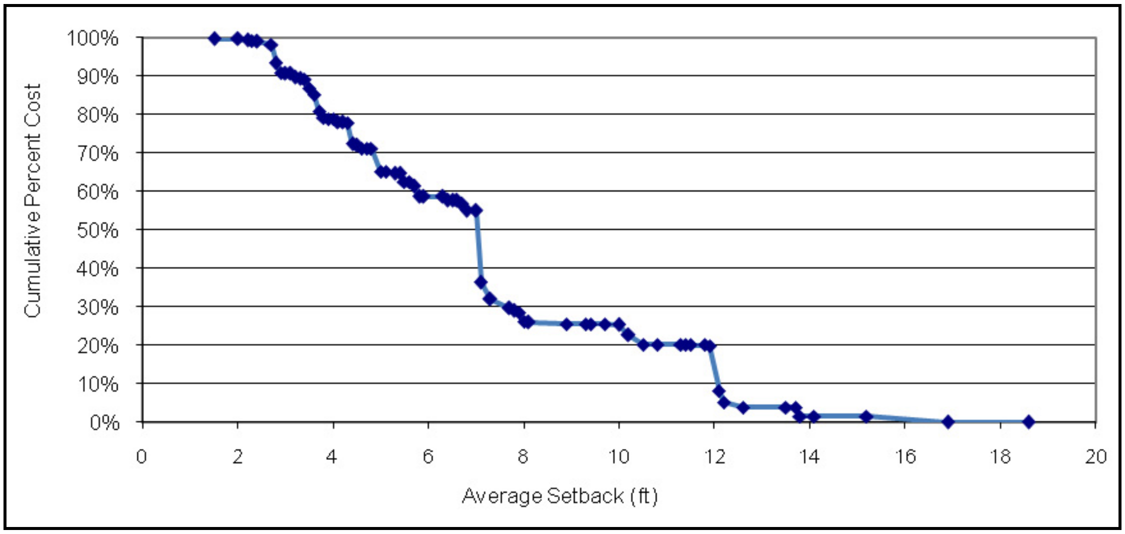

Figure 5-125. Cumulative cost average setback in block analysis at 35 mph

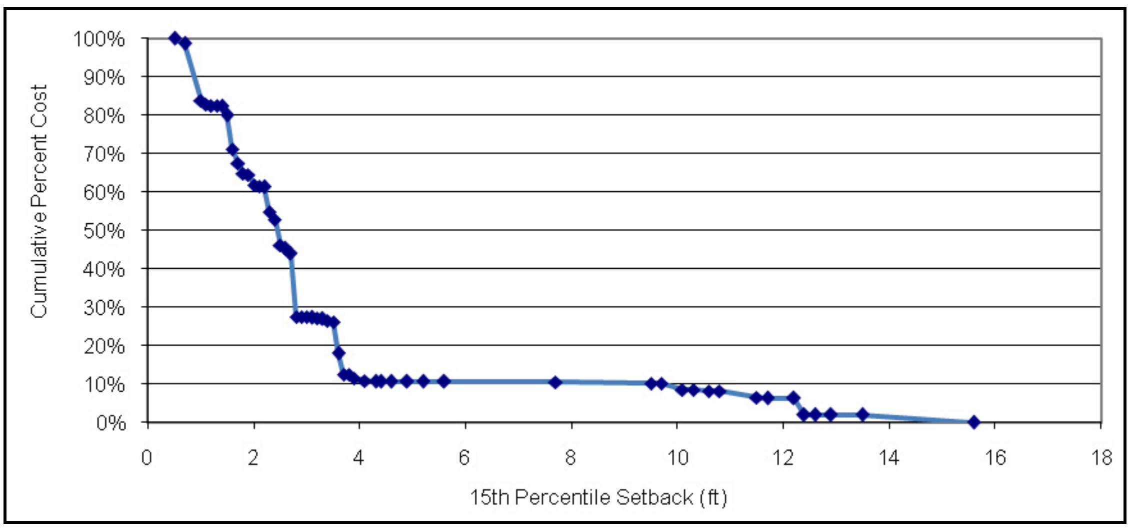

Figure 5-126. Cumulative cost 15th percentile setback in block analysis at 35 mph

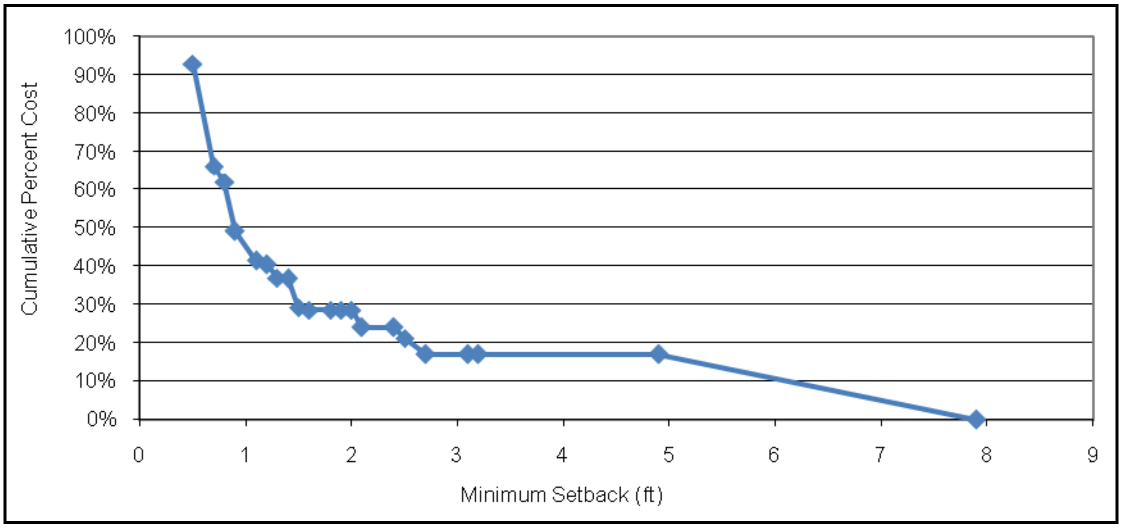

Figure 5-127. Cumulative cost minimum setback in block analysis with a 1,500–6,000 ADT

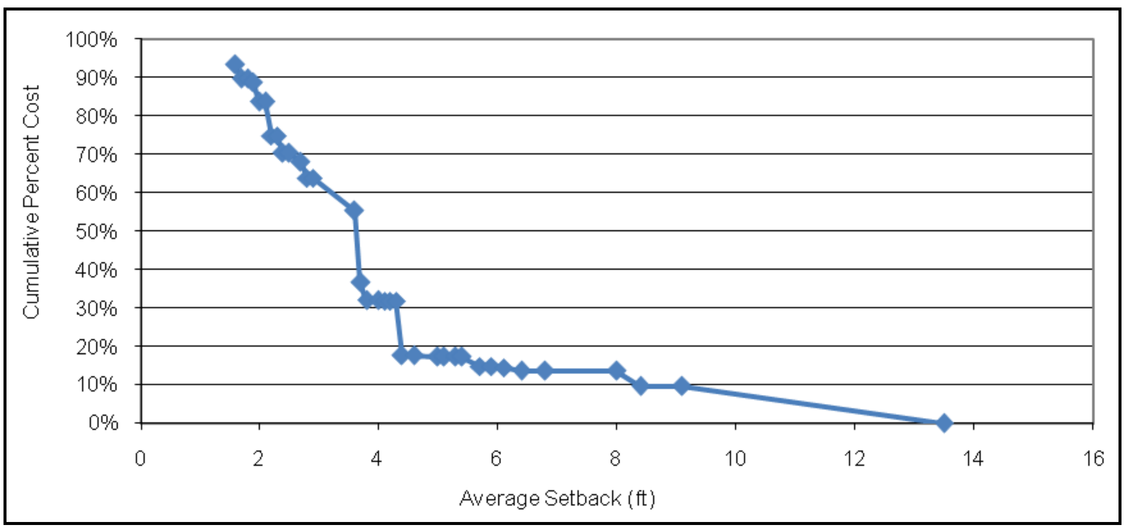

Figure 5-128. Cumulative cost average setback in block analysis with a 1,500–6,000 ADT

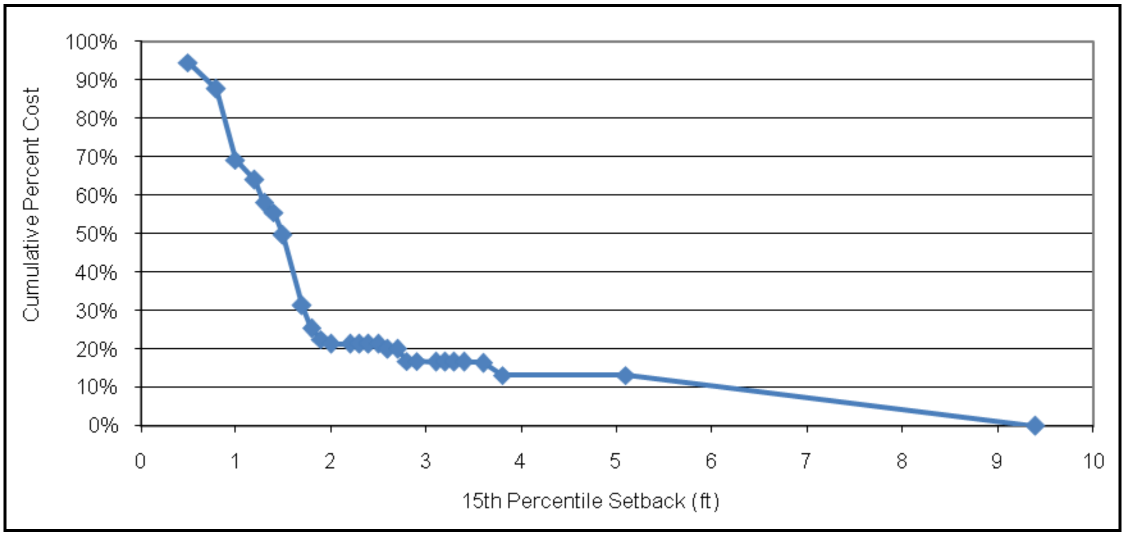

Figure 5-129. Cumulative cost 15th percentile setback in block analysis with a 1,500–6,000 ADT

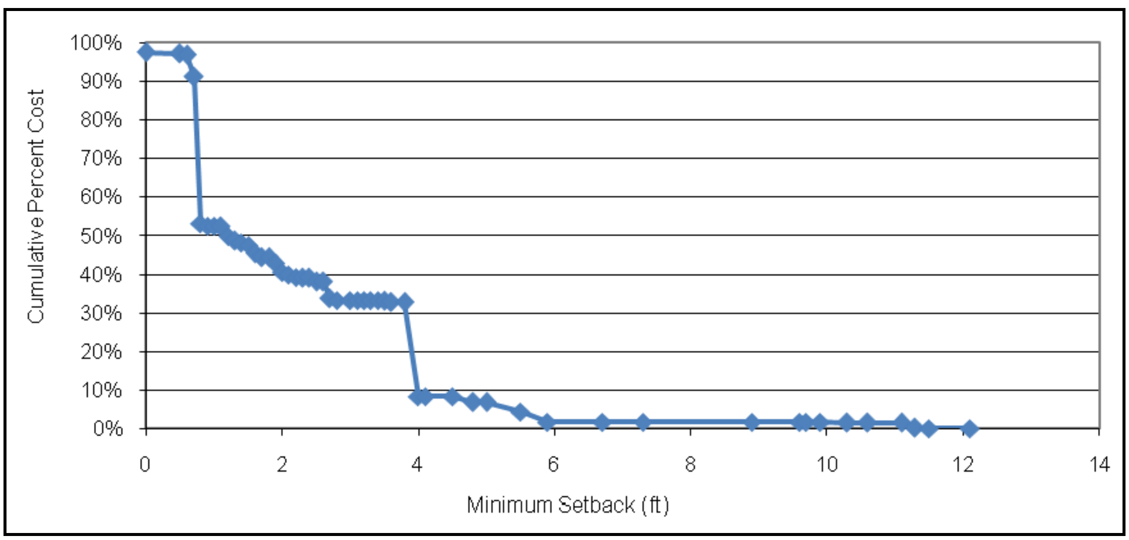

Figure 5-130. Cumulative cost minimum setback in block analysis with over 6,000 ADT

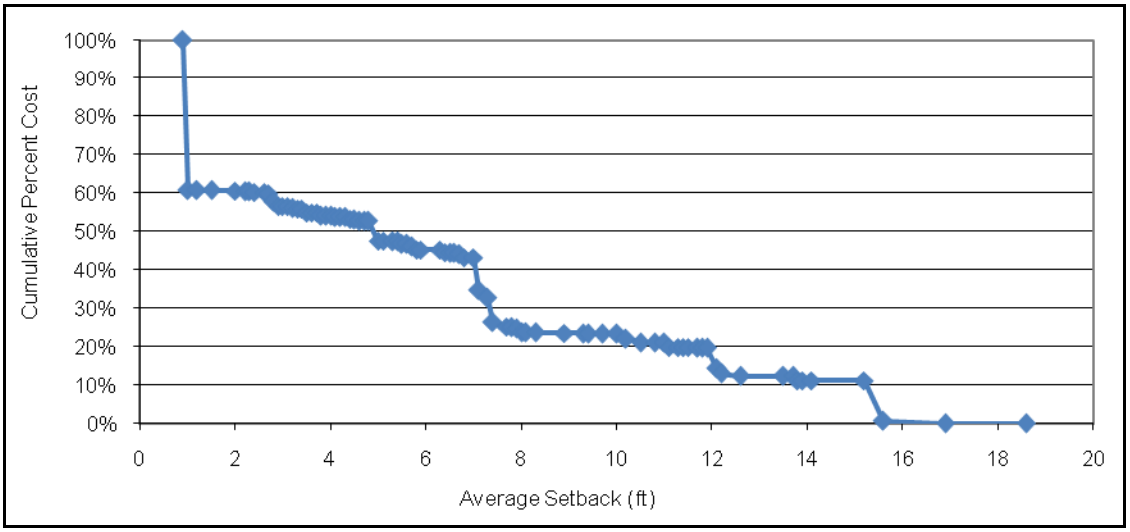

Figure 5-131. Cumulative cost average setback in block analysis with over 6,000 ADT

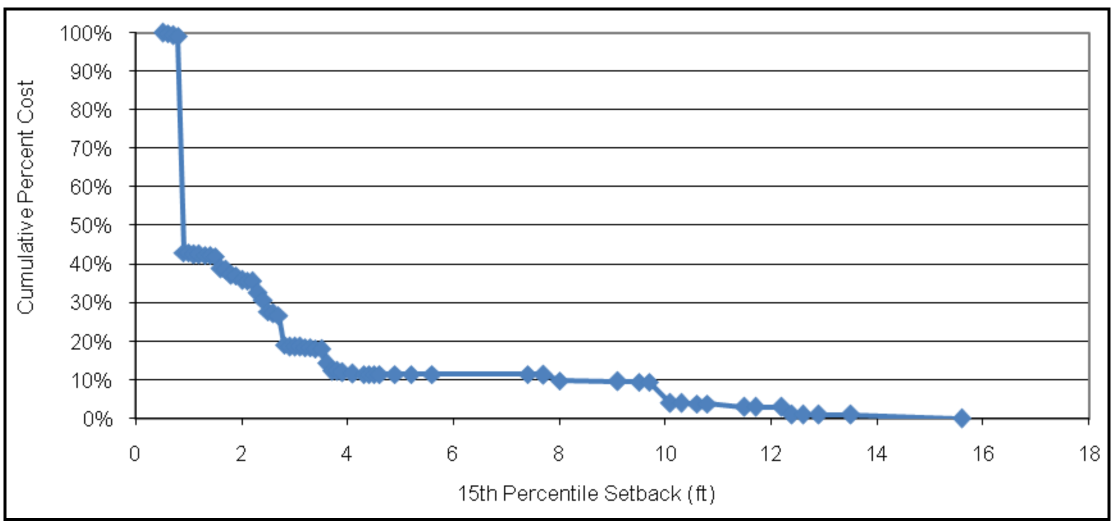

Figure 5-132. Cumulative cost 15th percentile setback in block analysis with over 6,000 ADT

5.10.3. 15 m Analysis

The 15 m analysis, shown in Figures 5-133 through 5-135, indicates varying distances where 90% of fixed object costs occur. The minimum, average, and 15th percentile setback measurements showed that 90% of fixed object crash costs occur within the first 20 ft of the pavement edge. All three measurements show a highly linear relationship between crash costs and setback distance within the first 3 ft of the pavement edge.

The same analysis was done for each speed limit, shown in Figures 5-136 through 5-141. At a 30 mph speed limit, the setback distance where 90% of fixed object crash costs occurred for the minimum, average, and 15th percentile setback measurements were 15 ft, 15 ft, and 15 ft, respectively. At a 35 mph speed limit, the setback distance where 90% of fixed object crash costs occurred for the minimum, average, and 15th percentile setback measurements were 20 ft, 20 ft, and 20 ft, respectively. At a 40 mph speed limit, there were only a few observations, and thus significant conclusion could not be drawn.

The same analysis was completed again for ADT ranges of 1,500–6,000 and over 6,000, shown in Figures 5-142 through 5-147. At an ADT of 1,500–6,000, the setback distance where 90% of fixed object crash costs occurred for the minimum, average, and 15th percentile setback measurements were all 10 ft. At an ADT of over 6,000, the setback distance where 90% of fixed object crash costs occurred for the minimum, average, and 15th percentile setback measurements were all 18 ft.

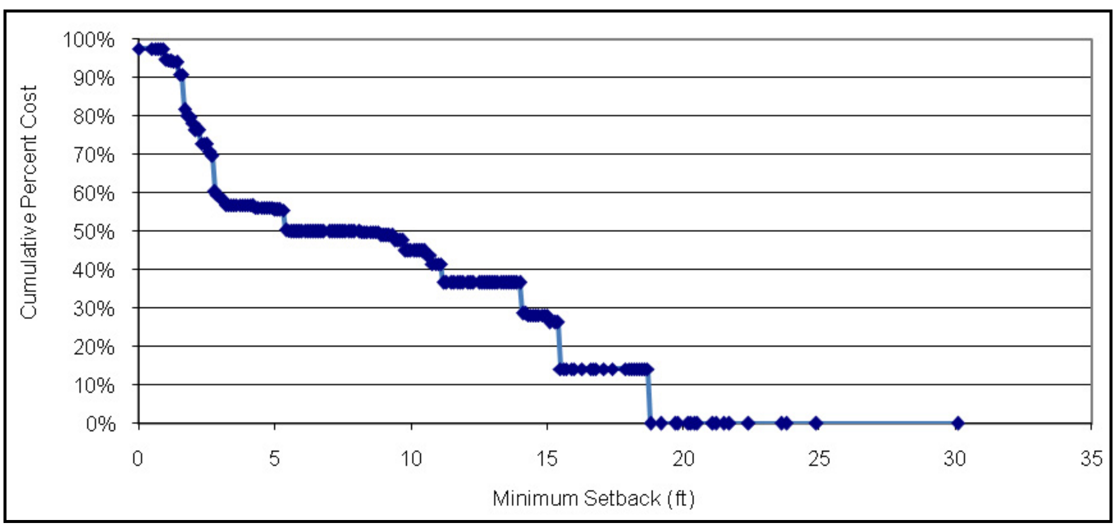

Figure 5-133. Cumulative cost minimum setback in 15 m analysis

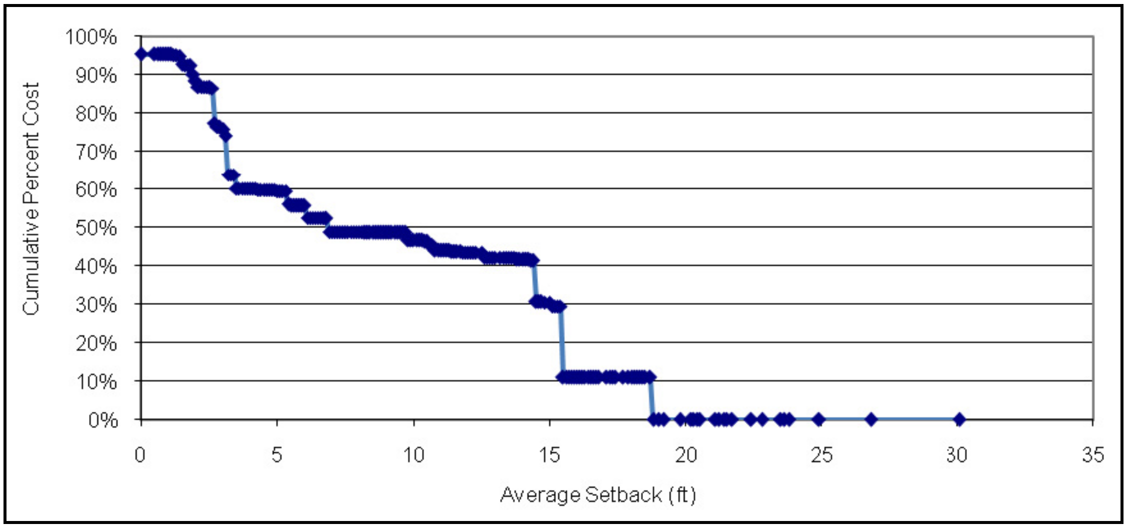

Figure 5-134. Cumulative cost average setback in 15 m analysis

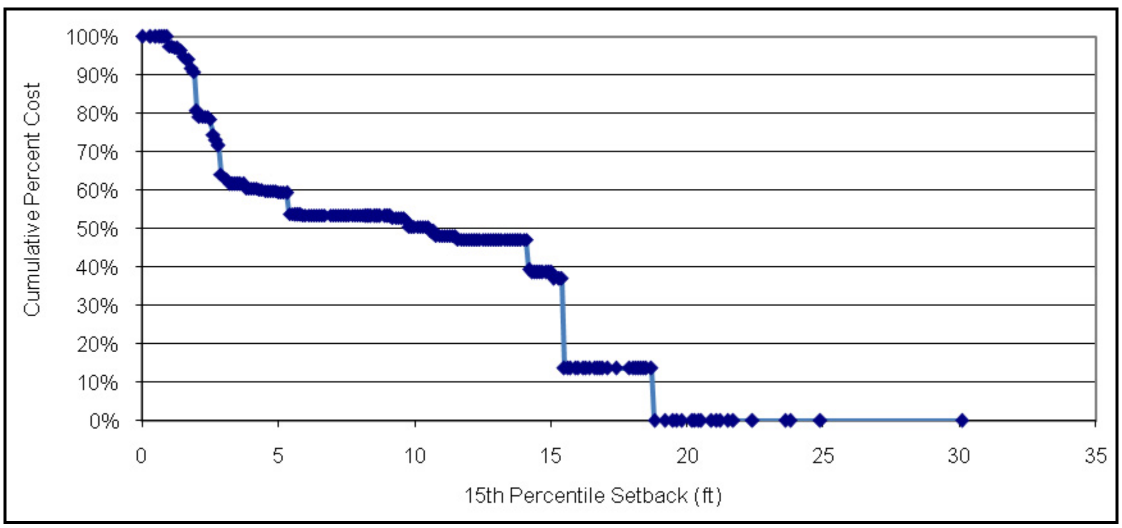

Figure 5-135. Cumulative cost 15th percentile setback in 15 m analysis

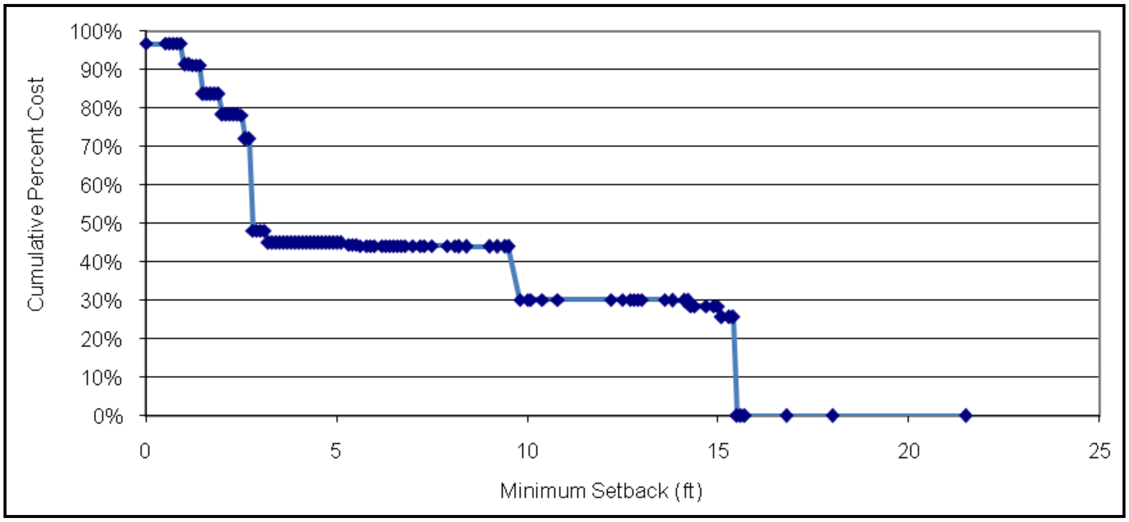

Figure 5-136. Cumulative cost minimum setback in 15 m analysis at 30 mph

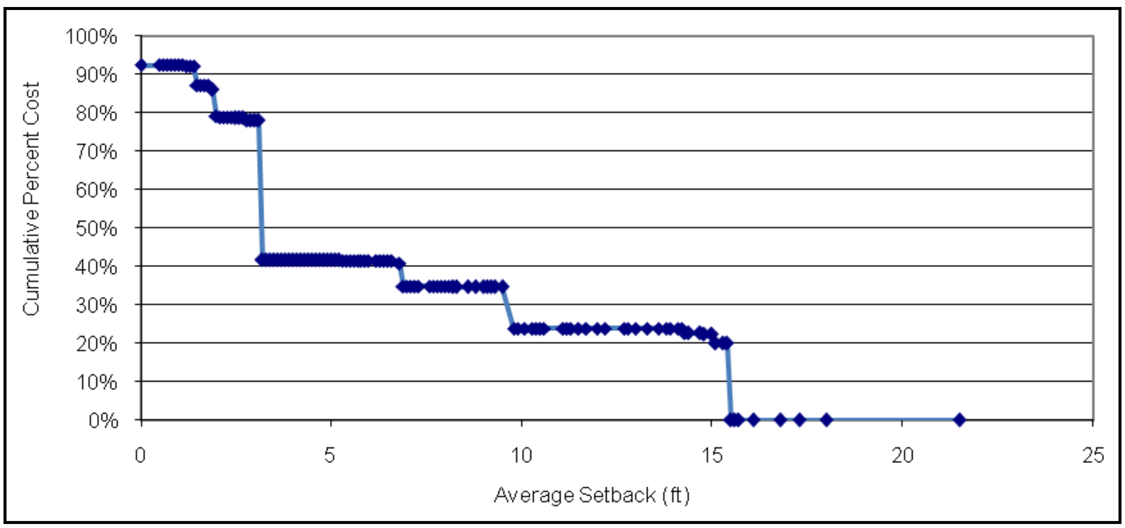

Figure 5-137. Cumulative cost average setback in 15 m analysis at 30 mph

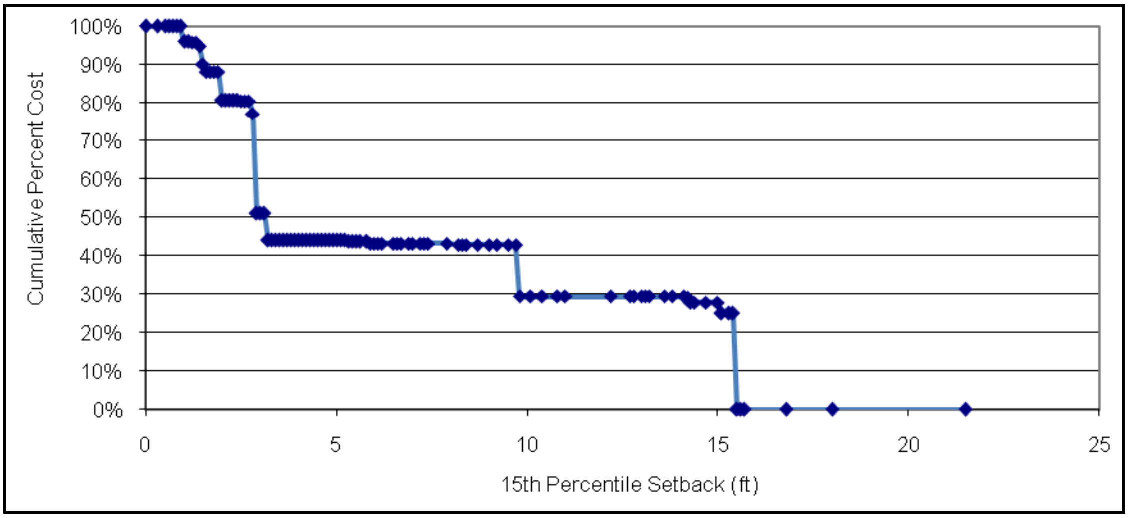

Figure 5-138. Cumulative cost 15th percentile setback in 15 m analysis at 30 mph

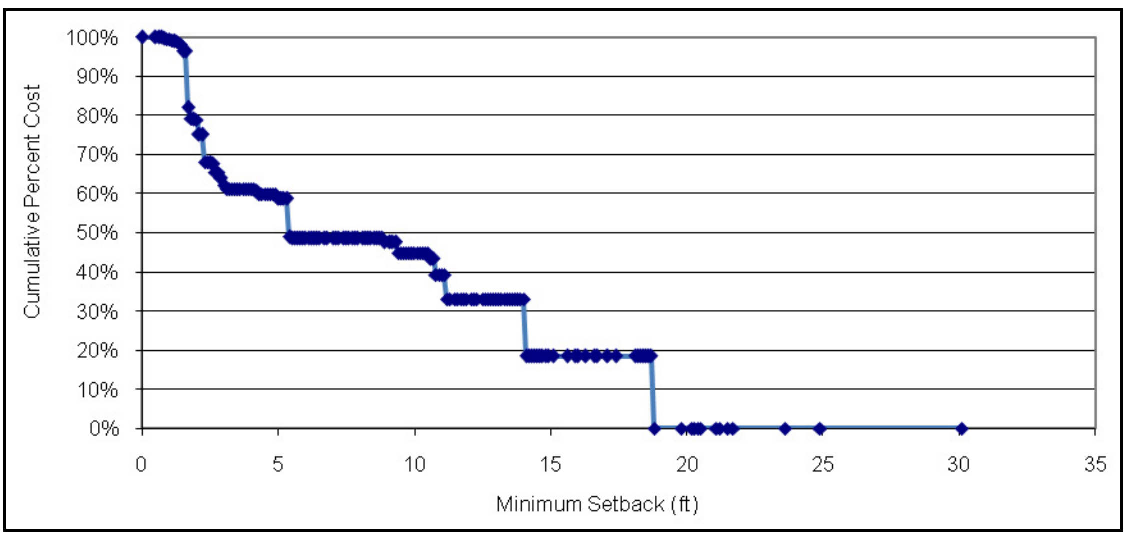

Figure 5-139. Cumulative cost minimum setback in 15 m analysis at 35 mph

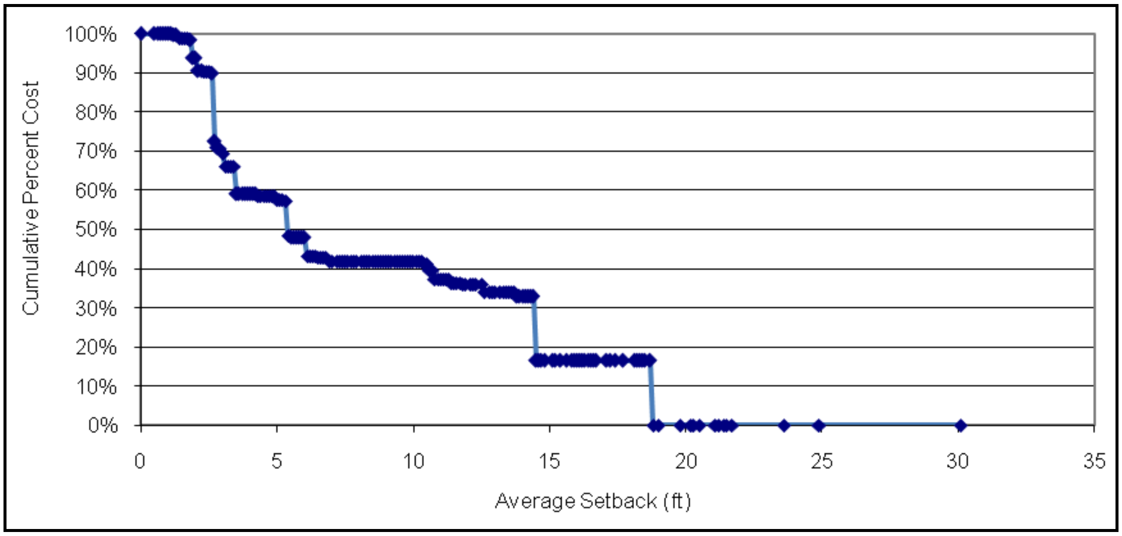

Figure 5-140. Cumulative cost average setback in 15 m analysis at 35 mph

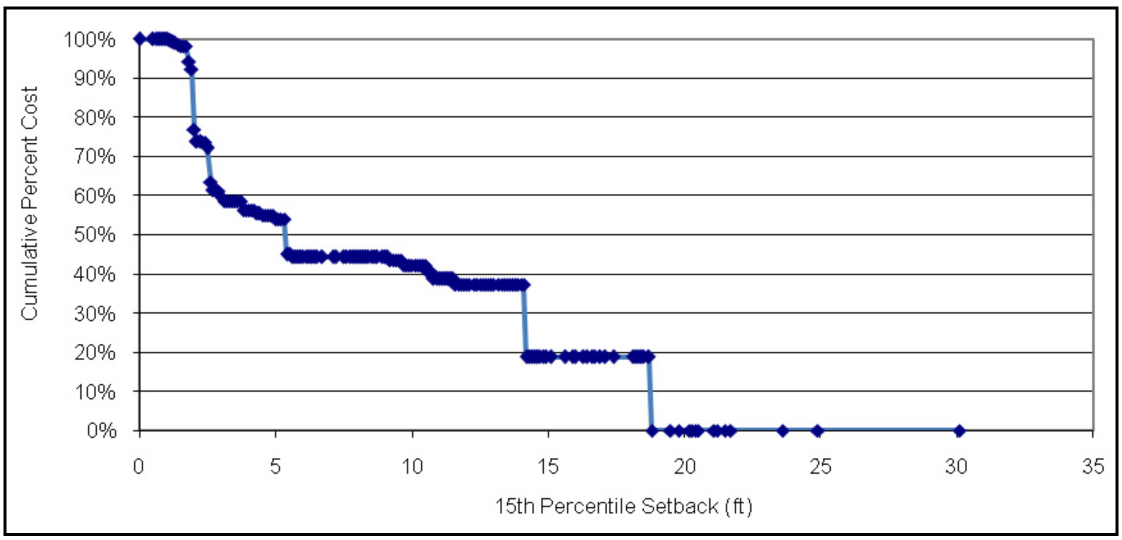

Figure 5-141. Cumulative cost 15th percentile setback in 15 m analysis at 35 mph

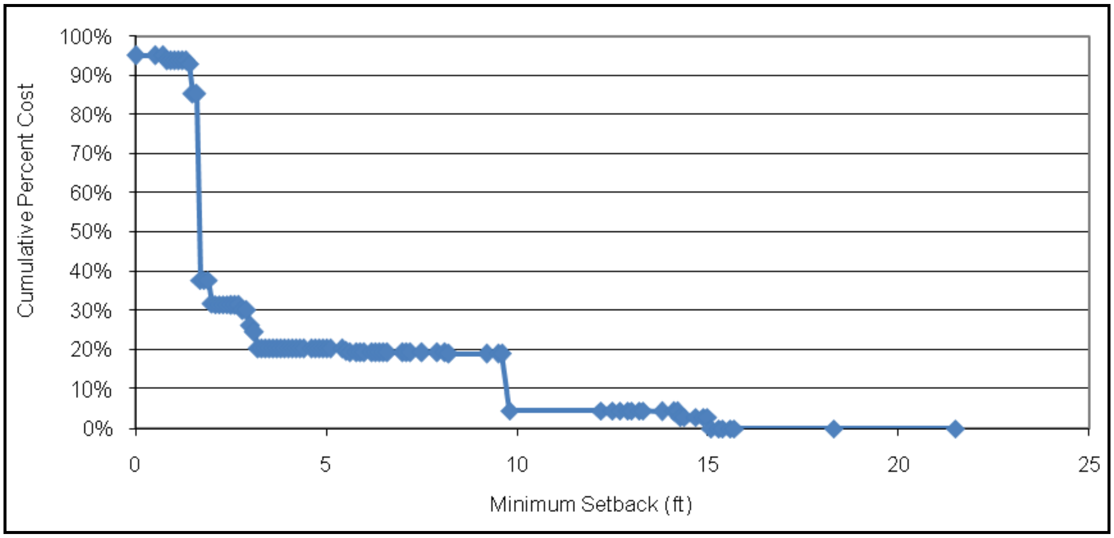

Figure 5-142. Cumulative cost minimum setback in 15 m analysis with a 1,500–6,000 ADT

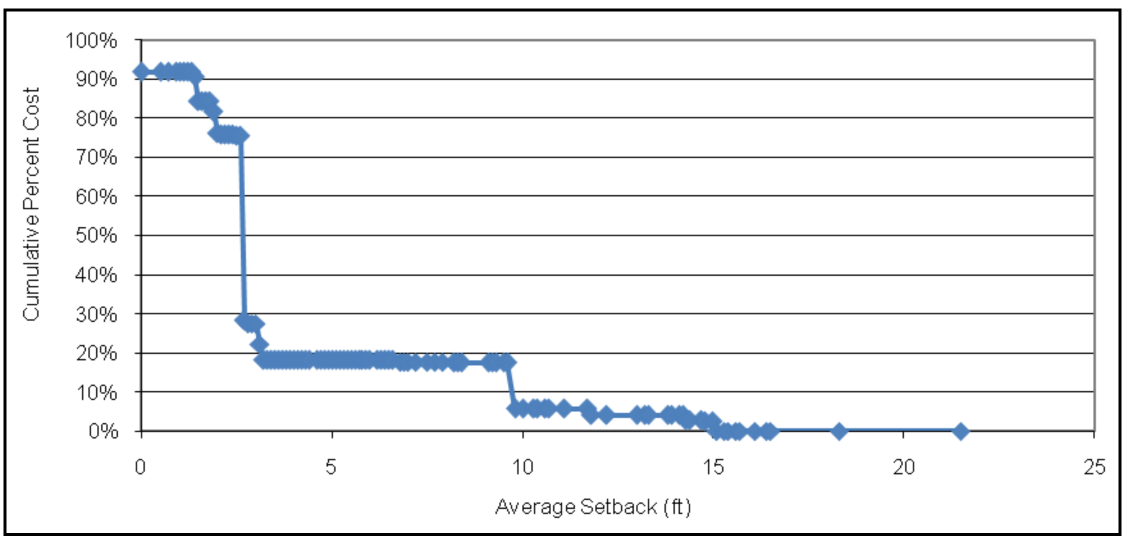

Figure 5-143. Cumulative cost average setback in 15 m analysis with a 1,500–6,000 ADT

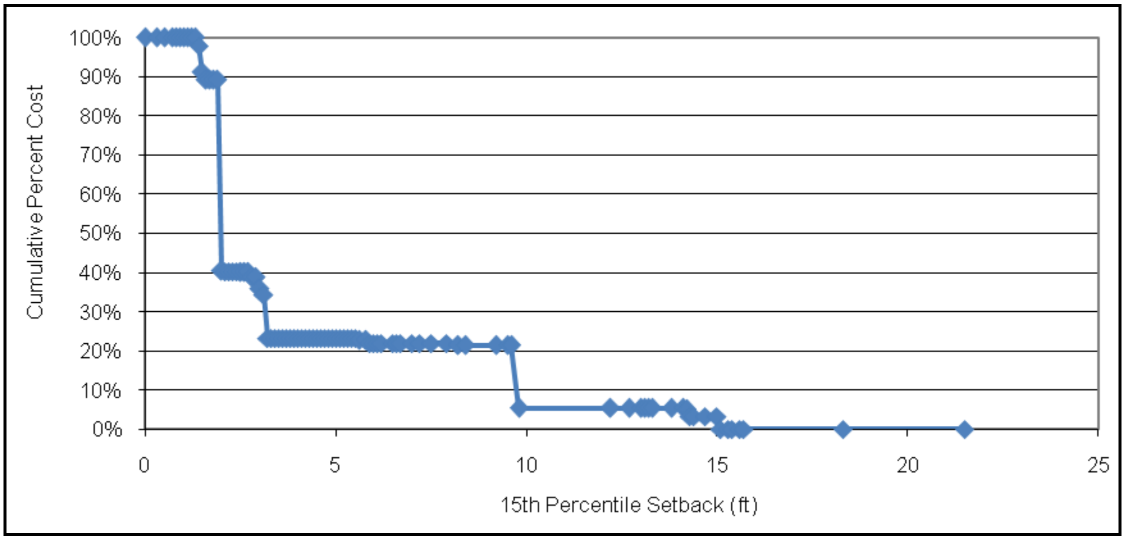

Figure 5-144. Cumulative cost 15th percentile setback in 15 m analysis with a 1,500–6,000 ADT

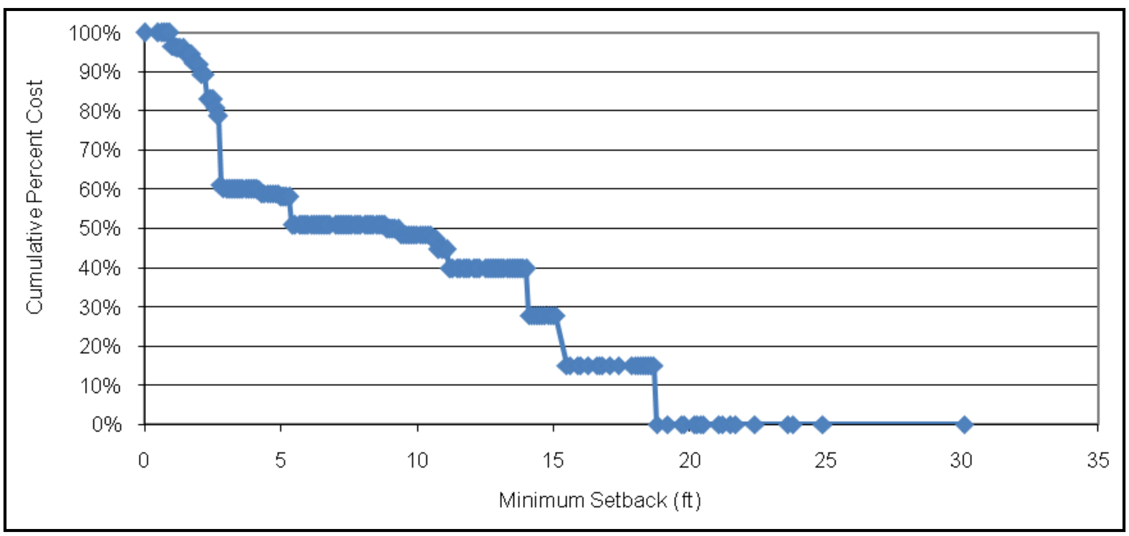

Figure 5-145. Cumulative cost minimum setback in 15 m analysis with over 6,000 ADT

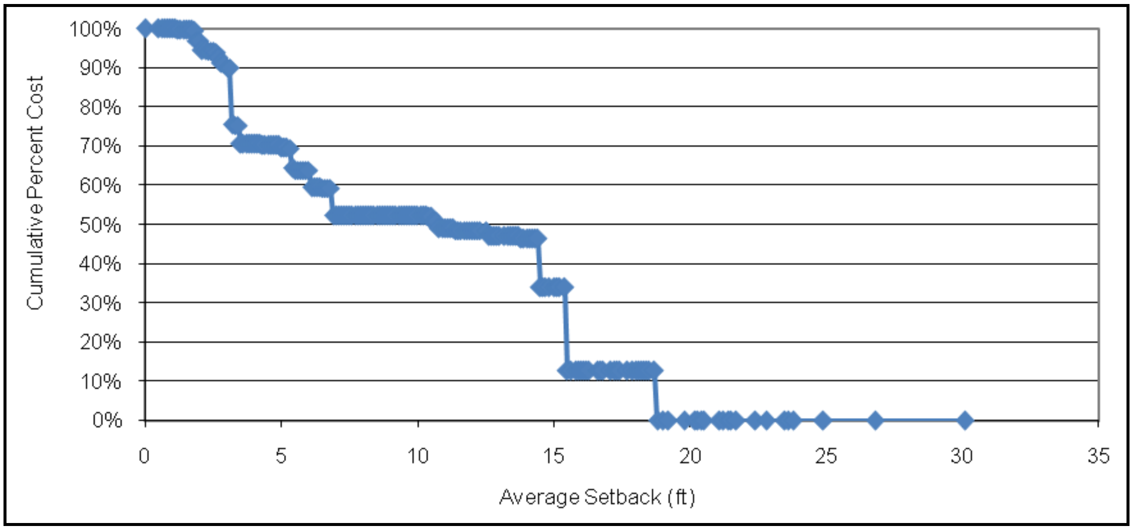

Figure 5-146. Cumulative cost average setback in 15 m analysis with over 6,000 ADT

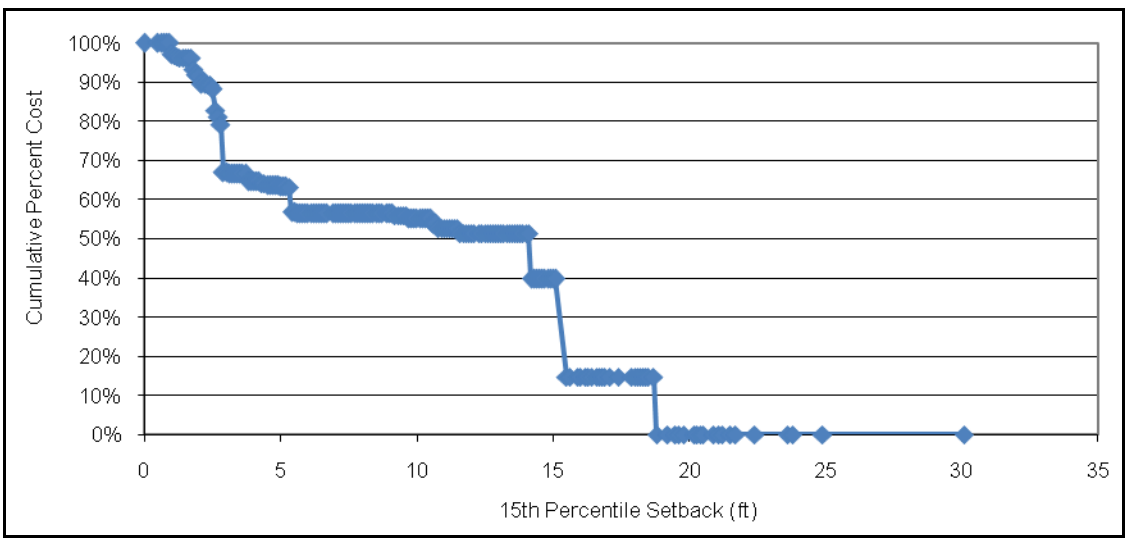

Figure 5-147. Cumulative cost 15th percentile setback in 15 m analysis with over 6,000 ADT

5.11. Economic Evaluation

To determine the dollar benefit of increasing the fixed object setback, an incremental cost table was created for each of the three section lengths. The incremental benefits listed in Tables 5-12 through 5-28 are the dollar benefits per year that are estimated to be attained by increasing the setback by one ft. The greatest benefits were found to occur when the setback distance was increased to 3 ft and to 5 ft. It was found that at higher speed limits or higher ADT, increased setbacks did not result in large cost savings.

5.11.1. Segment Analysis

In the segment analysis (Table 5-12), cost savings were over $30,000 for all three setback distance measurements when the setback distance was increased to 2 ft. There were also significant cost savings for the minimum and average setback measurements when the setback was increased to five ft. The average setback and 15th percentile setback measurements showed large cost savings when the setback was increased to 3 ft and again to 8 ft. When the setback was increased to 7 ft and to 11 ft, only the average setback measurement showed a significant cost savings.

The same analysis was performed for each speed limit, shown in Tables 5-12 through 5-15. At 30 mph, there are large cost savings for all three setback measurements at 2 ft and for the average setback measurement at 3 ft. At 35 mph, there are large cost savings at 2 ft for the minimum and 15th percentile setback measurements, 3 ft for the average and 15th percentile setback measurements, and 5 and 8 ft for the average setback measurement. At 40 mph, there are too few observations to draw a conclusion.

The same analysis was performed again for the ADT ranges of 1,500–6,000 and over 6,000, shown in Tables 5-16 through 5-17. At an ADT of 1,500–6,000, there are large cost savings at 2 ft for the minimum and 15th percentile setback measurements and at 3 ft and 5 ft for the average setback measurement. At an ADT of over 6,000, there are large cost savings at 2 ft for all three setback measurements, 3 ft for the average and 15th percentile setback measurements, 5 ft for the minimum setback measurement, and seven and 8 ft for the average setback measurement.

Table 5-12. Incremental benefit in segment analysis

Increased Setback	Average Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2	$ 40,123	$ 609,383	$ 103,102
3	$ 10,134	$ 63,034	$ 29,638
4	$ 3,772	$ 6,998	$ 4,814
5	$ 35,339	$ 51,352	$ 4,517
6	$ 8,350	$ 5,449	$ 4,500
7		$ 39,202	
8	$ 4,129	$ 41,051	$ 81,333
9			
10		$ 6,658	$ 1,406
11	$ 1,250	$ 24,714	$ 12,108

Table 5-13. Incremental benefit in segment analysis at 30 mph

Increased Setback	Average Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2	$ 86,116	$ 609,383	$ 176,770
3	$ 5,100	$ 42,228	$ 13,443
4			$ 2,925
5	$ 12,341	$ 6,254	$ 8,817
6		$ 20,308	
7		$ 9,883	
8			
9			
10		$ 1,925	
11			$ 15,866

Table 5-14. Incremental benefit in segment analysis at 35 mph

Increased Setback	Average Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2	$ 41,965		$ 52,506
3	$ 27,527	$ 142,905	$ 39,275
4	$ 3,772	$ 7,654	$ 6,156
5		$ 61,808	
6	$ 8,350	$ 9,683	$ 4,500
7		$ 23,329	
8	$ 4,129	$ 41,051	
9			
10		$ 4,500	$ 1,406
11	$ 1,250	$ 24,714	$ 8,350

Table 5-15. Incremental benefit in segment analysis at 40 mph

Increased Setback	Average Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2			
3	$ 217		
4			
5	$ 81,333		$ 217
6			
7			
8			$ 81,333
9			
10			
11			

Table 5-16. Incremental benefit in segment analysis at 1,500–6,000 ADT

Increased Setback	Average Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2	$ 57,195		$ 163,856
3	$ 5,100	$ 82,749	$ 17,976
4			$ 2,925
5	$ 15,866	$ 77,938	
6		$ 3,656	
7			
8			
9			
10			
11			$ 15,866

Table 5-17. Incremental benefit in segment analysis at over 6,000 ADT

Increased Setback	Average Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2	$ 52,331	$ 609,383	$ 75,369
3	$ 18,424	$ 78,073	$ 35,279
4	$ 3,772	$ 7,654	$ 6,156
5	$ 45,075	$ 18,520	$ 4,517
6	$ 8,350	$ 9,683	$ 4,500
7	$ -	$ 31,265	$ -
8	$ 4,129	$ 41,051	$ 81,333
9	$ -	$ -	$ -
10	$ -	$ 6,658	$ 1,406
11	$ 1,250	$ 24,714	$ 8,350

5.11.2. Block Analysis

The block analysis (Table 5-18) indicated large cost savings for all three setback distance measurements when the setback distance was increased to 2 ft. (In this analysis, large cost savings were considered to be a savings of $10,000 per year.) For the minimum setback measurement, increasing the setback to 5 ft produced large cost savings. The average setback measurement showed large cost savings when the setback was increased to 8 ft.

The same analysis was performed for each speed limit, shown in Tables 5-19 through 5-21. At 30 mph, there are large cost savings at 2 ft for all three setback measurements, at 8 ft for the minimum and average setback measurement, and 10 ft for the 15th percentile setback. At 35 mph, there are large cost savings at 8 ft for the average setback measurements. At 40 mph, there are too few observations to draw a conclusion.

The same analysis was performed again for ADT ranges of 1,500–6,000 and over 6,000, shown in Tables 5-22 through 5-23. At an ADT of 1,500–6,000, there are large cost savings at 8 ft for the minimum setback measurement, 4 ft for the average setback measurement, and 2 and 10 ft for the 15th percentile measurement. At an ADT of over 6,000, there are large cost savings at 2 ft for all three setback measurements and at 8 ft for the average setback measurement.

Table 5-18. Incremental benefit in block analysis

Increased Setback	Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2	$ 10,684	$ 41,115	$ 25,719
3	$ 3,011	$ 4,065	$ 6,264
4	$ 181	$ 3,868	$ 3,085
5	$ 17,389	$ 2,356	$ 381
6	$ 5,722	$ 3,553	$ 31
7		$ 1,620	
8	$ 9,662	$ 20,382	$ 146
9		$ 2,844	$ 8,817
10		$ 65	$ 5,206
11	$ 417	$ 4,683	$ 7,728

Table 5-19. Incremental benefit in block analysis at 30 mph

Increased Setback	Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2	17,043	70,520	26,260
3	2,162	5,078	3,416
4	83	1,250	1,042
5	-	568	
6	8,817	1,237	
7		1,844	
8	19,325	24,979	
9		4,063	8,817
10			10,100
11			

Table 5-20. Incremental benefit in block analysis at 35 mph

Increased Setback	Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2	$ 8,441	$ 1,027	$ 7,843
3	$ 3,792	$ 8,133	$ 7,412
4	$ 91	$ 5,116	$ 3,094
5	$ 1,296	$ 3,129	$ 440
6	$ 4,175	$ 4,953	$ 61
7		$ 2,493	
8		$ 19,668	$ 292
9		$ 3,450	
10		$ 88	$ 417
11	$ 417	$ 4,138	$ 1,837

Table 5-21. Incremental benefit in block analysis at 40 mph

Increased Setback	Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2			
3	$ -		
4			
5	$ 81,883		
6			
7			
8			
9			
10			
11			$ 81,883

Table 5-22. Incremental benefit in block analysis at 1,500–6,000 ADT

Increased Setback	Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2	$ 7,361	$ 5,060	$ 11,998
3	$ 2,720	$ 5,961	$ 1,121
4	$ -	$ 25,622	$ 1,181
5	$ -	$ 6,438	$ -
6	$ -	$ 1,030	$ -
7	$ -	$ 875	$ -
8	$ 19,325	$ -	$ -
9		$ 4,063	$ -
10		$ -	$ 19,325
11		$ -	

Table 5-23: Incremental benefit in block analysis at over 6,000 ADT

Increased Setback	Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2	$ 14,918	$ 152,346	$ 17,922
3	$ 3,481	$ 8,489	$ 7,835
4	$ 91	$ 2,180	$ 3,020
5	$ 1,037	$ 1,366	$ 352
6	$ 5,722	$ 4,619	$ 61
7	$ -	$ 2,857	$ -
8	$ -	$ 20,634	$ 292
9	$ -	$ 3,450	$ 8,817
10	$ -	$ 117	$ 708
11	$ 833	$ 417	$ 2,783

5.11.3. 15 m Analysis

In the 15 m analysis (Table 5-24), all three setback measurements showed large cost savings when the setback distance was increased to 3 ft. (A large cost savings was considered to be a savings of $500 per year.) There was a large cost savings in the average setback measurement when the setback was increased to 4 ft.

The same analysis was performed for each speed limit, shown in Tables 5-25 and 5-26. At 30 mph, there are large cost savings at 2 and 4 ft for the average setback measurements, at 3 ft for the minimum and 15th percentile setback measurements, and at 10 ft for the minimum setback measurement. At 35 mph, there are large cost savings at 2 ft for the minimum setback measurement and at 3 ft for the average and 15th percentile setback measurements. At 40 mph, there are too few observations to make a conclusion.

The same analysis was completed again for the ADT ranges of 1,500–6,000 and over 6,000, shown in Tables 5-27 and 5-28. At an ADT of 1,500–6,000, there are large cost savings at 2 ft for the minimum and average setback measurements, at 3 ft for the average and 15th percentile setback measurements, at 4 ft for the minimum setback measurements, and at 10 ft for all three setback measurements. At an ADT of over 6,000, there are large cost savings at 3 ft for the minimum and 15th percentile setback measurement and at four and 7 ft for the average setback measurements.

Table 5-24. Incremental benefit in 15 m analysis

Increased Setback	Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2	$ 442	$ 281	$ 196
3	$ 721	$ 635	$ 981
4	$ 90	$ 745	$ 131
5	$ 28	$ 12	$ 24
6	$ 218	$ 192	$ 234
7	$ -	$ 317	$ -
8	$ -	$ -	$ -
9	$ 36	$ 5	$ 9
10	$ 142	$ 92	$ 101
11	$ 125	$ 123	$ 83

Table 5-25. Incremental benefit in 15 m analysis at 30 mph

Increased Setback	Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2	$ 429	$ 601	$ 340
3	$ 1,243	$ 306	$ 1,401
4	$ 167	$ 1,832	$ 134
5			
6	$ 33	$ 9	$ 31
7		$ 449	
8			
9	$ 50	$ 28	$ 42
10	$ 655	$ 353	$ 573
11			

Table 5-26. Incremental benefit in 15 m analysis at 35 mph

Increased Setback	Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2	$ 585	$ 211	$ 211
3	$ 448	$ 786	$ 889
4	$ 83	$ 345	$ 131
5	$ 36	$ 19	$ 31
6	$ 425	$ 363	$ 355
7		$ 252	
8			
9	$ 48		
10	$ 48		$ 72
11	$ 127	$ 126	$ 117

Table 5-27. Incremental benefit in 15 m analysis at 1,500–6,000 ADT

Increased Setback	Incremental Benefit		
	Minimum Setback	Average Setback	15th Percentile Setback
2	$ 1,394	$ 779	$ 329
3	$ 289	$ 1,703	$ 1,504
4	$ 21,833	$ 404	$ 347
5	$ -	$ -	$ -
6	$ 56	$ -	$ 56
7	$ -	$ 20	$ -
8	$ -	$ -	$ -
9	$ 83	$ 50	$ 83
10	$ 917	$ 509	$ 917
11	$ -	$ -	

Table 5-28. Incremental benefit in 15 m analysis at over 6,000 ADT

Increased Setback	**Incremental Benefit**		
	Minimum Setback	Average Setback	15th Percentile Setback
2	$ 199	$ 257	$ 244
3	$ 925	$ 248	$ 928
4	$ 9	$ 868	$ 60
5	$ 36	$ 19	$ 31
6	$ 433	$ 341	$ 350
7	$ -	$ 518	$ -
8	$ -	$ -	$ -
9	$ 41	$ -	$ -
10	$ 45	$ -	$ 63
11	$ 117	$ 124	$ 110

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

In urban communities, there is limited right-of-way available to establish a safe, clear run-out zone. On roadway projects, the clear zone recommended by the administering jurisdiction is sometimes not implemented or defined because of the presence of established buildings, trees, or other fixed objects that would be too difficult or costly to remove.

To address this issue, the research presented in this thesis was conducted in two phases. The first phase involved a synthesis of clear zone practices, which included a literature review and a survey of the practices in jurisdictions with developmental and historical patterns similar to those of Iowa. The second phase was to investigate the benefits of an established 10 ft clear zone, which involved collecting and examining data from recommended urban corridors in Iowa that met and did not meet the 10 ft clear zone goal.

6.1. Summary of Findings

The synthesis of practice developed in the first phase of this research indicates that the 20 state agencies surveyed followed an array of urban clear zone guidance. Some states followed the minimum operational setback recommended by AASHTO, while other states have created their own guidance, which is currently being followed by design engineers. Some states went as far as to ignore the presence of the curb and to require the use of the AASHTO-recommended setback distances for non-curbed roads.

The descriptive analysis conducted in the second phase of this research investigated the effects of clear zones and effectively updated the analysis by Turner et al. (1989), which is believed to have been the impetus for the 10 ft minimum setback requirement in Iowa. The findings of this phase of the research are as follows:

- It was found that the minimum, average, and 15th percentile setback distances do not have a statistically significant relation to fixed object crashes at the 90% confidence interval.

- Within 45 m of an intersection, roadways were found to have a statistically significant increase in the number of fixed object crashes at the 90% confidence interval.
- A consistent fixed object offset helps reduce the number of fixed object crashes.
- A weak relationship was found between the number of fixed object crashes and the posted speed limit on the roadway.
- There is no significant relationship between the density of fixed objects and the number of fixed object crashes.
- When minimizing the number of fixed object crashes is a primary goal, a 5 ft clear zone is the most effective setback distance. Of the 53 predictors described in section 5.8 of this thesis, 43 indicated a highly linear relationship between setback distance and the number of fixed object crashes within 5 ft of the pavement edge.
- When minimizing the cost of fixed object crashes is a primary goal, a 3 ft clear zone is the most effective setback distance. Of the 44 predictors described in section 5.9 of this thesis, 34 indicated a highly linear relationship between setback distance and the cost of fixed object crashes within 3 ft of the pavement edge.
- In the incremental cost analysis, the greatest benefits accrued when the setback distance was increased to 3 ft and to 5 ft from the curb. On roadways with higher speeds or with a higher ADT, increasing the setback did not result in large cost savings.

6.2. Policy Implications

The policy question that can be addressed as a result of this research is, What is the optimal fixed object setback on urban curbed roads? This research has shown that there is a natural break in the fixed object crash frequency at a fixed object setback of 5 ft. There is also a natural break in the fixed object crash cost at a fixed object setback of 3 ft. Therefore, there is very little benefit of increasing the fixed object setback to more than 5 ft from the face of the curb.

6.3. Limitations and Future Research

The scope of this study was limited to the evaluation of only 13 corridors in Iowa. More conclusive results would be attainable if the sample size were significantly increased. Additionally, in this study there were very few observations on roadways with a speed limit of 40 mph. This lack of data may have led to unreliable findings in the speed limit analysis and in evaluating the cumulative percent cost, cumulative percent crashes, and incremental cost benefits at a 40 mph speed limit. Different corridor characteristics (e.g., turning percentages, access point density, truck percentages, and winter weather conditions) may also provide additional insight into the crash behavior on urban curbed roads. Finally, the safety that fixed objects located between the roadway and the sidewalk provide to pedestrians was not studied, though this safety consideration may impact the walkability of an urban area.

The coding capabilities of the methods used for this project were also limited. The first limitation is that the Iowa DOT crash database does not have extremely accurate longitude-latitude information that describes where a crash occurred. Because of this impreciseness, a crash may be described in the database as having occurred at midblock when the crash actually took place near the intersection, or a crash may be described as having occurred in one section when it actually occurred in an adjacent section. The second limitation is that buildings and fences were represented during data analysis by two points at either end of the object's area, not by a line that represents the edge of the object. Because of this limitation, the effects of buildings and fences may have been underrepresented during the analysis.

APPENDIX A. SURVEY AND QUESTIONNAIRE

A.1. Survey

The following questions were sent to the 20 state agencies to provide clarification on what clear zone guidance they are using and how they adhere to the guidance. The agencies are assumed to be representative of current design practices.

Contact Info

Agency:	Phone #:
Name:	Email:
Title:	Other:

Questions

For the Federal Aid portion of your state system:

1. Are there established guidelines for clear zone (setback) on **curbed** streets? Are these guidelines available in a reference document, web site, or printed copy that we can get at? If so where/how?
2. Do clear zone guidelines differ based on the type of project (new versus partial rebuild or3R/rehabilitation)?
3. How often are clear zone exceptions requested and by whom (what are some typical reasons)?
4. How are these requested variances dealt with?
5. How often are these requested exceptions granted? Are there additional requirements attached to these granted variances?
6. How does your agency enforce clear zone policy/adherence?

For the State Aid portion of your state system:

1. Are there established guidelines for clear zone (setback) on **curbed** streets? Are these guidelines available in a reference document, web site, or printed copy that we can get at? If so where/how?
2. Do clear zone guidelines differ based on the type of project (new versus partial rebuild or 3R/rehabilitation)?
3. How often are clear zone exceptions requested and by whom (what are some typical reasons)?
4. How are these requested variances dealt with?
5. How often are these requested exceptions granted? Are there additional requirements attached to these granted variances?
6. How does your agency enforce clear zone policy/adherence?

Other Comments:

For additional contacts names within your state:

- Please provide the names and telephone numbers of two local government engineers/planners (probably city engineers but could be county engineers in urbanized states) that are familiar with the application of clear zone guidelines in your state on state or federally financed reconstruction projects.
- Please provide the names and telephone numbers of two local district/local systems engineers/planners (probably city engineers but could be county engineers in urbanized states) that are familiar with the application of clear zone guidelines in your state on state or federally financed reconstruction projects.

A.2. Local Questions

The following questions were asked of the local agencies to provide clarification on what clear zone design exception processes they are using. The agencies are assumed to be representative of the current design practices by the research team.

We are interested in how your agency handles requests when the lateral offset to an object is less than standard design criteria.

1. Is there a formal procedure or policy we could get a copy of?
2. How often would you say these types of requests occur?
3. Could you provide some idea of how frequently these requests are made for both NEW and RECONSTRUCTION projects?
4. What is the process for approving such requests?
5. Are there any formal submittal requirements for evaluation of alternatives or risk?
6. For approved projects, do you monitor and evaluate the in-service performance?

APPENDIX B. STATE RESPONSES

B.1. California

Respondent Contact Information

Kevin Herritt - Chief, Office of Geometric Design Standards

Lateral Clearance Requirements

California uses the same lateral offset distance requirements for state aid projects and federal aid projects. The design requirements can be found in the California Department of Transportation (Caltrans) *Highway Design Manual*, Topic 309 (Caltrans 2008a). The manual states that "on conventional highways with curbs, typical in urban conditions, a minimum horizontal clearance of 1 ft 6 in. should be provided beyond the face of curbs to any obstruction." The manual also states that "on curbed highway sections, a minimum clearance of 3 ft should be provided along the curb." When there are sidewalks present immediately adjacent to the curb, the fixed objects should be located beyond the back of the sidewalk. The California design guidelines do not give lateral offset requirements specific to 3R/Rehabilitation projects.

Design Exceptions

In California, design exceptions are requested by the Project Engineer who is the Responsible Charge Engineer for the project. A design exception would be requested if street furniture, poles, etc. were not able to be relocated. When there is a request for a design exception, California uses a design exception process to document deviations from published standards in the *Highway Design Manual* and *Design Information Bulletins* (Caltrans 2008a; 2008b). The clear recovery zone standard is a Mandatory Design Standard in Caltrans' terminology, which requires that a Mandatory Design Standard Fact Sheet be approved by the Design Coordinator. The Fact Sheet documents the design decision on why it is necessary to deviate from the standard and why it is acceptable to do so at that specific location. The Design Coordinator is an individual who is based in the Department Headquarters Division of Design and assigned to a District. The Design Coordinator is the designated person to approve or deny design exception requests.

When a design exception is received, it is evaluated on a case-by-case basis. If it is deemed acceptable to grant the request, it is documented and approved. In some instances, it is decided to place “additional requirements” upon the site. If there are any “additional requirements” needed, they are discussed in the Fact Sheet for the project and placed during construction. Caltrans enforces clear zone policy adherence continuously, project-by-project, during the project delivery process.

B.2. Colorado

Respondent Contact Information

Ken Nakao - Professional Engineer 1

Local Contacts

- Jon Padon - City of Lakewood
- Don Wyman - Denver Water Department
- Jeff Bailey - City of Loveland

Lateral Clearance Requirements

Colorado uses the same lateral offset distance requirements for state aid projects and federal aid projects. Colorado uses the guideline of 1.5 ft that is specified in AASHTO’s *A Policy on Geometric Design of Highways and Streets*, and AASHTO’s *Roadside Design Guide* (AASHTO 1984; 2006). The Colorado design guidelines do not give specific lateral offset requirements for 3R/Rehabilitation projects.

The Denver water department requires that its easements be completely free of aboveground fixed objects. This is to allow the department to dig up its utilities when needed. The only fixed objects that it encounters are fire hydrants, which are generally located directly behind the sidewalk.

Design Exceptions

When there is a request for an exception from the Colorado Department of Transportation, the section for “requesting a variance and why” of Form 463 must be submitted.

The city of Lakewood, Colorado, uses the AASHTO design criteria for non-curbed roads on their urban curbed roads, as shown in Table B-1 (AASHTO 2006, Table 3.1). When an exception is requested, the city reverts to the minimum AASHTO guidance for curbed roads, of 1.5 ft. Requests for this exception occur on approximately 40% of projects. The approval for these exceptions is granted following site plan reviews and engineering reviews, at which time there should be documentation as to why the city standards cannot be met.

Table B-1. AASHTO specifications for non-curbed roads (ft)

Design Speed	Design ADT	Fill Slopes			Cut Slopes		
		1:6 or Flatter	1:5 to 1:4	1:3	1:3	1:4 to 1:5	1:6 or Flatter
40 mph or less	under 750	7 - 10	7 - 10	**	7 - 10	7 - 10	7 - 10
	750 - 1500	10 - 12	12 - 14	**	10 - 12	10 - 12	10 - 12
	1500 - 6000	12 - 14	14 - 16	**	12 - 14	12 - 14	12 - 14
	over 6000	14 - 16	16 - 18	**	14 - 16	14 - 16	14 - 16
45 - 50 mph	under 750	10 - 12	12 - 14	**	8 - 10	8 - 10	10 - 12
	750 - 1500	14 - 16	16 - 20	**	10 - 12	12 - 14	14 - 16
	1500 - 6000	16 - 18	20 - 26	**	12 - 14	14 - 16	16 - 18
	over 6000	20 - 22	24 - 28	**	14 - 16	18 - 20	20 - 22
55 mph	under 750	12 - 14	14 - 18	**	8 - 10	10 - 12	10 - 12
	750 - 1500	16 - 18	20 - 24	**	10 - 12	14 - 16	16 - 18
	1500 - 6000	20 - 22	24 - 30	**	14 - 16	16- 18	20 - 22
	over 6000	22 - 24	26 - 32	**	16 - 18	20 - 22	22 - 24
60 mph	under 750	16 - 18	20 - 24	**	10 - 12	12 - 14	14 - 16
	750 - 1500	20 - 24	26 - 32	**	12 - 14	16 - 18	20 - 22
	1500 - 6000	26 - 30	32 - 40	**	14 - 18	18 - 22	24 - 26
	over 6000	30 - 32	36 - 44	**	20 - 22	24 - 26	26 - 28
65 - 70 mph	under 750	18 - 20	20 - 26	**	10 - 12	14 - 16	14 - 16
	750 - 1500	24 - 26	28 - 36	**	12 - 16	18 - 20	20 - 22
	1500 - 6000	28 - 32	34 - 42	**	16 - 20	22 - 24	26 - 28
	over 6000	30 - 34	38 - 46	**	22 - 24	26 - 30	28 - 30

The city of Loveland, Colorado, does not have any requirements for clear zones in urban areas. This is primarily based on the fact that the majority of their urban roadways are low speed, having a speed limit of 35 mph or lower.

B.3. Illinois

Respondent Contact Information

Kevin Burke - Local Policy & Technology Engineer

Lateral Clearance Requirements

Illinois uses the same lateral offset distance requirements for state aid projects and federal aid projects. Where the street has curbs, no obstacles should be located closer than 1.5 ft from the face of curb. This distance is not considered a clear zone by the Illinois Department of

Transportation (IDOT), but an operational offset. Where parallel parking lanes are included, a 1 ft clearance to the face of curb may be considered (IDOT 2005, Section 33 3.07c). The IDOT design manual states that "Hazards behind curbs preferably should be located outside of the clear zone shown for uncurbed roadways." See Table B-2 (IDOT 2005, Section 35 2.02(f), Figure 35-2A).

Table B-2. Illinois clear zone distance (ft)

Design Speed	Design Year ADT	Front Slopes		Back Slopes		
		1V:6H or Flatter	1V:5H to 1V:4H	1V:3H	1V:5H to 1V:4H	1V:6H or Flatter
40 mph or less	Under 750	7	7	7	7	7
	750 or Over	10	10	10	10	10
45 - 50 mph	Under 750	10	12	10	10	10
	750 - 1500	12	16	10	12	14
	1500 - 6000	16	20	12	14	16
	Over 6000	18	24	14	18	20
55 mph	Under 750	12	14	10	10	10
	750 - 1500	16	20	10	14	16
	1500 - 6000	20	24	14	16	20
	Over 6000	22	26	16	20	22
60 mph	Under 750	16	20	10	12	14
	750 - 1500	20	26	12	16	20
	1500 - 6000	26	30	14	18	24
	Over 6000	30	30	20	24	16

Design Exceptions

Design exceptions for variances from clear zone requirements in Illinois are requested on less than 5% of local projects. Of these exception requests, less than 1% are granted. The most frequent reason given is environmental concern.

Requests for variances may be submitted in writing to the district. IDOT will send the written approval to the local agency (IDOT 2005, Section 27 7(3)). When exceptions are requested, the respective IDOT BLRS Project Development Engineer handles the request for their local agencies. When there is a request for an exception, BLR Form 22210 must be completed and submitted to the IDOT Project Development Engineer. When an exception is granted, the local agency must fully document its evaluation of the project's design and must clearly demonstrate that a design variance is justified. The designer should prepare a statement for use at the district coordination meeting that (IDOT 2005, Section 27 7(3)):

- Identifies the design element
- Identifies BLRS design criteria
- Discusses the proposed design
- Provides justification for the design variance

Any contemplated design variance should be discussed at the district coordination meetings. These meetings are usually scheduled bimonthly (monthly in District 1) and are attended by representatives from the FHWA, Central BLRS, and the local agencies and their consultants. The minutes of the coordination meeting may serve as documentation of the approval (IDOT 2005, Section 27 7(3)).

B.4. Indiana

Respondent Contact Information

Richard L. Van Cleave - Roadway Standards Team Manager

Local Contacts

- Brad Davis - Executive Director - Hamilton County Highway Department
- Larry Jones - Department of Public Works – City of Indianapolis

Lateral Clearance Requirements

Indiana uses the same lateral offset distance requirements for state aid projects and federal aid projects. For urban arterials, collectors, and local streets with barrier curbs at either the edge of the travel lane or the edge of shoulder, the minimum lateral clearance is 10 ft from the edge of the travel lane or to the right-of-way line, whichever is less (INDOT 2005, Section 49-2.0). On 3R/Reconstruction projects where the curb is at least 6 in. in height and the design speed limit is 45 mph or below, the minimum lateral clearance requirement from the face of the curb should be 2 ft. Where traffic signal supports are present, the minimum lateral clearance requirement should be 3 ft (INDOT 2005, Section 55-5.02).

Design Exceptions

Design exceptions for lateral clearance of fixed objects in Indiana are considered Level Two design exceptions. In a Level Two design exception, the designer must document in the project file that the criteria have not been met and provide a brief explanation for not meeting the Level Two criteria. For local agency projects, the local agency should furnish written concurrence with any Level Two design exceptions signed by a local elected official. There have been no lateral clearance exception requests to date within the memory of the Indiana Department of Transportation (INDOT) official interviewed. In Hamilton County, officials have stated that design exceptions are very infrequent, occur less than once per year, and only occur on 3R/Reconstruction projects.

To enforce clear zone policy personnel, of each of the six INDOT highway districts in Indiana must physically monitor projects while under construction. Then the projects must have cursory monitoring thereafter. On non-access controlled projects, primarily, any proposed construction activity within the highway right-of-way must submit a construction permit application and receive INDOT approval to carry out the activity. This permit process helps control any future infringements into the clear zones.

In the city of Indianapolis, where a majority of construction projects are reconstruction, design exceptions occur fairly often. The city outsources all of its engineering tasks, so when there is a request for a design exception, the consultant must document why the exception must be made. The request must be approved by the city and then sent to the state for review and approval.

B.5. Iowa

Respondent Contact Information

- Chris Poole - Litigation/Roadside Safety Engineer
- Charlie Purcell - Deputy Director, Office of Local Systems

Lateral Clearance Requirements

Iowa uses the same lateral offset distance requirements for state aid projects and federal aid projects. Iowa's guidelines are published in the Iowa DOT, Office of Design Manual, Section 1C-2 (Iowa DOT 2008b). Table B-3 outlines the lateral clearance requirements on Iowa's urban curbed roads.

Table B-3. Iowa clear zone distances (ft)

Speed Limit	Minimum Clearance	Desirable Clearance
35 mph	10	12
25 mph	6	12
Parking Lane	2	12
Turning Lane	4	12

Design Exceptions

The Iowa DOT does not track the number of design exceptions that are requested. However, the survey respondents report that they are requested infrequently. The exceptions that are requested are due to limited right-of-way or the high cost of relocating obstructions.

B.6. Kansas

Respondent Contact Information

Rod Lacy - Assistant Bureau of Local Projects

Local Contacts

- Gary Janzen - City of Wichita
- Tim Green - City of Lenexa

Lateral Clearance Requirements

Kansas uses the same lateral offset distance requirements for state aid projects and federal aid projects. The Kansas Department of Transportation (KDOT) uses the Bureau of Local Projects Project Development Manual for Non-NHS Local Government Road and Street Projects (KDOT 2003) as their design guidance. The manual states in Appendix B, Section 3 that on curbed roads every effort should be made to ensure that a minimum lateral offset distance of 6 ft be used.

KDOT does use different design guidelines for 3R/Rehabilitation Projects which are outlined in the BLP Project Development Manual, Section 6.4. It states that a 3 ft lateral offset distance be used.

Design Exceptions

KDOT has design exceptions requested relatively infrequently. When a request is made, there is a review of the engineering site specific study and the crash history; engineering judgment is also used to determine if the exception should be allowed.

KDOT enforces the clear zone guidelines by plan review and by providing feedback to its consultant partners who are developing the plans.

In the City of Wichita, requests for design exceptions occur frequently in the downtown area, mostly due to utility poles in the right-of-way. Exceptions are approved through field checks with the consultants project by project.

The City of Lenexa reported that it has no specific process for design exceptions; it requires every location to follow the 1.5 ft lateral clearance requirement.

B.7. Kentucky

Respondent Contact Information

Jeff Jasper - Transportation Engineering Branch Manager

Lateral Clearance Requirements

Kentucky uses the same lateral offset distance requirements for state aid projects and federal aid projects. The Kentucky Transportation Cabinet (KYTC) lateral offset distance requirements are not affected by the presence of curbs. KYTC uses the clear zone design tables from the AASHTO *Roadside Design Guide* (AASHTO 2006), Table 1.

KYTC does not have different design guidelines for new projects versus 3R/Rehabilitation projects. However, the use of context-sensitive solutions may lead to a lower actual clear zone width than what is documented in the AASHTO design tables.

Design Exceptions

In Kentucky, the clear zone is excluded from the design exception process because it is not one of the 13 specific controlling criteria given by FHWA.

B.8. Michigan

Respondent Contact Information

Carlos Torres - Crash Barrier Engineer

Lateral Clearance Requirements

Michigan uses the same lateral offset distance requirements for state aid projects and federal aid projects. The Michigan Department of Transportation (MDOT) lateral offset distance requirements are not affected by the presence of curbs. The lateral offset distance requirements are outlined in Table B-4 (MDOT 2003, Section 7.01.11).

Table B-4. Michigan clear zone distance (ft)

Design Speed	Design ADT	Fill Slopes			Cut Slopes		
		1:6 or Flatter	1:5 to 1:4	1:3	1:3	1:4 to 1:5	1:6 or Flatter
40 mph or less	under 750	7 - 10	7 - 10	*	7 - 10	7 - 10	7 - 10
	750 - 1500	10 - 12	12 - 14	*	10 - 12	10 - 12	10 - 12
	1500 - 6000	12 - 14	14 - 16	*	12 - 14	12 - 14	12 - 14
	over 6000	14 - 16	16 - 18	*	14 - 16	14 - 16	14 - 16
55 mph	under 750	12 - 14	14 - 18	*	8 - 10	10 - 12	10 - 12
	750 - 1500	16 - 18	20 - 24	*	10 - 12	14 - 16	16 - 18
	1500 - 6000	20 - 22	24 - 30	*	14 - 16	16 - 18	20 - 22
	over 6000	22 - 24	26- 32	*	16 - 18	20 - 22	22 - 24
60 mph	under 750	16 - 18	20 - 24	*	10 - 12	12 - 14	14 -16
	750 - 1500	20 - 24	26 - 32	*	12 - 14	16 - 18	20 - 22
	1500 - 6000	26 - 30	32 - 40	*	14 - 18	18 - 22	24 - 26
	over 6000	30 - 32	36 - 44	*	20 - 22	24 - 26	26 - 28
65 - 70 mph	under 750	18 - 20	20 - 26	*	10 - 12	14 - 16	14 - 16
	750 - 1500	24 - 26	28 - 36	*	12 - 16	18 - 20	20 - 22
	1500 - 6000	28 - 32	34 - 42	*	16 - 20	22 - 24	26 - 28
	over 6000	30 - 34	38 - 46	*	22 - 24	26 - 30	28 - 30

** Since recovery is less likely on the unshielded, traversable 1:3 slopes, fixed objects should not be present in the vicinity of the toe of these slopes.*

The MDOT design manual offers several treatments that can be used when obstacles are located inside the lateral offset distance outlined in Table 4. Where the following conditions exist, it may be necessary to retain trees that otherwise would be considered for removal (MDOT 2003):

- At landscaped areas, parks, recreation or residential areas, or where the functional and/or aesthetic value will be lost
- Exceptional or unique trees (because of their size, species, or historic value)
- On designated heritage roads and low speed roads (including low speed urban areas)

- At locations where cumulative loss of trees would result in a significant change in character of the roadside landscape
- Behind non-traversable back slopes
- Behind barrier curbs, particularly in low-speed areas
- Where shrubs and/or ornamental trees exist that would have a mature diameter of 4 ft or less at 4 ft 6 in. above ground line.
- Where removal would adversely affect endangered/threatened species, wetlands, or water quality or would result in significant erosion/sedimentation problems

The Michigan design guidelines do not give specific lateral offset requirements for 3R/Rehabilitation projects, but do offer lenience on the current standards. The manual states that "Clear zone for 3R-nonfreeway projects must be selective and generally 'fit' conditions within the existing right-of-way and character of the road." The manual suggests that removal, relocation, or shielding of objects be considered when the lateral offset requirements cannot be met.

Design Exceptions

Design exceptions are rarely requested on Michigan projects. The few requests have been associated with projects with highly unusual constraints. Exception requests are rarely granted, as MDOT does everything possible to comply with the established clear zone requirements. The designers of the granted exceptions then work with the Traffic and Safety Division of MDOT to address the lateral offset issues on a case by case basis. The MDOT Geometric Design Unit reviews all designs to ensure compliance with clear zone policy. MDOT designers and personnel are also advised to contact this unit whenever there are unresolved roadside safety issues.

B.9. Minnesota

Respondent Contact Information

James Rosenow - State Geometrics Engineer

Local Contacts

Klayton Eckles - Woodbury City Engineer

Lateral Clearance Requirements

The Minnesota Department of Transportation (Mn/DOT) uses different design guidance for federal aid projects and for state aid projects. For federal aid projects, Mn/DOT uses the Road Design Manual (RDM) (Mn/DOT 2008a). Minnesota RDM Chapter 4, Section 6.05 states that on urban arterials, collectors, and local streets with curbs, the minimum lateral clearance is a distance of 1.5 ft from the face of the curb (Mn/DOT 2008a). This distance is used as an operational offset that permits curbside parking, but does not adversely affect traffic flow. This distance does not apply to approved traffic barriers that should be installed at an offset consistent with standard practice, with parking prohibited accordingly. The RDM does not give different design requirements for 3R/Rehabilitation projects.

For state aid projects, the State Aid Rules, Section 8820.9936 states that a lateral clearance of 1.5 ft from the face of the curb to fixed objects must be provided when the posted speed is 40 to 45 mph (Mn/DOT 2008b). When the speed exceeds 45 mph, a 10 ft lateral clearance measured from the driving lane to the fixed object must be provided.

The City of Woodbury uses a lateral clearance requirement of 7 ft on local roads and a requirement of 10 ft on major roads.

Design Exceptions

On federal aid projects, design exceptions are requested infrequently. Only one has been requested within the tenure of the respondent. Lateral clearance exceptions in Minnesota require a formal exception that is routed for approval in a formal process with standardized paperwork. Approval is required from the State Design Engineer and the FHWA Division Office for full federal oversight projects. These exceptions are almost always granted, occasionally with additional requirements.

On state aid projects, design exceptions are requested relatively infrequently and are requested by the owner/initiating agency. Design exceptions are typically caused by existing fixed objects to be retained and, in rare cases, proposed objects, including landscaping and retaining walls. These exceptions requests and frequently granted with occasional additional requirements attached, depending on the judgment of the committee. The formal process for requests for exceptions is outlined in Section 8820.3300 of the State Aid Rules (Mn/DOT 2008b). It states that a written request must be submitted to the commissioner.

The City of Woodbury has had very good compliance with the lateral clearance requirements, as there are rarely requests for design exceptions. When an exception is requested, it must go through engineering review and then be reviewed by the Traffic Control Committee. In-service performance is monitored by the right-of way officer who deals with citizens who install fixed objects in the clear zone.

B.10. Missouri

Respondent Contact Information

Joseph G. Jones - Engineering Policy Administrator

Lateral Clearance Requirements

Missouri uses the same lateral offset distance requirements for state aid projects and federal aid projects. The Missouri Department of Transportation does not have a lateral clearance requirement in its state design manual. Instead it refers to AASHTO's recommendation of 1.5 ft on curbed roads.

Design Exceptions

The frequency with which clear zone design exceptions are requested is unknown. Project managers are responsible for requesting exceptions and are instructed to do so whenever there is a clear zone violation on an existing project. Design exceptions are reviewed and approved by the district engineers.

B.11. Nebraska

Respondent Contact Information

Phil TenHulzen

Lateral Clearance Requirements

Nebraska uses the same lateral offset distance requirements for state aid projects and federal aid projects. The Nebraska Department of Roads (NDOR) lateral offset distance requirements are not affected by the presence of curbs. The Nebraska minimum lateral offset distance requirements for new and reconstructed projects vary from 16 ft to 35 ft. The requirements state that "the clear zone, measured from the edge of the through driving lane, shall have 6:1 side slopes or flatter, which may have crashworthy or breakaway obstacles and shall be free of non-shielded obstacles except:

- Traffic signals, signal poles, railroad signals, railroad tracks, bridge rails, ditches, driveways, intersections, bike/pedestrian paths, earth dikes, curbs, raised islands, guardrails, median barriers, crash cushions, drainage inlets, drainage flumes, culverts with flared end sections, erosion control devices, fire hydrants, roadway lighting, and traffic control devices
- Other obstacles if the NDOR, in its sole discretion, determines based upon an accident review and a Roadside Safety Analysis Program review or a comparable AASHTO approved economic analysis, that the cost to remove or treat such obstacle exceeds the benefits from such removal or treatment."

For 3R/Rehabilitation projects, the lateral offset distance requirements vary from 12 to 25 ft. The requirements state that "the clear zone, measured from the edge of the through driving lane, may have crashworthy or breakaway obstacles and shall be free of non-shielded obstacles except:

- Traffic signals signal poles, railroad signals, railroad tracks, bridge rails, ditches, side slopes, driveways, intersections, bike/pedestrian paths, earth dikes, and parallel drainage culverts; curbs, raised islands, guardrails, median barriers, crash cushions, drainage inlets, drainage flumes, culverts with flared end sections, erosion control devices, fire hydrants, and traffic control devices
- Other obstacles if the NDOR, in its sole discretion, determines based upon an accident review and a Roadside Safety Analysis Program review or a comparable AASHTO approved economic analysis, that the cost to remove or treat such obstacle exceeds the benefits from such removal or treatment.

For scenic and recreation projects, the Nebraska requirements state that the width of the shoulder will be the clear zone.

Design Exceptions

Lateral offset design exception requests are dealt with by identifying the experience of other jurisdictions with respect to the application of traffic calming designs and/or context-sensitive solutions and then used in low-speed municipal areas.

B.12. Nevada

Respondent Contact Information

Dennis Coyle - Standards and Manuals Supervisor

Local Contacts

- Lucein Paet - Las Vegas
- Fidel Calixto - Southern Nevada Regional Transportation Commission (RTC)

Lateral Clearance Requirements

Nevada uses the same lateral clearance distance requirements for state aid projects and federal aid projects. The Nevada Department of Transportation's lateral clearance requirement is the AASHTO *Roadside Design Guide* (2006), outlined in Table 1.

Design Exceptions

In Nevada, formal design exceptions are not applicable to clear zones. When a clear zone cannot be achieved, written justification must be included in the project workbook. Usually these clear zone issues arise in mountainous terrain and developed areas. When a clear zone issue arises during the design phase of a project, it is dealt with when the chief design engineer reviews problems and approves solutions in the Preliminary Design Field Study Report and addendums. When clear zones are adjusted during construction, they are dealt with as part of the standards compliance review and/or change order processes.

In Las Vegas, most fixed objects are located outside of the 5 ft sidewalk. However, when this distance cannot be met, the developer must submit a Deviations from Standards form to the Land Development Section at the public works department. This Deviation from Standards form is then approved by the Assistant City Engineer.

The Southern Nevada Regional Transportation Commission (RTC) requires that fixed objects be located 18 in. from the curb. When a variation from the standard is required, it is documented in the Design Report and Safety Audit. This variation is then approved by the public works directors and their design teams.

B.13. North Carolina

Respondent Contact Information

Jay A. Bennett - State Roadway Design Engineer

Lateral Clearance Requirements

North Carolina uses the same lateral clearance distance requirements for state aid projects and federal aid projects. The North Carolina Department of Transportation's (NCDOT's) lateral offset distance requirements are not affected by the presence of curbs. North Carolina uses the guidelines that are specified in AASHTO's *A Policy on Geometric Design of*

Highways and Streets (AASHTO 1984), and AASHTO's *Roadside Design Guide* (AASHTO 2006), Table 2-1. On 3R/Rehabilitation projects, North Carolina allows for a 50% reduction in Lateral Clearance Requirements, with a minimum lateral clearance shown in Table B-5 (NCDOT 2008).

Table B-5. North Carolina 3R/rehabilitation minimum clear zone (ft)

Speed Limit	Minimum Clear Zone
35 mph	5 ft
45 mph	10 ft
55 mph	15 ft

Design Exceptions

Clear zone exceptions are requested for the placement of utilities. Utility owners make a variance request to NCDOT. For active highway projects, the requests for variance involving utilities that will not be installed as part of the project are presented to the utility coordination agent. For utilities to be installed as part of the project, the requests are forwarded to the utility engineer. If the requests are documented and found to be acceptable to all interested parties within the department, they are granted as part of the official encroachment agreement process. Encroachment requests not involving active highway projects are initiated at the district engineer's level. Most of the encroachment requests are administered by the district engineer. Specific types of encroachment requests are forwarded to the Utilities Coordination Section for review and issuance.

Requests are granted when there is an extreme hardship associated with obtaining lateral clearance requirements and occasionally when there are extenuating circumstances such as other above ground fixed objects that will be inside the lateral clearance requirement (buildings, trees, etc.) but outside the right-of-way. Consideration is also given to protection of the utilities, but this is generally viewed as undesirable.

For active highway projects, the resident engineer assures that the utilities are installed at the agreed upon location. The district engineer assures that utilities not involving highway projects are installed at the agreed upon location.

B.14. North Dakota

Respondent Contact Information

Cameron Scott

Lateral Clearance Requirements

North Dakota uses the same lateral offset distance requirements for state aid projects and federal aid projects. The North Dakota DOT (NDDOT) lateral offset distance requirements are not affected by the presence of curbs. North Dakota uses five road project types to define lateral clearance. These requirements are outlined in Table B-6.

Table B-6. North Dakota clear zone distance (ft)

Project Type	Clear Zone Requirement
Preventative Maintenance	Use existing clear zone
Minor Rehabilitation	Use existing clear zone
Structural Improvement	20 foot clear zone
Major Rehabilitation	Upgrade safety work to a 20 foot clear zone exceot when ADT > 2000, then use AASHTO roadside design clear zone guidance
New / Reconstruction	Use AASHTO Roadside Design Clear Zone guidance

Design Exceptions

A design exception needs to be requested. However, according to NDDOT's design exception records, no exceptions have been requested.

B.15. Ohio

Respondent Contact Information

Dirk Gross - Administrator, Office of Roadway Engineering

Local Contacts

- Dean C. Ringle
- Randy Bowman

Lateral Clearance Requirements

Ohio uses the same lateral offset distance requirements for state aid projects and federal aid projects. At speeds greater than 25 mph, the Ohio Department of Transportation (Ohio DOT) uses a desired clear zone that is calculated as if the curb was not present. The minimum lateral offset distance of 1.5 ft should be provided from the face of curb, with 3 ft at intersections. The desired lateral offset distance requirements are outlined in Table B-7 (Ohio DOT 2006, Figure 600-1E).

Table B-7. Ohio clear zone distance (ft)

Design Speed	Design ADT	Foreslope		Backslope		
		6:1 or Flatter	Steeper than 6:1 to 4:1	6:1 or Flatter	Steeper than 6:1 to 4:1	Steeper than 4:1
40 mph or less	< 750	8	8	8	8	8
	750 - 1500	11	13	11	11	11
	1501 - 6000	13	15	13	13	13
	> 6000	15	17	15	15	15
45 - 50 mph	< 750	11	13	11	9	9
	750 - 1500	13	18	15	13	11
	1501 - 6000	17	23	17	15	13
	> 6000	19	26	21	19	15
55 mph	< 750	13	16	11	11	9
	750 - 1500	17	22	17	15	11
	1501 - 6000	21	27	21	17	15
	> 6000	23	29	23	21	17
60 mph	< 750	17	22	15	13	11
	750 - 1500	22	29	21	17	13
	1501 - 6000	28	36	25	21	16
	> 6000	31	40	27	25	21
65 - 70 mph	< 750	19	23	15	15	11
	750 - 1500	25	32	21	19	14
	1501 - 6000	30	38	27	23	18
	> 6000	32	42	28	28	23

On 3R/Rehabilitation projects, unless crash history, public complaint, or site inspections indicate a problem, the clear zone criteria shown in Table 6 may be reduced by 50%. The clear zone width shall not be less than 1.5 ft in curbed urban areas, and all obstacles within these zones shall be removed, treated, or protected (Ohio DOT 2006, Section 906.1).

Design Exceptions

The Ohio DOT has no formal process for clear zone exceptions. All variances from the design guidelines are decided on as a part of the normal plan review process. As part of the plan review, the clear zone is expected to be obtained unless there are significant impacts to obtaining it.

B.16. Oregon

Respondent Contact Information

Rich Crossler-Laird - Senior Urban Design Engineer

Local Contacts

- Mike Morris
- Floyd Harrington

Lateral Clearance Requirements

Oregon uses the same lateral offset distance requirements for state aid projects and federal aid projects. The Oregon Department of Transportation (Oregon DOT) lateral offset distance requirements are not affected by the presence of curbs. The lateral offset distance requirements are outlined in Table B-8 (Oregon DOT 2003, Table 5-9).

Table B-8. Oregon clear zone distance (ft)

Design Speed	Design ADT	Fill Slopes			Cut Slopes		
		1:6 or Flatter	1:5 to 1:4	1:3	1:3	1:4 to 1:5	1:6 or Flatter
40 mph or less	under 750	7 - 10	7 - 10	*	7 - 10	7 - 10	7 - 10
	750 - 1500	10 - 12	12 - 14	*	10 - 12	10 - 12	10 - 12
	1500 - 6000	12 - 14	14 - 16	*	12 - 14	12 - 14	12 - 14
	over 6000	14 - 16	16 - 18	*	14 - 16	14 - 16	14 - 16
45 - 50 mph	under 750	10 - 12	12 - 14	*	8 - 10	8 - 10	10 - 12
	750 - 1500	12 - 14	16 - 20	*	10 - 12	12 - 14	14 - 16
	1500 - 6000	16 - 18	20 - 26	*	12 - 14	14 - 16	16 - 18
	over 6000	18 - 20	24 - 28	*	14 - 16	18 - 20	20 - 22
55 mph	under 750	12 - 14	14 - 18	*	8 - 10	10 - 12	10 - 12
	750 - 1500	16 - 18	20 - 24	*	10 - 12	14 - 16	16 - 18
	1500 - 6000	20 - 22	24 - 30	*	14 - 16	16 - 18	20 - 22
	over 6000	22 - 24	26- 32	*	16 - 18	20 - 22	22 - 24
60 mph	under 750	16 - 18	20 - 24	*	10 - 12	12 - 14	14 -16
	750 - 1500	20 - 24	26 - 32	*	12 - 14	16 - 18	20 - 22
	1500 - 6000	26 - 30	32 - 40	*	14 - 18	18 - 22	24 - 26
	over 6000	30 - 32	36 - 44	*	20 - 22	24 - 26	26 - 28
65 - 70 mph	under 750	18 - 20	20 - 26	*	10 - 12	14 - 16	14 - 16
	750 - 1500	24 - 26	28 - 36	*	12 - 16	18 - 20	20 - 22
	1500 - 6000	28 - 32	34 - 42	*	16 - 20	22 - 24	26 - 28
	over 6000	30 - 34	38 - 46	*	22 - 24	26 - 30	28 - 30

** Since recovery is less likely on the unshielded, traversable 1:3 slopes, fixed objects should not be present in the vicinity of the toe of these slopes.*

Design Exceptions

Design exceptions for clear zones are frequently requested. The most prevalent reason given for not attaining the full clear zone distance is lack of right-of-way. Design exceptions for clear zone guidelines on 3R projects are the responsibility of the five Regional Technical Centers within the Oregon DOT. Design exceptions for clear zone requirements on 4R projects are reviewed under the normal design exception process and are dealt with on a case-by-case basis. Each requested exception is analyzed in depth prior to approval or rejection. The analysis studies crash history at the location as well as probable future crashes after project completion. Clear zone design exceptions are usually granted after analysis.

In Region 1 of the Oregon DOT, there are requests for lateral clearance design exceptions on nearly every urban project, as there are almost always utility poles, trees, benches, fire hydrants, etc. in the clear zone. The Oregon DOT has found that the right-of-way is often constrained in urban areas and very expensive to acquire. When the clear zone is widened in urban areas, there have been significant impacts to residential and business owners, who may have to be relocated. In Region 1, design exceptions are reviewed by the roadway manager, lead engineer, region traffic engineer, region maintenance manager and/or district maintenance manager. Once it has been determined that an exception can be supported, it is signed by the engineer of record, a program manager, and the region technical center manager. On 3R/Reconstruction projects, the same signatures are gathered in the region, and then the exception is forwarded to the state traffic and roadway engineer for consideration. The state traffic and roadway engineer can deny or approve any exception. No formal risk assessments are completed to evaluate the level of risk involved in an exception. After the completion of the project, the crashes are tracked to determine if the exception was related to the cause of the crash.

The Portland area Metropolitan Planning Organization (MPO) uses a lateral offset of 2.0 ft for fixed objects on curbed roads. The interviewee noted that there have not been any exception requests in his one-year tenure at the MPO. There is not a formal exception process, but when the lateral offset is not met, documentation is required.

B.17. South Dakota

Respondent Contact Information

Mark A. Leiferman - Chief Road Design Engineer

Lateral Clearance Requirements

South Dakota uses the same lateral offset distance requirements for state aid projects and federal aid projects. The South Dakota Department of Transportation (SDDOT) *Road Design Manual* outlines preferred lateral clearance distances (SDDOT 2007). Table B-9 summarizes these requirements.

Table B-9. South Dakota clear zone distance (ft)

Roadway	Distance
Construction/Reconstruction or urban, low speed (<40 mph) projects with curb and gutter	6 feet is desireable (measured from the back of curb), 2 feet is the minimum
3R urban, low speed (<40 mph) projects with curb and gutter	6 feet is preferred where practical (measured from the back of curb), 2 feet is the minimum
Construction/Reconstruction of suburban, intermediate speed (45-50 mph) projects with or without curb and gutter	Lower speeds may consider a clear zone down to 6 feet (measured from the back of curb) whereas higher speeds a clear zone between 6 feet and 30 feet may be considered. Engineering judgment shall be used to determine the clear zone

Design Exceptions

Clear zone design exceptions are requested from SDDOT two to three times per year. The requests are submitted by the SDDOT staff completing the scope and/or design of a project. The requests are usually made when there are low crash rates, slow speeds, or when the cost to meet the clear zone requirements is too great. The requests for design exceptions are generally granted, because exceptions are generally not submitted until after discussions about the likelihood of granting the variance have been completed.

B.18. Texas

Respondent Contact Information

Aurora (Rory) Meza - Director, Roadway Design Section, Design Division

Lateral Clearance Requirements

Texas uses the same lateral offset distance requirements for state aid projects and federal aid projects. The Texas Department of Transportation (TXDOT) has defined lateral clearance requirements for curbed roads in urban areas and on 3R/Rehabilitation projects. TXDOT uses the same lateral clearance requirements on curbed and non-curbed roads in suburban areas. Table B-10 outlines these requirements (TXDOT 2006, Table 2-11).

Table B-10. Texas clear zone distance (ft)

Location	Functional Classification	Design Speed (mph)	ADT	Lateral Clearance (ft)	
				Minimum	Desirable
Suburban	All	All	< 8000	10	10
Suburban	All	All	8000-12000	10	20
Suburban	All	All	12000-16000	10	25
Suburban	All	All	>16000	20	30
Urban	All (Curbed)	≥50	All	Use above suburban criteria insofar as available border permits	
Urban	All (Curbed)	≤45	All	1.5	3
Urban 3R	All	30	All	Back of curb	

Design Exceptions

At TXDOT, variations from the design requirements are handled with design waivers at the district level, which follows its own procedures regarding approval. When an exception is approved, the complete documentation is retained permanently in the district project files, or the documentation is forwarded to the Design Division of TXDOT for retention. TXDOT enforces clear zone policy at the plan review stage prior to letting the project to ensure that the design requirements are adhered to.

B.19. Washington State

Respondent Contact Information

Dave Olson - Design Policy, Standards, and Research Manager

Local Contacts

Drew Woods - Columbia County

Lateral Clearance Requirements

The Washington State Department of Transportation lateral offset distance requirements are not affected by the presence of curbs. The state does not have differing guidelines for 3R/Rehabilitation projects. For right-of-ways that are managed by local agencies, the clear zone must be consistent with city and county design standards. Table B-11 outlines the design requirements that Washington uses (WSDOT 2007, Figure 700-1).

Table B-11. Washington clear zone distance (ft)

Posted Speed mph	ADT	Cut Section (Backslope) (H:V)						Fill Section (H:V)					
		3:1	4:1	5:1	6:1	8:1	10:1	3:1	4:1	5:1	6:1	8:1	10:1
35 or less		10											
40	Under 250	10	10	10	10	10	10	*	13	12	11	11	10
	251-800	11	11	11	11	11	11	*	14	14	13	12	11
	801-2000	12	12	12	12	12	12	*	16	15	14	13	12
	2001-6000	14	14	14	14	14	14	*	17	17	16	15	14
	Over 6000	15	15	15	15	15	15	*	19	18	17	16	15
45	Under 250	11	11	11	11	11	11	*	16	14	13	12	11
	251-800	12	12	13	13	13	13	*	18	16	14	14	13
	801-2000	13	13	14	14	14	14	*	20	17	16	15	14
	2001-6000	15	15	16	16	16	16	*	22	19	17	17	16
	Over 6000	16	16	17	17	17	17	*	24	21	19	18	17
50	Under 250	11	12	13	13	13	13	*	19	16	15	13	13
	251-800	13	14	14	15	15	15	*	22	18	17	15	15
	801-2000	14	15	16	17	17	17	*	24	20	18	17	17
	2001-6000	16	17	17	18	18	18	*	27	22	20	18	18
	Over 6000	17	18	19	20	20	20	*	29	24	22	20	20
55	Under 250	12	14	15	16	16	17	*	25	21	19	17	17
	251-800	14	16	17	18	18	19	*	28	23	21	20	19
	801-2000	15	17	19	20	20	21	*	31	26	23	22	21
	2001-6000	17	19	21	22	22	23	*	34	29	26	24	23
	Over 6000	18	21	23	24	24	25	*	37	31	28	26	25
60	Under 250	13	16	17	18	19	19	*	30	25	23	21	20
	251-800	15	18	20	20	21	22	*	34	28	26	23	23
	801-2000	17	20	22	22	23	24	*	37	31	28	26	25
	2001-6000	18	22	24	25	26	27	*	41	34	31	29	28
	Over 6000	20	24	26	27	28	29	*	45	37	34	31	30
65	Under 250	15	18	19	20	21	21	*	33	27	25	23	22
	251-800	17	20	22	22	24	24	*	38	31	29	26	25
	801-2000	19	22	24	25	26	27	*	41	34	31	29	28
	2001-6000	20	25	27	27	29	30	*	46	37	35	32	31
	Over 6000	22	27	29	30	31	32	*	50	41	38	34	33
70	Under 250	16	19	21	21	23	23	*	36	29	27	25	24
	251-800	18	22	23	24	26	26	*	41	33	31	28	27
	801-2000	20	24	26	27	28	29	*	45	37	34	31	30
	2001-6000	22	27	29	29	31	32	*	50	40	38	34	33
	Over 6000	24	29	31	32	34	35	*	54	44	41	37	36

** Since recovery is less likely on the unshielded, traversable 1:3 slopes, fixed objects should not be present in the vicinity of the toe of these slopes.*

Design Exceptions

Washington occasionally receives design exception requests from state designers for reasons such as building setbacks or rock slope cuts. Columbia County has not had any requests during the tenure of the individuals interviewed. Failure to provide a clear zone that is consistent with the design guidelines requires a design deviation. Deviations require approval and documentation, which must address crash history, crash analysis, benefit/cost analysis, engineering judgment, environmental issues, and route continuity. The approving authority for exceptions is involved throughout the design process, so when a formal exception request is submitted, the authority is already aware of the alternatives that have been considered. The agency enforces the clear zone policy by reviewing projects in each region to determine compliance with project development processes and criteria.

B.20. Wisconsin

Respondent Contact Information

Eric Emerson - Standards Development Engineer

Lateral Clearance Requirements

The Wisconsin Department of Transportation uses the same lateral clearance standards for state aid and federal aid projects. On 3R/Rehabilitation projects, Wisconsin has a desirable lateral clearance of 4 ft, with a minimum clearance of 2 ft when the design AADT is less than 1,500. When possible, fixed objects shall be relocated to an area adjacent to the right-of-way line, or as far from the traveled way as practical (WisDOT 2004). Table B-12 outlines the lateral clearance distance standards for curbed roads in Wisconsin.

Table B-12. Wisconsin clear zone distance (ft)

Posted Speed Limit	Desired Clearance	Minimum Clearence
40 mph or less	2	1
45 mph	Shoulder width	1.8
50 mph or greater	Shoulder width	1.8

Design Exceptions

In Wisconsin, if the lateral clearance requirements are not met, no formal exception to the standard is needed because it is not a controlling criterion. However, if a designer wishes to use a value that does not meet the requirements, they should document their decision in the Design Study Report. Typically, the designer will discuss the need to divert from the requirements with the Project Services Section prior to the Design Study Report, usually near the 30% design stage. These reduced clear zones are typically accepted.

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