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Modeling the Influence of Land Use Developments on Transportation System Performance

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MINETA TRANSPORTATION INSTITUTE

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MINETA TRANSPORTATION INSTITUTE
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MODELING THE INFLUENCE OF LAND USE DEVELOPMENTS ON TRANSPORTATION SYSTEM PERFORMANCE

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16. Abstract

The growth in the urban population has influenced urban sprawl, congestion, and subsequently, delays on the existing road infrastructure. New land use developments occur in every part of the city due to rapid economic development and to meet the demand for better living standards. The induced traffic volume generated from such land use developments often results in increased congestion and vehicular delay on the existing roads. With recent advancements in the technology, it is possible to capture continuous, and comprehensive travel time data for every major corridor in a city. Therefore, the goal of this research is to model the influence of land use developments on travel time variations to improve the mobility of people and goods.

Data for 259 road links were selected within the city of Charlotte, North Carolina (NC). Three years of travel time data, from the year 2013 to the year 2015, were collected from the private agency. Thirty-five different types of land use developments were considered in this research. The spatial dependency was incorporated by considering the land use developments within 0.5 miles, 1 mile, 2 miles, and 3 miles of the selected road link. Forty-eight statistical models were developed.

The results obtained indicate that land use developments have a significant influence on travel times. Different land use categories contribute to the average travel time based on the buffer width, area type, and the link speed limit. Developing the models by classifying the links based on the speed limit (< 45 mph, 45 to 50 mph, and > 50 mph) was observed to be the best approach to examine the relationship between land use developments and the average travel time. Also, typically travel time on a selected road link is higher during the evening peak period compared to the morning peak and the afternoon off-peak period. Further, the results obtained indicate that the number of lanes and the posted speed limit are negatively associated with the travel time of the selected link.

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EXECUTIVE SUMMARY

From the year 2000 to the year 2010, the total population in the United States increased by 12.1%. About ~80% of the total population resides in urban areas. The growth in the urban population influenced the urban sprawl, congestion, and, subsequently, delays on the existing road infrastructure. Urban sprawl is directly linked to land developments and has a significant influence on the operational performance of the neighboring links (i.e., roads), leading to congestion and delay. In this research, a link is a segment of a road and Traffic Message Channel (TMC) code is the unique ID for the link.

The traffic condition, day-of-the-week, time-of-the-day, and network characteristics of the upstream, downstream, cross streets, and intersecting links also influence the operational performance of the link. Therefore, one needs to consider spatial dependency and the influence on links within the proximity (based on the distance decay effect), over time, to compute travel time variability or reliability. The goal of this research is to model the influence of developments on travel time variations to improve the mobility of people and goods. The objectives of this research are:

1. To identify the predictor variables which could influence the operational performance of links in terms of travel time and travel time variations,

2. To identify the extent to which the influence of proximal land use developments, on travel times, persists,

3. To compare before and after travel times and travel time variations on neighboring links of new developments, and,

4. To examine the relationship between land use developments on travel times and travel time variations on neighboring links by land use type, area type [Central Business District (CBD), CBD fringe, and urban area], and by speed limit categories (speed limit < 45 mph, 45 – 50 mph, > 50 mph).

Data for 259 road links were selected within the city of Charlotte, North Carolina (NC). The land use developments and network characteristics were collected from the local agencies, while real-world travel time data were collected from the private agency. Three years of data, from the year 2013 to the year 2015, were considered in this research.

Thirty-five different types of land use developments were considered in this research. The spatial dependency was incorporated by considering the land use developments within 0.5 miles, 1 mile, 2 miles, and 3 miles of the selected link. Network characteristics of the upstream, downstream, upstream and downstream cross street, and intersecting links were also considered to address the spatial dependency.

Pearson correlation coefficients were computed by considering before-and-after data to investigate the relationship between land use developments and travel time measures. Forty-eight models were developed in this research. Of these, twelve models were developed by considering different buffer widths, eighteen models were developed by classifying the links by area type [Central Business District (CBD), CBD Fringe / Other Business District (OBD), and urban area], and eighteen models were developed by classifying the links based on the speed limit (< 45mph, 45 to 50 mph, and > 50mph). Each of the developed models was validated using the Root Mean Square Error (RMSE), the Mean Absolute Percentage Error (MAPE), and the Mean Percentage Error (MPE), considering data for links which were not used for model development.

Gamma log-link distribution-based model was observed to be the best-fitted model for the data used in this research. In this research, a link represents a road segment and log-link is a function in generalized estimation equations. Models were developed by incorporating all the predictor variables, eliminating one at a time (backward elimination) and also by selecting the independent variables based on Pearson correlation coefficients. The results obtained indicate that land use developments have a significant influence on travel times. Different land use categories contribute to the average travel time based on the buffer width, area type, and the link speed limit. Developing the models by classifying the links based on the speed limit (< 45 mph, 45 to 50 mph, and > 50 mph) was observed to be the best approach to examine the relationship between land use developments and the average travel time. However, capturing the land use developments within 1 mile from a link was observed to be the best approach to examine the relationship between the land use developments and the average travel time by buffer width and area type.

Typically travel time on a selected link is higher during the evening peak period compared to the morning peak and the afternoon off-peak period. The results obtained indicate that the number of lanes and the posted speed limit are negatively associated with the travel time of the selected link. Some of the important findings are listed next.

1. Car wash, convenience store, department store, multi-family, office, fast food, funeral home, hospital, and supermarket type land uses within 0.5 miles from a link increase the average travel time.

2. In the CBD area, department store, government and multi-family type land use within 1 mile from a link increase the average travel time.

3. In the CBD fringe / OBD area, daycare, multi-family, shopping mall, and supermarket type land use within 1 mile from a link increase the average travel time.

4. In the urban area, convenience store, department store, fast food, funeral home, multi-family, recreational, retail, and supermarket type land use within 1 mile from a link increase the average travel time.

Such findings aid professionals and planners in land use planning decisions and can reduce congestion through proactive implementation of mitigation measures. In addition to the procedure followed in the traffic impact studies, the developed relationships could be helpful to quantify the influence of land use developments on travel time based on the type of land use development, area type, and the speed limit of the link.

I. INTRODUCTION

Transportation planning decisions influence land use development activities, while land use development decisions influence travel demand patterns and operational performance of the transportation system. This research focuses on examining and understanding the relationship between land use developments and the operational performance of transportation systems.

BACKGROUND AND MOTIVATION

The United States of America has experienced growth in economic development, population, and health standards in the last few decades. As a result of this economic development, people have migrated to major cities from other countries as well as from rural areas. This has contributed to urban sprawl in many major cities. From the year 2000 to the year 2010, the urban population in the United States increased by 12.1% (Census data, 2012).[1] About ~80% of the population resides in urban areas.

The growth in the urban population has influenced urban sprawl, congestion, and subsequently, delays on the existing road infrastructure. Furthermore, with the construction of high-quality highways, which connect the central business district (CBD) to suburban areas, people tend to live farther from the city center. This leads to an increase in trip lengths and traffic volume on existing roads, resulting in higher travel times and delays. Safe, reliable, and ecologically sound transportation infrastructure is, therefore, a timely necessity. On the other hand, one can also argue that economic development and land use development are as a result of improved transportation facilities and accessibility.

A “land use development” refers to a parcel of land used for residential, commercial, recreational, institutional or other activities. It can be further classified as civic, offices, medical, hospital, hotel/motel, institutional, residential (single family attached / detached and multi-family), recreational, parking lots, mixed-use, etc. type land uses. Generally, new land use developments influence the operational performance on neighboring road links in terms of traffic volume and travel time. For example, if a multi-family residential complex is developed in any part of the city, the vehicle owners living in that complex will contribute to additional traffic volume on the existing neighboring roads.

New land use developments occur in every part of the city due to rapid economic development and to meet the demand for better living standards. The induced traffic volume generated from such land use developments often results in increased congestion and vehicular delay on the existing roads. The increase in traffic congestion and vehicular delay leads to additional travel time, increase in fuel consumption, and an increase in vehicles’ wear and tear. Also, increased congestion on major corridors influences the economy and reduces air quality due to increased emissions from vehicles. This justifies the need to study the impact of the new land use development on existing transportation facilities. This will help planning authorities to make improved land use planning decisions and to identify proactive solutions to mitigate mobility and congestion problems (for example, to increase the capacity of existing roads or to construct new roads within the vicinity of the new land use development).

New land use developments influence traffic volume and travel time performance measures within the vicinity. Also, the influence of new land use developments on travel time can vary based on the area/part of the city (Central Business District (CBD), urban and suburban) and on land use type. For example, a multi-story building in the CBD / downtown area will generate a different amount of traffic volume than will a mid-sized commercial complex in an urban area. Likewise, the influence of a small size commercial development within the vicinity of low speed limit roads, in terms of traffic generation/attraction, would be different from that of a small size commercial development within the vicinity of freeways. Therefore, evaluating the influence of new land use developments, based on the land use type, area type, and speed limit of the road, on the travel time performance measures and variation in travel times on neighboring road links / along the corridor, would help in understanding the impact of new land use development on the transportation infrastructure.

PROBLEM STATEMENT

Researchers have been examining the relationship between land use characteristics and travel behavior over the last three decades. These efforts include examining the relationships between land use development and associated changes in travel behavior in terms of vehicle miles traveled (VMT); trip length; mode choice; and vehicle hours traveled (Ewing and Cervero, 2010) [2]. The relationship between land use development and travel behavior is influenced by countless predictor variables, such as demographic, socioeconomic status, dependency on personal cars, car ownership, the distance between residential and job location, selection of the mode of transportation, etc. Data collection for some of the parameters, for every individual, is a meticulous task. In addition, there may be some privacy concerns. Therefore, due to the complexity and the influence of several external factors on the travel behavior parameters, researchers are still arguing about whether land use characteristics affect travel behavior or vice versa.

In addition to the relationship between land use developments and travel behavior, researchers have been examining the relationship between land use decisions and travel time performance measures, indirectly, using traffic impact studies or transportation modeling or traffic simulation software. However, with recent advancements in the technology, it is possible to capture continuous, and comprehensive travel time data for every major corridor in a city. This data helps to examine the relationship between land use developments and travel time performance measures directly. This will help to understand how and to what extent land use developments influence transportation system performance.

RESEARCH OBJECTIVES

The objectives of this research are as follows:

1. To identify the predictor variables which could influence the operational performance of a segment of a road in terms of travel time and travel time variations;

2. To identify the extent to which the influence of proximal land use developments, on travel times, persists;

3. To compare before and after travel times and travel time variations of neighboring links of new developments; and,

4. To examine the relationship between land use developments on travel times and travel time variations of neighboring links, by land use type, area type [Central Business District (CBD), CBD fringe, and urban area], and speed limit categories (speed limit < 45 mph, 45 – 50 mph, > 50 mph).

ORGANIZATION OF THE REPORT

The rest of the report is comprised of eight chapters. Chapter II summarizes previous studies on different approaches to conducting traffic impact studies and on quantifying the influence of new land use developments on travel behavior. Data collection and data processing adopted for this research are discussed in Chapter III. Chapter IV provides a comprehensive framework to investigate the influence of new land use developments on transportation system performance, in terms of travel time and on travel time variation. Chapter V discusses the results of the correlation analysis. Chapter VI, Chapter VII and Chapter VIII discuss the model development and validation by buffer width, area type, and speed limit, respectively. Lastly, conclusions from this research are presented in Chapter IX.

II. LITERATURE REVIEW

This chapter comprises information related to traditional traffic impact studies, which investigate the influence of different land use developments on neighboring links in terms of traffic volume. This chapter also presents different ideologies and approaches, from the last three decades to address the relationship between land use developments and travel behavior.

TRAFFIC IMPACT STUDY (TIS) AND LIMITATIONS IN TIS ASSESSMENT

Traditionally, a traffic impact study (TIS) is conducted to investigate the impact of land use developments on nearby road links by forecasting the increase in traffic volume. Typically, the TIS is conducted before the implementation of new development. The Institute of Transportation Engineers (ITE) Trip Generation Manual is commonly used to predict the number of trips due to the new development (Muldoon and Bloomberg, 2008).[3] The most recent version, 9th edition (ITE, 2012) of the Trip Generation Manual, considers a total of 172 land use types.[4]

The ITE Trip Generation Manual helps to forecast the number of trips generated by a land use type by considering its area. Each land use type is typically measured in terms of gross floor area, in 1,000s of square feet. However, recreational type land use (park/ golf course/ marina/ campground) area is typically measured in acres. Furthermore, residential type land use is measured in dwelling units, while lodging (motel/ hotel/resort hotel) type land use is measured in terms of the number of rooms. In addition, trip generation rates are typically forecasted for morning and evening peak hours (AM and PM Peak Hour).

Schneider and Hong (1990) researched the use of small-sized traffic analysis zones (TAZ) in suburban areas of large metropolitan areas to conduct TISs[5]. Here, regression analysis was used by considering rentable building space, development, and housing densities as the predictor variables, and the number of trips attracted to the TAZ as the dependent variable. The research suggested that the proposed regression analysis will help in the review and approval process of building permits. Wang (2005) integrated simulation models, GIS, and visualization for traffic impact analysis in terms of Level of Service (LOS).[6] In their study, the LOS for each road was defined based on the volume/capacity ratio.

It is important to compare the forecasted traffic and actual post-development traffic condition. This will help assess the effectiveness and limitations of TIS. Muldoon and Bloomberg (2008) studied thirty TISs of private large developments, such as retail, church, industrial, prison, and office land use area located in Oregon.[3] They compared the forecasted traffic and actual post-development traffic condition for the selected developments. It was observed that predicted values for parameters such as intersection operations, daily trips, and trip distributions were partially consistent with the actual condition. However, predicted turning movements for peak-hour trips were least consistent with the actual condition. In addition, for retail type land use area, the difference between the predicted and actual peak hour trip generation was observed in the range of -55% to 153%. For industrial and office type land use areas, the predicted peak hour trip generation is higher than the actual traffic scenario. Furthermore, selected TIS studies were reviewed based on the location type (urban, urban fringe, and rural). The difference between the predicted and actual peak hour trip generation was observed to be -55% to 105% for the developments in the urban area.

Another approach is to use travel demand models (TDMs) to forecast traffic generated by a proposed new development on neighboring links. As stated by Mamun et al. (2011a), there are two approaches in TISs using TDMs: the link distribution percentage approach, and the special generator approach.[7] They conducted an empirical study on the Alachua / Gainesville Metropolitan Planning Organization model to compare the effectiveness of both the methods. It was observed that both methods provide similar results. However, the study recommended a link distribution percent approach due to its greater simplicity of implementation. Another study by Mamun et al. (2011) proposed an origin-destination based approach to conduct TISs and demonstrated the application of the methodology on a network located in Sioux Falls, South Dakota.[8]

Pulugurtha and Mora (2015) compared what was forecasted with the observed field conditions at six TIS sites.[9] They concluded that the construction of new development will lead to increases in traffic volume, in the number of stops, and in delay at the intersections near the new development. Also, traffic generated due to off-site developments is either underestimated or not typically considered in the TISs. Therefore, incorporating peak hour factors, off-site developments, regional traffic growth rates, and the percentage of heavy vehicles into TISs would provide better forecasts. Phase-wise planning and implementation, in which TISs are conducted for multiple years based on the magnitude of a development, may also assist with better utilization of the resources.

Each Department of Transportation (DOT) have developed their own guidelines to conduct TIS assessments (Dey and Fricker, 1992;[10] California DOT, 2002;[11] NCDOT, 2003).[12] Muldoon and Bloomberg (2008) stated that, typically, land use codes from the ITE Trip Generation Manual are matched with the proposed land use development. However, the actual characteristics of the proposed land use development and the description provided by ITE Trip Generation Manual may not match.[3] In addition, for a particular land use development, different land use codes can be applied due to overlapping of definitions in the ITE Trip Generation Manual. It is sometimes difficult and confusing to get accurate trip forecasts even though the manual provides strong guidelines to forecast trips. Further, DeRobertis et al. (2014) pointed out that the assumptions followed in TISs need to be readdressed.[13] Firstly, the assumption that trip generation rates due to the future land use development are similar to the past land use developments is problematic; it does not account for transit and pedestrian infrastructure developed within the vicinity of the development. Secondly, the mitigation measures typically include increasing the road capacity; however, such increased road capacity could result in induced demand or other profound effects. Thirdly, TISs do not consider the effect of an increase in vehicle traffic on the safety of other modes of transportation such as cycling, walking, and taking public transit.

RELATIONSHIP BETWEEN LAND USE AND TRAVEL BEHAVIOR

Ewing (1995) argued that there are typically two approaches to address the relationship between land use and travel time.[14] The first approach assumes that land use patterns affect the travel behavior, while the second approach assumes that there are no significant effects of this sort on the relationship. Several researchers have studied the relationship between the land use characteristics and travel behavior (Crane, 1996;[15] Banister, 1997;[16] Wegener and Fürst, 1999;[17] Crane, 2000;[18] Meurs and Haaijer, 2001;[19] Stead, 2001;[20] Stead and Marshall, 2001;[21] Handy 2002;[22] Zhang, 2013).[23] The results of these research studies are summarized next.

Ewing and Cervero (2010) stated that the most commonly used parameters of travel behavior are VMT, trip length, mode choice, and vehicle hours traveled [2]. To quantify the built environment, Cervero and Kockelman (1997) established three 'D's' as variables: density, design, and diversity.[24] Two more D's were added afterward and defined as destination accessibility and distance to transit (Ewing et al., 2009).[25]

Density is measured as abundance per unit area. Variables such as population, dwelling units, and building floor area are generally expressed as densities. The net or gross area can be used to convert net abundances into densities. Design indicates the characteristics of the road network. Road networks in CBD / downtown areas are different from road networks in urban/suburban areas. Design parameters include variables such as the width of the road, the presence of sidewalk, and pedestrian crossings. Diversity indicates the variability of land use areas within a study area. Typically, diversity can be represented using a normalized entropy index and a dissimilarity index (Cervero and Kockelman, 1997),[26] with the normalized entropy index being the more commonly used. The normalized entropy index is defined mathematically as:

$$Entropy_{norm} = \sum_{i=1}^{I} \frac{P_i \ln(P_i)}{\ln(I)} \tag{1}$$

where P_i is the proportion of land uses that are of the i^{th} land use type, and I is the total number of land use types under consideration in the particular study area.

The normalized entropy index lies between 0 and 1, since it is normalized against the natural logarithm of the total number of land use types under consideration. A value of zero indicates homogeneous land use pattern in a study area, and a value of one indicates that all land use types are equally distributed in the study area.

The dissimilarity index, developed by Cervero and Kockelman, is defined as the "proportion of dissimilar land uses among hectare grid cells within a tract" (Cervero and Kockelman, 1997).[26] Its mathematical formula is:

$$Dissimilarity = \sum_{j}^{K} \sum_{i=1}^{8} \frac{X_i/8}{K} \tag{2}$$

where K is the number of developed grid cells in a census block, j indexes over grid cells, and i indexes over the j'th grid cell's eight neighboring grid cells; $X_i=1$ if neighbors have different land uses, and $X_i=0$ otherwise.

Crane (1996) stated that auto (car) travel may or may not increase with the change in land use and with improved transit-and-pedestrian accessibility[15]. It may increase with current demand for auto travel if demand is price-elastic or income elastic. At the macro-level, Wegener and Fürst (1999) summarized the results of past empirical studies and concluded that residential density and prevalence of mixed land use are both negatively correlated with trip length.[17] In terms of choice of mode of transportation, residential density is negatively correlated with the use of private vehicle/car and positively correlated with public transportation. Furthermore, Handy (2005) conducted a literature review and concluded that an increase in highway capacity would influence development activities (in urban and suburban areas through urban sprawl).[27] However, the degree of development activities is uncertain and depends upon the local condition.

Holtzclaw (1994) studied the effect of neighborhood characteristics such as residential density, household size, household income, shopping, pedestrian and transit accessibility with car ownership, on VMT per household.[28] The regression coefficient indicated that total VMT and the number of households decrease by ~25% with a 200% increase in density. Similarly, Burchell et at. (1998)[29] and Ewing (1997)[30] concluded that highly dense land use areas reduce VMT. Ewing and Cervero (2001) concluded that 100% increase in local density reduces vehicle miles traveled (VMT) and vehicle trips (VT) decreases by ~5.[31]

Overall, most studies have concluded that highly dense development will result in a reduction in VMT. On the other hand, Crane (2000) argued that VMT per household might be lower than typically estimated, in highly dense places, due to low-income community and lack of other useful information in the dataset.[18] Furthermore, Stead (2001) conducted a research in Britain and concluded that land use characteristics explain only one-third of the variation in total distance traveled per capita.[20] However, their study also concluded that land use characteristics such as settlement size, mixed land use, and local amenities contribute to sustainable development.

Litman and Steele (2012) studied the effect of land use factors such as regional accessibility, density, land use mix, and connectivity of roads on travel behavior characteristics.[32] The study quantified the effectiveness of modeling the effect of land use on travel behavior at block level or census track level. Several other researchers (Gordon and Peers, 1991;[33] Walters et al., 2000;[34] McCormack et al., 2001;[35] Kuzmyak and Pratt, 2003;[36] Ewing and Cervero, 2010;[2] Sperry et al., 2012)[37] observed that modeling the effect of land use on travel behavior at block level or census track level is an effective way to quantify the relationship between land use and travel behavior.

Sperry et al. (2012)[37] conducted a study to analyze the induced trips generated by a mixed land use site located in the suburban area of Dallas, Texas. Their results indicated that VMT reduced in that region, even after the generation of induced trips by mixed land use area. In terms of population density, Jenks and Jones (2009) stated that the densely populated neighborhood would generate growth in the surrounding area.[38] This would influence travel times and shopping trips, which occur close to these neighborhoods.

To quantify the influence of new land use development, it is necessary to identify the boundary of the study area to better comprehend the relations. Harvey and Clark (1965) stated that, due to urban sprawl, time is wasted by traveling through vacant land between the city center and suburban areas.[39] Moreover, Jun (2004) studied the effect of urban growth boundary on development pattern and commuting in the Portland city, OR.[40] The findings indicate that, within the urban growth boundary, travel time increased drastically relative to the outside of urban growth boundary. In addition, it was concluded that, due to the development of more housing units in the suburban area, the commuting travel time is higher in the suburban area compared to the commuting travel time in the central city. Further, Cervero and Day (2008) argued that Transit Oriented Development (TOD) along the transit line may result in reducing the travel time.[41]

Land use density has been explored extensively to quantify the relationship between the built environment and travel behavior in terms of VMT. As per Ewing and Cervero (2001), VMT itself is a complex travel behavior parameter as it incorporates trip length, trip frequency, and mode choice of the individual.[31] However, the National Research Council (2010)[42] and Brownstone (2008)[43] pointed out that most researchers quantify the effect of land use density on VMT in terms of elasticities. For example, a 40% increase in land use density will reduce the VMT by 5%: the results obtained by Brownstone and Golob (2008) indicate that VMT will reduce by 1,200 miles per year per household for each additional 1,000 dwelling units per sq. mile;[44] here, Brownstone and Golob (2008) pointed out that 1,000 dwelling units represent 40% of density value in the dataset and 1,200 miles per year per household represent 5% of the sample mean. Such scenarios do not imply the strong relationship between land use density on VMT. Furthermore, the characteristics of built environment such as demographic, socioeconomic characteristics (household size, income, age), vehicle ownership, the distance between residential area and employment center, and available modes of transportation should be considered in the analysis (Badoe and Miller, 2000).[45]

Zhao and Chung (2001) have researched the estimation of annual average daily traffic (AADT), by considering land use characteristics.[46] Pulugurtha and Kusam (2012) estimated AADT on selected links, considering land use, demographic, and socioeconomic characteristics as predictor variables.[47] In their study, multiple buffer widths around the selected links were considered to capture geospatially distributed predictor variables. This was followed by another study to examine the role of spatial dependency on AADT of links (Kusum and Pulugurtha, 2015).[48] Duddu and Pulugurtha (2013) estimated AADT at the link level (as opposed to the point level or area level) by considering land use characteristics.[49] In their study, a negative binomial model and a multi-layered neural network model were developed to estimate AADT on the selected links. The principle behind their study was that the effect of land use characteristics on AADT of a selected link decreases with an increase in the distance from the subject link.

INFLUENCE OF LAND USE DEVELOPMENTS BY AREA TYPE

The land use characteristics of an area vary with respect to the area type (CBD, urban, and suburban area). Zhang (2013) investigated the relationship between land use developments and travel behavior in the suburban area of Phoenix Metropolitan Region.[23] Their study concluded that the residents in the suburban area are more intensive in their travel behavior than are the residents in the central city. Furthermore, it was observed that travel behavior between commuters in the suburban and urban area was similar to each other. The study was conducted using TAZ level data. Socioeconomic parameters were obtained from census data and were assigned to each respective TAZ. This methodology is beneficial to investigate travel behavior between the TAZs but not within the individual TAZ (at the micro-level / at road links / at corridor level near to the land use development).

After World War II, neo-traditional neighborhood design became popular to design and build suburban areas (Friedman et al., 1994).[50] In this design, residential and non-residential land uses are located in close proximity. The residential and non-residential land uses are well connected by a street network, pedestrian, and bike facilities (Friedman et al., 1994).[50] Friedman et al. (1994) investigated the traditional and standard suburban areas in the San Francisco Bay Area.[50] The regional travel survey data in the year 1980 were analyzed in their study. They also researched the effect of neo-traditional neighborhood design in the suburban area and concluded that this design has a significant effect on travel behavior. However, more factors such as household income, socioeconomic characteristics, and vehicle ownership should be considered to check the relative influence on travel behavior (Friedman et al., 1994).[50]

Ewing and Cervero (2001) stated that CBD areas with high accessibility will produce less VMT than dense mixed-land use developments in suburbs.[31] However, several other researchers have discussed flaws in the traditional methodology and concluded that there is no relationship between land use and travel pattern (Kitamura et al., 1997;[51] Boarnet and Sarmiento, 1998;[52] Crane and Crepeau, 1998;[53] Snellen et al., 2002;[54] Bagley and Mokhtarian, 2002;[55] Schwanen, 2003).[56]

Maat et al. (2005) concluded that the relationship between land use and travel behavior is a complex phenomenon which cannot be addressed through simplified distance-oriented and trip-oriented approaches.[57] Kitamura et al. (1997) studied the effect of attitudinal characteristics and land use characteristics on travel behavior in five diverse neighborhoods in San Francisco.[51] A total of 39 attitudinal characteristics related to urban life were considered in their study. These 39 attitudinal characteristics were classified into eight factors: pro-environment; pro-transit; urban villager; suburbanite; time pressure automotive mobility; willing to pay a toll on the uncongested road; and a workaholic. Their results obtained indicate that attitudes are more strongly correlated to travel behavior than land use characteristics are.[51]

Mane and Pulugurtha (2018) have studied the influence of land use developments, by area type (CBD, urban and suburban), on neighboring links, by comparing travel times before and after development [58]. Their study concluded that land use developments have an influence on travel time measures. However, multiple land use developments may occur along the particular link/route and could influence travel time measures of the selected link/route. Therefore, instead of identifying the land use development and quantifying its influence on neighboring links, capturing the land use developments along the corridor and then evaluating the influence of land use developments on travel time measures would be an effective way to investigate the aforementioned relationship.

APPROACHES TO EXAMINE THE RELATIONSHIP

There are different approaches to examine the relationship between land use and travel behavior. Handy (1996)[59] categorized the research approaches into three parts: simulation, disaggregate analysis, and aggregate analysis. In addition to these approaches, transportation mode choice and activity-based models are used to investigate the relationship between urban form and travel behavior.[59] Here, the term "urban form" does not refer only to land use patterns but also incorporates characteristics of urban design and transportation systems.

In simulation studies, TDMs are used to identify the impact of the built environment on travel behavior. Typically, researchers consider hypothetical situations in simulation studies (Kulash et al., 1990;[60] Stone et al., 1992;[61] McNally and Ryan, 1993).[62] In the disaggregate analysis, each household or individual person's data is used to examine the relationship between the built environment and travel behavior. In aggregate studies, aggregate data at TAZ or census tract level are used to model the relationship between characteristics of built environment and travel behavior (Friedman et al. 1994;[50] Cervero and Gorham, 1995).[63] In the majority of the studies, travel behavior (VMT, trip length, trip frequency, and mode choice) is used as the dependent variable and characteristics of built environment (access to work, density, network characteristics, era of development, socioeconomic characteristics, etc.) are used as the independent variables (Handy, 2005).[27]

In addition, as suggested by Handy (2002), there exists a difference between travel patterns and travel behavior.[22] The term "travel patterns" refers to travel characteristics at the aggregate level, such as the number of trips or mode split in the selected zones. The term "travel behavior" refers to households' and individuals' choices. The analysis of both travel pattern and travel behavior provides different results. Travel pattern studies provide information related to the effect of urban form on travel. On the other hand, travel behavior studies quantify what and how urban form relates to travel.

Descriptive analysis is an important tool to know what is going on (Crane, 2000).[18] However, multivariate statistical analysis helps to explain the reasons behind the relationship between outcome and input variables. Traditionally, the relationship between land use and travel behavior is developed using Ordinary Least Square (OLS) regression, where travel behavior is considered as the dependent variable and land use characteristics are considered as the independent variables.

Boarnet (2011) concluded that researchers have underestimated the standard error of the coefficient in multiple regression models and that this has resulted in exaggerated significance levels of estimated coefficients.[64] However, this can be corrected using multilevel linear modeling (Ewing et. al, 2004).[65] Zhang (2013) stated that, due to the drawbacks in OLS regression, structural equation modeling may provide insights into the role of land use characteristics on travel behavior.[23] Geographically Weighted Regression (GWR) is another method to evaluate the relationship between land use characteristics and travel behavior (Nowrouzian and Srinivasan, 2013).[66]

TRAVEL TIME AS A SYSTEM PERFORMANCE

Travel time provides intriguing details of travel behavior/patterns along a link/corridor. Motorists usually plan their travel so as to account for recurring congestion, which fluctuates based on day-of-the-week (DOW) and time-of-the-day (TOD). However, unexpected congestion on daily trips is worse for motorists. Therefore, the reliability of the routes plays an important role for motorists to plan their travel and selection of the route. Elefteriadou (2005) has defined travel time reliability as the level of variability between the expected travel time (scheduled, average or median travel time) and the actual travel time.[68] It can be used to represent the level of service (LOS) of a link/corridor. Minimizing the travel time variation helps provide reliable routes for commuters who travel by private vehicle/car.

Travel time can be quantified in different ways to represent a system's performance. Table 1 summarizes various travel time reliability measures that can be used to quantify the relationship between a new land use development and travel behavior in terms of travel time. Reliability measures such as Buffer Time Index (BTI) and Planning Time Index (PTI) can be used to compare different road links/corridors (Pulugurtha et al., 2015).[69] However, measures such as Buffer Time (BT) and Planning Time (PT) can be used to compare the before-and-after condition of a road (Pulugurtha et al., 2015).[69]

Table 1. Travel Time System Performance Measures

Index	Measure / Equation	Index	Measure / Equation
NCHRP (1998) Definition [70]	Standard deviation of travel time	λ_{skew} (Van Lint et al., 2004)[71]	
AASHTO (2008) Definition[72]	On-time arrival	λ_{Var} (Van Lint, & Van Zuylen, 2005)[73]	
TranSystems Definition (2005)[74]	Probability of on-time performance	Variability (Wakabayashi, 2012)[75]	$TT_{85} - TT_{15}$
Buffer Time (BT) (Lomax et al., 2004)[76]	$TT_{95} - TT_{Avg}$	Variability (Wakabayashi, 2012)[75]	$TT_{80} - TT_{20}$
Buffer Time Index (BTI) (Lomax et al., 2004)[76]		Variability (Wakabayashi, 2012)[75]	$TT_{70} - TT_{30}$
First worst travel time over a month (Wakabayashi & Matsumoto, 2012)[77]	TT_{95}	Acceptable Travel Time Variation Index (Wakabayashi, 2012)[75]	$P(TT_{avg} + ATTV)$
Second worst travel time over a month (Wakabayashi & Matsumoto, 2012)[77]	TT_{90}	Desired Travel Time Reduction Index (Wakabayashi, 2012)[75]	$P(TT_{avg} - DTTR)$
Planning Time (PT) (Wakabayashi & Matsumoto, 2012)[77]	TT_{95}	Travel Time Index (TTI) (Lyman & Bertini, 2008)[78]	
Planning Time Index (PTI) (Sisiopiku & Islam, 2012)[79]		Frequency of Congestion (Lyman & Bertini, 2008)[78]	Percent of days/periods that are congested
Travel Time Variability (TTV) (Tu et al., 2007)[8]0	$TT_{90} - TT_{10}$		

LIMITATIONS OF PREVIOUS RESEARCH

The review of past literature indicates that the relationship between land use characteristics and travel behavior needs further investigation. Moreover, different travel behavior parameters (VMT, trip length, mode choice, vehicle hours traveled, etc.) were extensively researched to investigate the relationships in the past. These parameters are difficult to capture, are time-consuming to collect, and require extensive surveys. Also, travel behavior parameters are influenced by many external factors such as demographic, socioeconomic characteristics, automobile ownership, distance from the residential area to an employment center, and availability of different modes of transportation (transit, bike, and pedestrian infrastructure). Capturing this data at the TAZ level is a meticulous and time-consuming process. Collecting some of the parameters related to individual persons involves privacy issues. Also, with constant development and consistent growth, it is difficult to quantify the magnitude of the effect of land use development on travel behavior.

Moreover, traditional TISs are meant to estimate the future trip generation rates that will be caused by future planned development. However, each of the DOTs has its own guidelines to perform TISs. Also, the guidelines provided by the ITE Trip Generation Manual has its own assumptions. Further, researchers observed a huge variation between the estimated number of trips and the actual number of trips using traditional TIS approach.

Ultimately, practitioners and researchers are interested in quantifying the influence of new developments, in terms of simple and intuitive parameters such as travel time. With advancements in technology, one can capture travel time information for most major links in a road network. As travel time influences travel behavior and can be easily understood by system managers and motorists, it is important to quantify the influence of new developments on travel time and travel time variations. Such an approach could change the way TISs are currently conducted. In addition, analyzing the influence of multiple land use developments by considering parcel level data along links/corridors would be a possible solution to quantify the relationship between land use developments and travel times. Furthermore, analyzing by area type and by classifying links based on the speed limit as a filtering factor will help generate the results based on the typical structure of urban areas in the United States.

III. STUDY AREA, DATA COLLECTION, AND DATA PROCESSING

This chapter presents the study area, data collection, and data processing adopted in this research.

SELECTION OF LINKS

In this research, the city of Charlotte, NC was considered as the study area. I-485 (freeway) is the outer beltway for the city of Charlotte and was considered as the study boundary limit. The regional travel demand model (RTDM) was obtained from the city of Charlotte Department of Transportation (CDoT). In the RTDM, each road link is geospatially coded in a geospatial environment. In this research, link is a segment of road and Traffic Message Channel (TMC) code is the unique ID for the link. The majority of the links with a TMC code (excluding local streets and drive-throughs) match with the Regional Integrated Transportation Information System (RITIS) database. The RITIS is the source of the travel time data for this research.

The main challenge lies within integrating the RTDM and RITIS databases in a geospatial environment. In the RITIS database, TMC code is assigned based on the particular direction of traffic movement. In the RTDM database, for a particular link, TMC codes are assigned as two separate columns based on the direction of traffic movement (TMC_AB and TMC_BA). In addition, the same stretch of the link is divided into multiple links in the RTDM database. Therefore, merging the multiple links with respect to their unique ID (TMC codes) in the RTDM database was the first step. This was carried out using the “merge” tool in ArcGIS, using one TMC code column at a time.

Further, the length of some links is less than 0.05 miles (264 feet), which were not considered in the selection of links in this research. The links less than 0.05 miles are typically connectors between the major corridors. Due to their small length, the travel time on these links is a few seconds (< 3 seconds). Hence, it does not provide the details of interest related to travel time variation.

The objective of this research is to identify the land use characteristics within the vicinity of road links and quantify their influence on travel time performance. Therefore, defining the boundary of the study area is an important decision to quantify the extent to which the results would be informative. Land use developments just outside the study boundary could have an influence on the links closer to the study boundary. Hence, the road links were selected in such a way that they are located at least 3 miles from the study boundary (I-485). In addition, link lengths between the RTDM and RITIS databases varied in some cases. Therefore, the road links were selected with an error = ± 0.1 miles (error being defined as the difference between the lengths from the RTDM and RITIS databases). In addition, every year the RITIS agency is adding more and more links to collect travel time data. Therefore, for analyzing data from multiple years, the selected links should be consistent, geospatially, over the years in both the databases. Finally, a total of 259 links were selected. Figure 1 illustrates the study boundary and selected road links in this research.

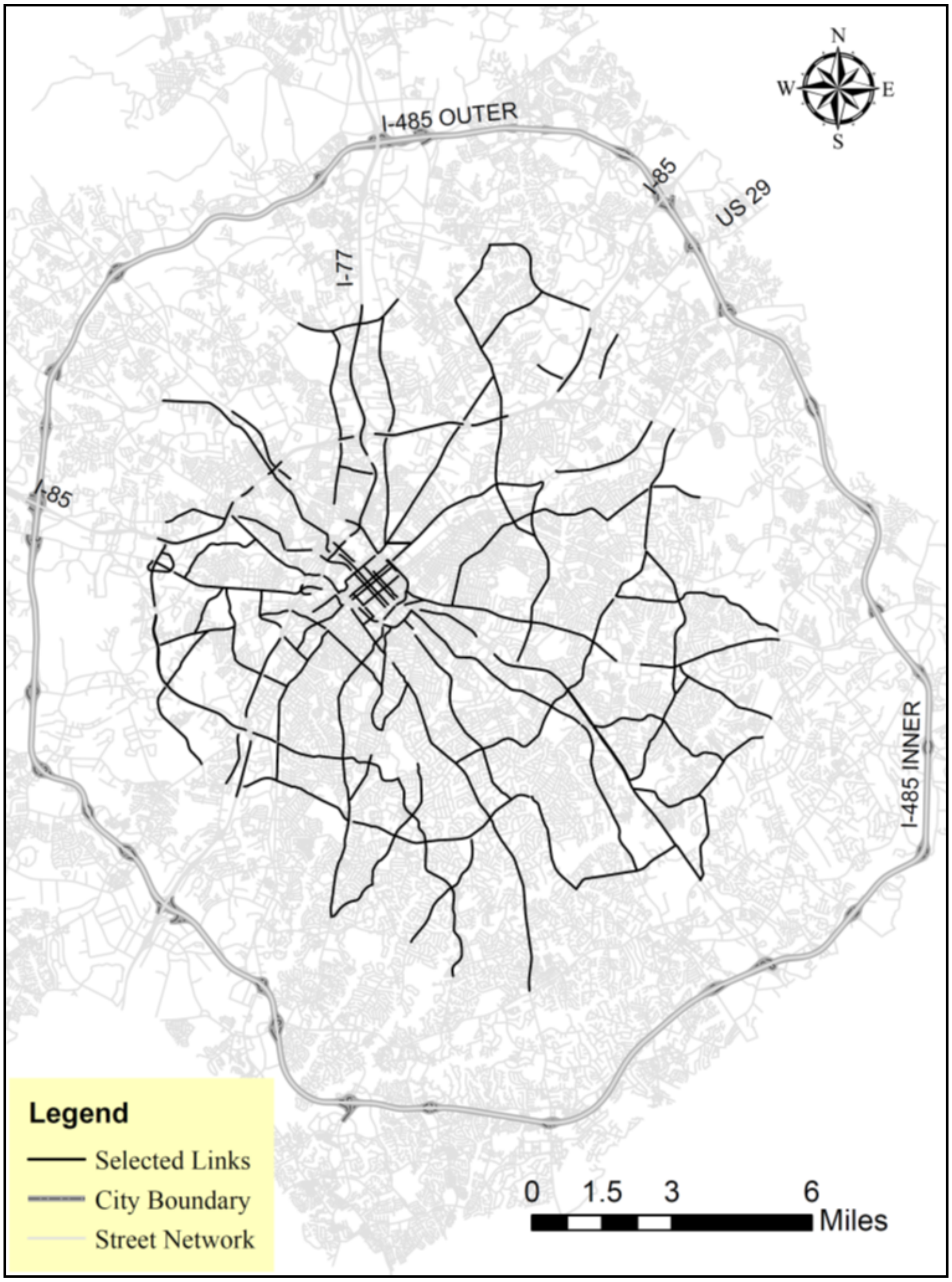

Figure 1. Selected Links in this Research

DATA COLLECTION

After selecting the road links, data collection was performed in different stages: travel time, parcel-level land use development, traffic, and network characteristics.

For the selected 259 links, travel time data from the year 2013 to the year 2015 were downloaded from the RITIS website (www.ritis.org) in a raw unprocessed format. The raw unprocessed data includes travel time for every one-minute interval. For every link, the RITIS provides speed, average speed, reference speed (estimated free flow speed or 85th percentile of observed speed data), travel time, and score. The score represents the type of data: 30 represents real-world travel time data, 20 represents real-world travel time data on multiple links, and 10 represents historical travel time data. Only the real-world travel time data (score = 30) were considered in this research.

Parcel-level land use development data were collected from the city of Charlotte Planning Division in geospatial format. The data includes the year of construction, heated area, and the number of units by land use type. Land use developments up until the year 2015 were considered in this research.

The upstream links, downstream links, upstream and downstream cross streets, and intersecting road links could have an influence on travel time measures of the selected link as illustrated in Figure 2. Therefore, the network characteristics of upstream links, downstream links, upstream and downstream cross streets, and intersecting road links were considered to address the spatial correlation aspect. On a selected link, if there are multiple intersecting road links, the average number of lanes and average speed limit were considered as the network characteristics of intersecting links. Figure 2 illustrates spatial dependency and criteria used to identify the upstream link, downstream link, cross streets and intersecting links for a selected link.

Network characteristics such as the speed limit and the number of lanes for the aforementioned links were captured using the RTDM database.

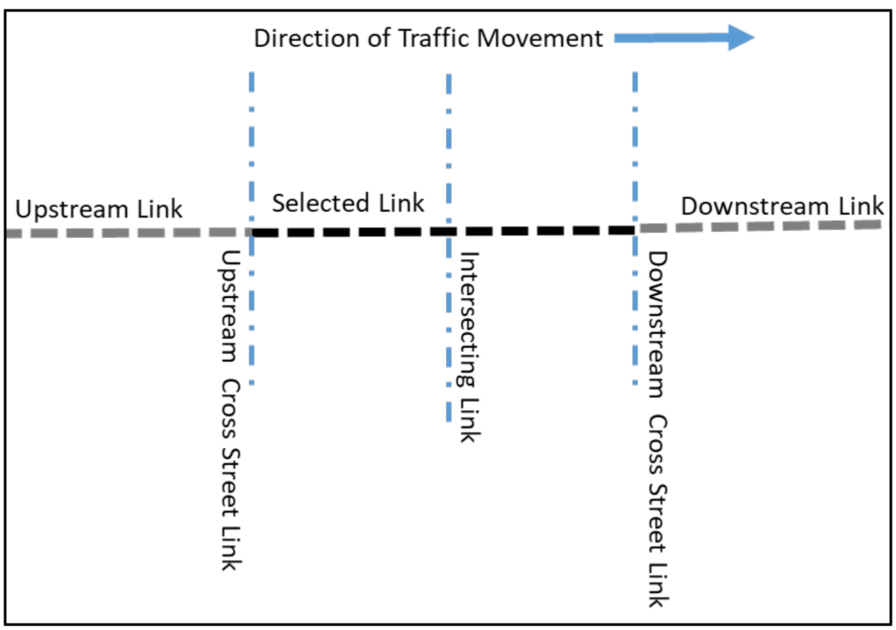

Figure 2. Spatial Dependency Criteria for a Selected Link

The AADT was collected for 213 links from the RTDM database. The RTDM considers traffic volume collected by CDOT and NCDOT, to compute Average Annual Weekday Traffic (AAWT). Also, the conversion factor between AAWT and AADT is considered as 1.08 by CDOT (AAWT = 1.08 * AADT). However, not all the links have computed AAWT in the RTDM database. Furthermore, traffic counts are typically collected once or twice in the year and sometimes only on alternating years. Therefore, AADT computed from traffic counts do not perfectly represent the actual traffic scenario on a link over the year.

DATA PROCESSING

Data processing is an important step before the analysis. It was carried out in two parts: parcel-level land use development and travel time data.

Travel Time

The raw real-world travel time data were imported into Microsoft SQL server. Missing data points were checked and removed from the database. For the selected 259 links, the travel time measures were computed for the years 2013, 2014, and 2015, separately. Several queries were written in Microsoft SQL server to compute travel time measures, such as 10th percentile travel time, 15th percentile travel time, 50th percentile travel time, 85th percentile travel time, 95th percentile travel time also known as planning time (PT), average travel time (ATT), Buffer Time Index (BTI), and Planning Time Index (PTI). These travel time measures were computed for each link by aggregating at the day-of-the-week (DOW) and the time-of-the-day (TOD). Day-of-the-week (DOW) was classified as a weekday (Monday to Friday) and weekend (Saturday and Sunday). TOD is classified as morning peak period (MPP) (7 AM to 9 AM), afternoon off-peak period (OPP) (9 AM to 4 PM), evening peak period (EPP) (4 PM to 7 PM), and nighttime period (NTP) (7 PM to 7 AM). These TOD categories reflect the general traffic trends in the city of Charlotte area, North Carolina. In addition, travel time measures were converted into travel time per mile (by dividing with link length) to reduce discrepancies that might arise due to varied link lengths. Finally, for all the selected 259 links, ATT, PT, BT, BTI, and PTI were computed for each year with respect to DOW and TOD.

The mathematical expressions to compute PTI, BT, and BTI are represented as Equation 3, Equation 4, and Equation 5, respectively. The term “free flow travel time” in Equation 3 refers to the 15th percentile travel time. The description of all the travel time measures is explained in Lomax et al. (2001).[81]

$$Planning\ Time\ Index = \frac{95th\ percentile\ Travel\ Time}{Free\ Flow\ Travel\ Time} \tag{3}$$

$$Buffer\ Time\ = 95th\ percentile\ Travel\ Time - Average\ Travel\ Time \tag{4}$$

$$Buffer\ Time\ Index = \frac{95th\ percentile\ Travel\ Time - Average\ Travel\ time}{Average\ Travel\ Time} \tag{5}$$

Land Use Development

Parcel-level land use development data were obtained in geospatial format (shapefile). ArcGIS software was used to examine and extract the land use development data. Missing values, abrupt values, and duplicate data points were removed from the dataset. The raw dataset consists of 95 distinct land use categories. Each of the parcels provides information, such as the number of units, built year, and heated area (in square feet). Typically, the heated area is the living area of any land use. In this research, land use developments were reclassified into thirty-five categories (Table 2).

Buffers were generated around each selected link using the “buffer” feature in ArcGIS. A buffer is used in the proximity analysis, and buffer width is the distance from the point of interest to the boundary of a buffer. In this research, a point of interest is a link. Four buffer widths (0.5 miles, 1 mile, 2 miles, and 3 miles) were generated around each of the selected links. The shapefile of land use developments was overlaid on the generated buffers (Figure 3). Land use developments within each of the generated buffers were extracted using the “intersect” feature in ArcGIS. The “intersected” files were imported into Microsoft Excel. Finally, based on the “year built” column, land use developments up until the years 2013, 2014 and 2015 were aggregated separately using the pivot table feature in Microsoft Excel. For example, within the proximity of 0.5 miles from a particular link, there are only five new developments in the year 2013. However, travel time on the selected link would be influenced by all the land use developments which were developed before the year 2013. Therefore, to examine the relationship between travel time measures and land use development for the year 2013, land use developments up until the year 2013 were captured in this research.

For each of the selected links, the sum of the heated area by land use categories within four different buffer widths and until the year 2013, 2014, and 2015 were aggregated separately in the land use database.

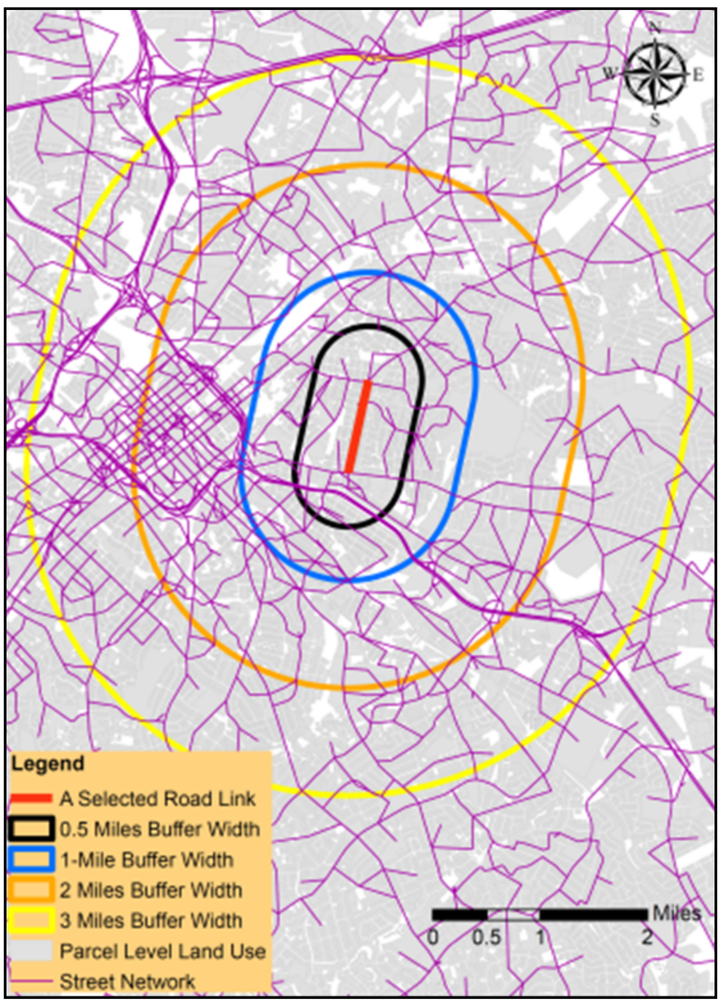

Figure 3. Spatial Overlay of Land Use on Different Buffer Widths Around a Road Link

Table 2. Description of Land Use Development Categories

Land Use Categories	Description
Attached Residential	Condo, condo hi-rise, townhouse
Auto Dealer	Auto dealer; auto dealer > 75,000 square ft.
Bank	Bank
Car Wash	Car wash self-service, car wash drive through
Church	Church
Commercial Service	Commercial / service, service station, commercial condominium, furniture showroom
Convenience Store	Convenience store
Daycare	Daycare
Department Store	Department and drug store
Fast Food	Fast food
Funeral Home	Funeral home
Government	County, state, federal, municipal government buildings
Hospital	Hospital
Hotel/Motel	Hotel Lodging High-Rise > 6 stories, Motel/hotel Lodging <7 stories
Industrial	Areas with manufacturing, processing, and assembling of parts, distribution centers and transportation terminals; specialized industrial operations
Industrial (large)	Industrial > 75,000 square ft.
Institutional	College-public, institutional, lab-research
Manufactured Home Construction	Manufactured home-double wide, manufactured home-single-wide
Manufacturing	Light manufacturing, heavy manufacturing; light & heavy manufacturing > 75,000 square ft.
Medical	Medical and medical condominium
Multi-Family Residential	Areas with a variety of housing types; 12–43 dwelling units per acre; apartment – townhouse, apartment – garden, apartment – hi-rise>6stories, nursing home, assisted living
Office	Office condominium, hi-rise> 6 stories
Parking Garage	Parking garage; parking garage > 75,000 square ft.
Recreational	Theatre, night club, bowling alley/ skating rink, club – lodge
Restaurant	Restaurant
Retail	Area utilized for retail shops
School	Area utilized for schools public private
Service Garage	Service garage; service garage>75,000 square ft.
Shopping Mall	Shopping mall
Single-Family Residential	Area with primarily single-family housing where houses have one common wall with the adjacent house / no walls are connected; patio, duplex, triplex, group home
Stadium/Arena	Stadium /arena
Supermarket	Supermarket
Truck Terminal	Truck terminal
Utility	Mechanical equipment building, utility
Warehouse	Area utilized for manufacturing and wholesale trade/distribution process; mini warehouse, lumber yard, food packing, bottler/brewery, cold storage

IV. METHODOLOGY

This chapter presents the methodology adopted in this research. Figure 4 represents the systematic procedure followed in this research.

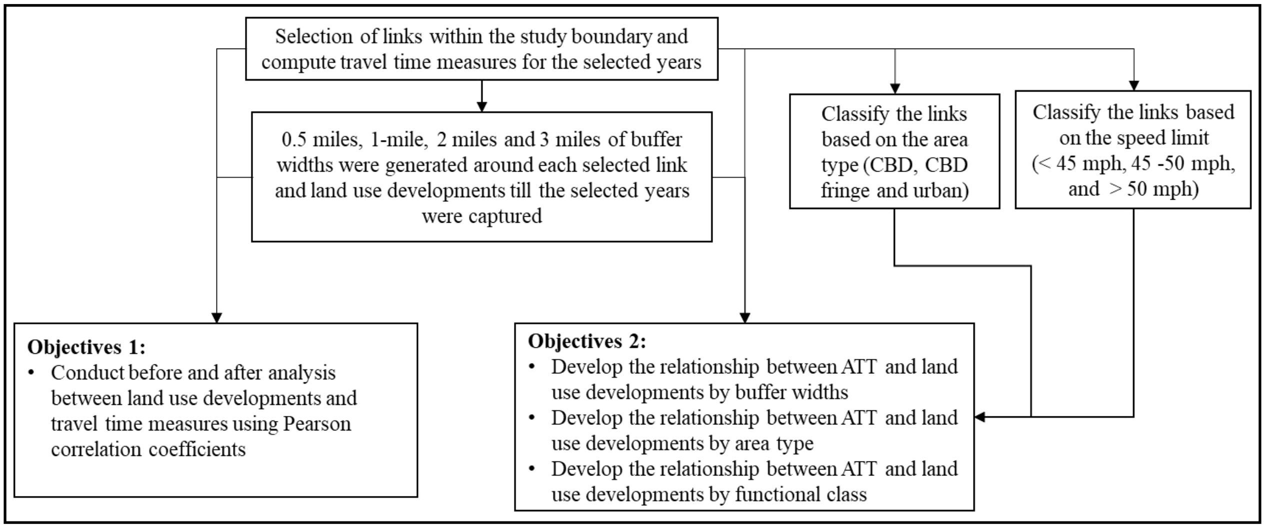

Figure 4. Methodology – Flowchart

CORRELATION ANALYSIS

In this research, correlation analysis was performed by computing Pearson correlation coefficients. The Pearson correlation coefficient measures the strength of a linear relationship between two variables and provides the confidence level at which the coefficient is statistically significant. The range of Pearson correlation coefficients is from -1 to +1. Pearson correlation coefficients that fell within a 95% confidence level were classified into six categories:

- High negative correlation (less than -0.5) represented as HN
- Moderate negative correlation (-0.5 to -0.3) represented as MN
- Low negative correlation (-0.3 to 0) represented as LN
- Low positive correlation (0 to +0.3) represented as LP
- Moderate positive correlation (+0.3 to +0.5) represented as MP
- High positive correlation (greater than 0.5) represented as HP

Correlation between Traffic, Land Use, and Network Characteristics

Twelve network characteristics were considered to examine the relationships. They are:

- Speed limit of the selected link (Link_SL)
- Number of lanes of the selected link (Link_# of Lanes)
- Speed limit of the upstream link (US_SL)
- Number of lanes of the upstream link (US_# of Lanes)
- Speed limit of the downstream link (DS_SL)
- Number of lanes of the downstream link (DS_# of Lanes)
- Speed limit of the upstream cross street (US_Cross street_SL)
- Number of lanes of the upstream cross street (US_Cross street_# of Lanes)
- Speed limit of the downstream cross street (DS_Cross street_SL)
- Number of lanes of the downstream cross street (DS_Cross street_# of Lanes)
- Speed limit of the intersecting links (Intersection_SL)
- Number of lanes of the intersecting links (Intersection_# of Lanes)

For each of the 213 selected links, twelve Pearson correlation coefficients were computed, between each of its aforementioned network characteristics and the AADT of the selected link. This is because, of the 259 selected links, the AADT data was available for 213 links in the RTDM database. Three years (2013 to 2015) of AADT were collected from the RTDM database. Individual year AADT data were considered for this analysis. The changes in the network characteristics by each year were not available in the RTDM or in any other database. Therefore, network characteristics were assumed to be unchanging over these three years. Overall, the sample size for the correlation analysis was 639 samples (213 links × 3 years). This type of dataset is also called as longitudinal dataset or panel dataset. In longitudinal data, for each subject, multiple observations are recorded over time.

A positive Pearson correlation coefficient indicates that AADT increases with an increase in the related network characteristic (the speed limit or the number of lanes), and a negative Pearson correlation coefficient indicates that AADT decreases with an increase in the related network characteristic.

Correlation between Travel Time Measures and Land Use Characteristics

Firstly, the ratios, between the travel time measures (ATT, PT, BT, BTI, and PTI) in the year 2014 and in the year 2013, were computed by DOW (weekday and weekend) and TOD (MPP, OPP, EPP, and NTP), for each selected link. Likewise, the ratios, between the travel time measures in the year 2015 and in the year 2014, were computed by DOW and TOD for each selected link. These ratios provide the before-and-after scenario for travel time measures.

Secondly, the ratios, between the land use developments up until the year 2014 and up until the year 2013, were computed for the four different buffer widths (0.5 miles, 1 mile, 2 miles, and 3 miles). Likewise, the ratios, between land use characteristics up until the year 2015 and up until the year 2014, were computed for the four buffer widths.

Finally, the ratios, both of travel time measures and of land use characteristics, for the year 2014 by the year 2013, and for the year 2015 by the year 2014, were amalgamated, for each link, and used for the Pearson correlation coefficient analysis. Overall, the sample size for the correlation analysis was 518 samples [259 links × 2 (Ratio between the year 2015 and year 2014, Ratio between the year 2014 and year 2013)]. A positive correlation coefficient indicates that the ratio of travel time measures on the link across years increases as the ratio of land use development across years increases. In other words, a positive correlation implies that travel time measures increase on the selected link with an increase in the land use development within the buffer width, and vice versa for the negative correlation.

Additionally, Pearson correlation coefficients were computed between land use developments and travel time measures based on the DOW and TOD for the four different buffer widths datasets.

MODEL DEVELOPMENT AND VALIDATION

The methodology adopted for developing the relationship between land use development and ATT, with respect to buffer widths, area type, and the speed limit, is discussed in this section. Statistical models were developed using a Generalized Estimating Equation (GEE). The GEE is developed by Liang and Zeger (1986).[82] It is an extension of generalized linear models and is applicable even if the dependent variable is not normally distributed. The dependent variable (ATT) has over three years of data with respect to multiple links, TOD and DOW. The influence of land use and network characteristics on travel time and travel time variation can be better captured through ATT than through other travel time measures, such as PT, BT, BTI, and PTI. Also, considering the PT or PTI as the dependent variable would illustrate the influence of land use developments and network characteristics on travel times during the first or second worst traffic scenario (say, during a month); however, these worst traffic scenarios might be the resultant of a crash. Therefore, in this research, ATT was considered as the dependent variable. The predictor variables are land use developments within different buffer widths, TOD, and DOW, for multiple years. This complete dataset is a longitudinal or panel dataset; Ballinger (2004) provides a detailed discussion regarding the applicability of GEE models for longitudinal datasets.[83]

Three main considerations required for developing a GEE model are the link function, the distribution, and the correlation structure of the dependent variable. Here, the link function is a function between the dependent and independent variables. However, road link is a segment of a road. Common choices of distribution, such as gamma, Poisson, binomial, negative binominal, normal, and multinomial distributions, can be selected based on the type of dependent variable; typically, Poisson and negative binominal distribution are better for count models. Common choices of link function include modeling the independent variable as the natural log, the square, the square root, or the reciprocal of the dependent variable. For the correlation structure, auto regressive, independent, exchangeable and unstructured models can be used (Ballinger, 2004).[83]

Pan (2001) proposed the Quasi Likelihood under Independence Model Criterion (QIC) and the Corrected Quasi Likelihood under Independence Model Criterion (QICC), to select the best-fitted model.[84]

In this research, several linear and non-linear functions, along with the several distributions of dependent variables, were explored. During model development in SPSS®, TMC codes, year, DOW, and TOD were kept between the subject variables. The subject variables are the combination of values of the specific variables which uniquely define the subjects within the dataset. In the longitudinal dataset, multiple observations are collected for each subject. Therefore, in the longitudinal dataset, each subject may occupy multiple cases in the dataset. For example, in this research, for every TMC code (subject), ATT is computed for each year, for each DOW and each TOD.

The best model was selected based on QIC and QICC values. The lower the QIC and QICC, the better is the fit. Moreover, the difference between QIC and QICC should be generally low for a good model. For further analysis, preferred buffer widths were selected based on the statistical performance measures such as QIC, QICC of the developed models.

Selection of Variables for Model Development

ATT, by DOW and by TOD, for all the three years (2013 to 2015), was considered as the dependent variable. Land use developments up until that year, and network characteristics of the selected, upstream, downstream, upstream and downstream cross streets and intersecting links were considered as predictor variables. In addition, DOW and TOD were considered as predictor variables. DOW was considered as a dichotomous variable with the weekday represented as ‘1’ and the weekend represented as ‘0’. In terms of TOD, four binary variables were generated, which are MPP, OPP, EPP, and NTP.

Checking for Multicollinearity between Predictor Variables

The selected predictor variables may be correlated with each other. To avoid multicollinearity between predictor variables, the cut-off value for Pearson correlation coefficients between them was set up as -0.3 and +0.3 (i.e., Pearson correlation coefficient values less than or equal to -0.3 or greater than or equal to 0.3 are assumed to imply correlation between the variables) (at least at a 95% confidence level). The correlation between the predictor variables was checked at a 95%+ confidence level. For model development, only one predictor variable was selected, between the two correlated predictor variables, at a time. This leads to multiple models with combinations of predictor variables.

Relationship between ATT and Land Use Developments by Buffer Width

Firstly, the relationships between ATT and land use developments, for different buffer widths (0.5 miles, 1 mile, 2 miles, and 3 miles), were developed. Out of the 259 links, 206 links (80%) were selected randomly for model development and the remaining 53 links (20%) were selected for validation of models. Overall, the sample size for model development was 4,944 samples (206 links × 3 years × 2 DOW × 4 TOD) and the sample size for validation was 1,272 samples (53 links × 3 years × 2 DOW × 4 TOD).

For each buffer width, three models were developed. The first model was developed by incorporating all the predictor variables in the model, and then removing predictor variables with p-values greater than 0.05, one at a time (begin by removing the predictor variable with the highest p-value); this process is known as the backward elimination method. The second and third models were developed based on the combination of predictor variables, which were independent of each other. In addition, the predictor variables such as DOW and TOD were enforced in the models to be able to predict the ATT on a particular DOW and TOD periods.

Relationship between ATT and Land Use Developments by Area Type

Similar to the models by buffer widths, the relationships between ATT and land use developments were developed by classifying the links by area type. In the RTDM database, area type is classified into five categories: CBD, CBD Fringe / Other Business District (OBD), urban, suburban and rural area. Each TAZ is assigned one of the area types based on population and employment density. Likewise, each link is assigned to an area type based on the surrounding TAZs (Table 3). Figure 5 illustrates the selection of links by area type.

Out of the 259 links, 48 links, 68 links, and 143 links were located in the CBD, CBD fringe / OBD, and urban area, respectively. A total of 38 links in the CBD, 55 links in the CBD fringe / OBD, and 113 links in the urban area (80%) were selected randomly for model development. The remaining 10 links in the CBD, 13 links in the CBD fringe / OBD, and 30 links in the urban area (20%) were selected randomly for model validation. The selected land use developments within the preferred buffer widths, network characteristics, DOW, and TOD were considered as the predictor variables. Overall, the sample sizes, for model development of the CBD, the CBD fringe/ OBD, and the urban area, were 912 samples (38 links × 3 years × 2 DOW × 4 TOD), 1,320 samples (55 links × 3 years × 2 DOW × 4 TOD), and 2,712 (113 links × 3 years × 2 DOW × 4 TOD), respectively. Likewise, the sample sizes for validation of the CBD, the CBD fringe/ OBD, and the urban area models were 240, 312, and 720 samples, respectively.

Similar to the models by buffer widths, three models were developed for each of the area types and buffer widths. For each area type and each selected buffer width, the first model was developed using the backward elimination method. The other two models were developed by selecting the predictor variables which were independent of each other (at a 95% confidence level).

Table 3. Classification of Area Type based on Population and Employment Density

Area Type	Population Density (per square mile)	Employment Density (per square mile)
CBD	<375 / or >=375	>10,500
CBD Fringe / OBD	<375 / or >=375	>2,600
Urban	Population Density + (Employment Density /1.6) > 2,100	
Suburban	Population Density + (Employment Density /1.6) <= 2,100	
Rural	< 375	0 to 2,600

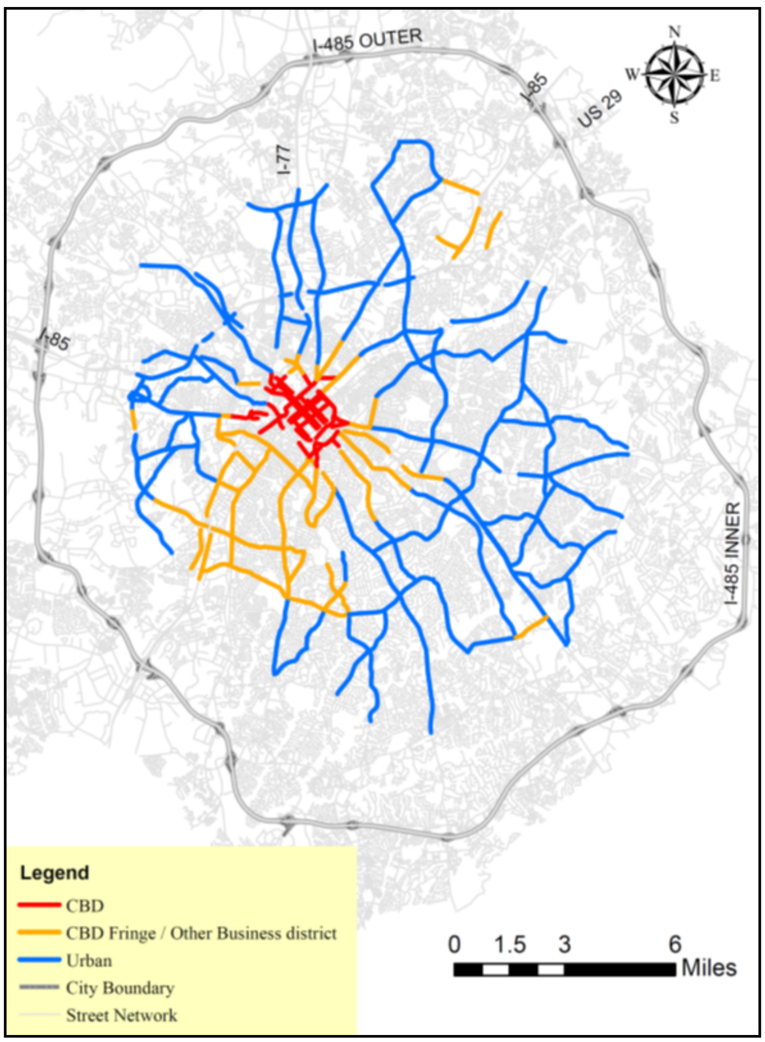

Figure 5. Classification of Links by Area Type

Relationship between ATT and Land Use Developments by the Speed Limit

Similarly, to the models by area type, the relationship between ATT and land use developments were developed by classifying the links by the speed limit. The speed limit is divided into three categories: less than 45 mph, 45 to 50 mph, and greater than 50 mph. Each of the classifications resembles a unique traffic and driving experience. Out of the 259 links, 112 links, 114 links, and 33 links have a speed limit less than 45 mph, between 45 – 50 mph, and greater than 50 mph, respectively. Figure 6 illustrates the selection of links by the speed limit. A total of 89 links with a speed limit less than 45 mph, 91 links with a speed limit between 45 to 50 mph, and 26 links with a speed limit greater than 50 mph were selected for model development. This total accounts for about 80% of the total sample. The remaining 23 links with a speed limit less than 45 mph, 23 links with a speed limit between 45 to 50 mph, and 7 links with a speed limit greater than 50 mph were selected for model validation. The validation sample accounts for about 20% of the total sample. The selected land use developments within the preferred buffer widths, network characteristics, DOW, and TOD were considered as the predictor variables. Overall, the sample sizes for model development of links with speed limit less than 45 mph, 45 to 50 mph, and greater than 50 mph were 2,136 samples (89 links × 3 years × 2 DOW × 4 TOD), 2,184 samples (91 links × 3 years × 2 DOW × 4 TOD), and 624 (26 links × 3 years × 2 DOW × 4 TOD), respectively. Likewise, the sample sizes for validation of links with a speed limit less than 45 mph, 45 to 50 mph, and greater than 50 mph were 552, 552, and 168 samples, respectively.

Similar to the models by buffer widths, three models were developed for each of the speed limit categories and buffer widths. For each speed limit category and each selected buffer width, the first model was developed using the backward elimination method. The other two models were developed by selecting the predictor variables which were independent of each other (at a 95% confidence level).

Validation of the Models

Each of the developed models was validated using the Root Mean Square Error (RMSE), the Mean Absolute Percentage Error (MAPE), and the Mean Percentage Error (MPE). The RMSE, MAPE, and MPE are computed using Equation 6, Equation 7, and Equation 8:

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{t=1}^{n}(\mathrm{Actual}_{ATT} - \mathrm{Predicted}_{ATT})^2}{n}} \tag{6}$$

$$\mathrm{MAPE} = \frac{1}{n}\sum_{t=1}^{n} \left| \frac{\mathrm{Actual\_ATT} - \mathrm{Predicted\_ATT}}{\mathrm{Actual\_ATT}} \right| \tag{7}$$

$$\mathrm{MPE} = \frac{1}{n}\sum_{t=1}^{n} \left(\frac{\mathrm{Actual\_ATT} - \mathrm{Predicted\_ATT}}{\mathrm{Actual\_ATT}} \right) \tag{8}$$

where

n = number of observations,

Actual_ATT = Observed average travel time, and

Predicted_ATT = predicted average travel time.

RMSE, MAPE and MPE closer to zero indicate the best-fitted model. Also, a positive percentage sign in MPE indicates that the model under-predicts compared to the actual ATT. In this research, MPE was considered to check whether the model under-predicts or over-predicts compared to the actual ATT.

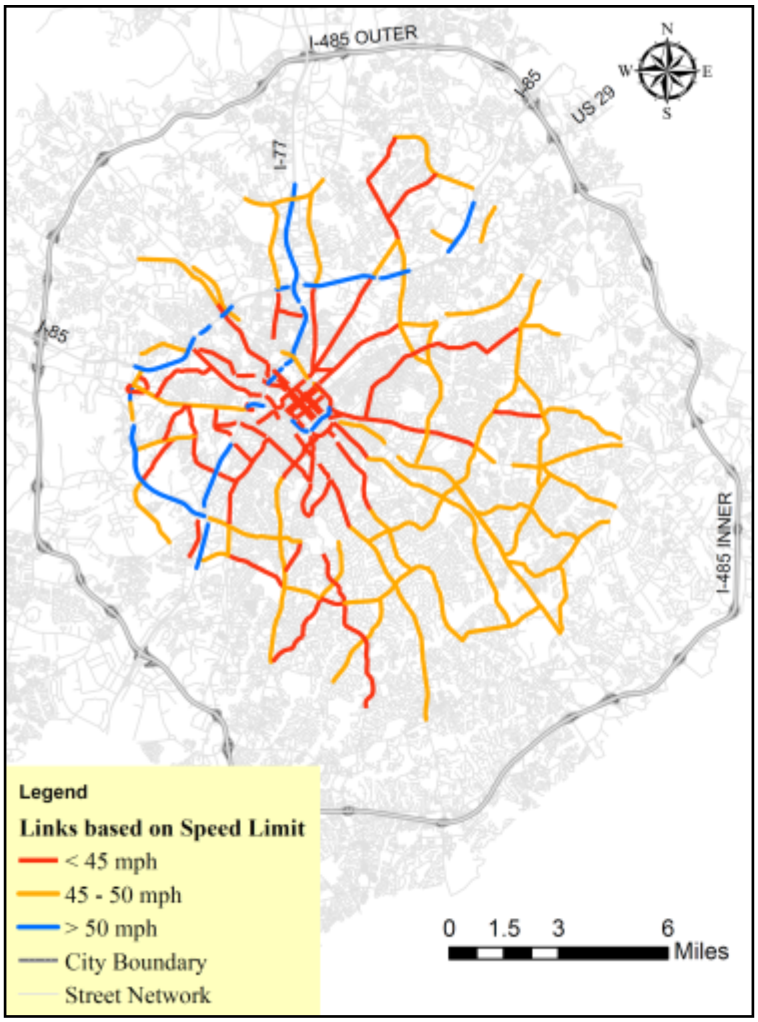

Figure 6. Classification of Links by the Speed Limit

V. CORRELATION ANALYSIS

This chapter presents the results obtained from the correlation analysis. The correlation between traffic and network characteristics was examined in order to find a surrogate parameter to represent traffic volume in the model development process. For this analysis, the correlations between AADT of each individual year (2013 to 2015), and network characteristics from the RTDM database were examined. In addition, the correlations between travel time measures and land use developments, for different time periods, were examined based on the computed ratios. A positive correlation coefficient indicates that the ratio across years of travel time measures increases on the link as the ratio across years of a land use development increases. In other words, a positive correlation implies that travel time measure increases on the selected link with an increase in the land use development within the buffer width, and vice versa for the negative correlation.

CORRELATION BETWEEN TRAFFIC AND NETWORK CHARACTERISTICS

Table 4 summarizes the correlations between traffic and network characteristics. The number of lanes and the speed limit of the selected links, the number of lanes of downstream links, and the number of lanes and the speed limit of upstream links are highly correlated with the AADT. In this research, for each link, the computed AADT was collected from the RTDM database in terms of AAWT. Also, for each link, the AAWT is typically computed based on the traffic counts once or twice in a year. For a particular link, typically, travel times are collected at every 1-minute interval. Accounting for the disparity in data sources and to make the data consistent with the real-world scenario, instead of considering AADT as the predictor variable, the network characteristics of the selected link were considered as the surrogate predictor variables for AADT.

Table 4. Correlation between Traffic and Network Characteristics

Parameters	AADT	Link_# of Lanes	Link_SL	DS_# of Lanes	DS_SL	US_# of Lanes	US_SL	DS_Cross street_# of Lanes	DS_Cross street_SL	US_Cross street_# of Lanes	US_Cross street_SL	Intersection_# of Lanes
Link_# of Lanes	HP		MP	HP	MP	HP	MP	LN	LN	LN	LP	LN
Link_SL	HP	MP		MP	MP	MP	HP	MN		LN	MP	MN
DS_# of Lanes	HP	HP	MP		HP	MP	MP	LN		LN		LN
DS_SL	MP	MP	MP	HP		LP	LP	LN		LN	LP	LN
US_# of Lanes	HP	HP	MP	MP	LP		HP	LN	LN	LN		LN
US_SL	HP	MP	HP	MP	LP	HP		LN		LN	LP	LN
DS_Cross street_# of Lanes	LN	LN	MN	LN	LN	LN	LN		LP	MP	LN	MP
DS_Cross street_SL		LN				LN		LP		LP	LP	LP
US_Cross street_# of Lanes	LN	LN	LN	LN	LN	LN	LN	MP	LP		LP	LP
US_Cross street_SL	LP	LP	MP		LP		LP	LN	LP	LP		LN
Intersection_# of Lanes	MN	LN	MN	LN	LN	LN	LN	MP	LP	LP	LN	
Intersection_SL	MN	LN	MN	LN	LN	LN	LN	MP	LP	LP	LN	HP

CORRELATION BETWEEN TRAVEL TIME MEASURES AND LAND USE DEVELOPMENT AREAS – MORNING PEAK PERIOD

Table 5 summarizes the Pearson correlation coefficient results obtained for the morning peak period. The results obtained indicate that, during a weekday morning peak period, for car washes and retail stores within 0.5 miles and 1 mile from a link, there is a positive correlation between land use area and BT, and between land use area and BTI. Likewise, for hotels/motels and multi-family type land uses within 0.5 miles and 1 mile from a link, there is a positive correlation between land use area and ATT. Furthermore, for multi-family residential type land uses and supermarkets within 2 miles and 3 miles from a link, there are positive correlations between land use area and most of the travel time measures.

With respect to the weekend morning peak period, for hotels/ motels within 0.5 miles and 1 mile from a link, there is are positive correlations between land use area and ATT, PT, and PTI. Likewise, for banks, retail type land uses and supermarkets within 0.5 miles from a link, there are positive correlations between land use area and, both, BT and BTI. Similarly, for convenience stores, parking garages, and retail type land uses within 1 mile from a link, there are positive correlations between land use area and, both, BT and BTI. Furthermore, for multi-family residential type land uses, recreational type land uses, retail type land uses, and service garages within 2 miles from a link, there are positive correlations between land use area and the majority of the travel time measures (PT, BT, and BTI). For convenience stores, multi-family residential type land uses, recreational facilities, and supermarkets within 3 miles from a link, there are also positive correlations between land use area and most of the travel time measures.

CORRELATION BETWEEN TRAVEL TIME MEASURES AND LAND USE DEVELOPMENT AREAS – AFTERNOON OFF-PEAK PERIOD

Table 6 summarizes the Pearson correlation coefficient results obtained for the afternoon off-peak period. During weekdays, for hotels/motels, service garages, and single-family residential type land uses within 0.5 miles from a link, there is a positive correlation between land use area and ATT. Likewise, for banks, car washes and retail type land uses within 0.5 miles from a link, there are positive correlations between land use area and, both, BT and BTI. Similarly, for multi-family type land uses within 1 mile, 2 miles, and 3 miles from a link, there are positive correlations between land use area and all the travel time measures. In addition, for retail type land uses, service garages, and supermarkets within 2 miles and 3 miles from a link, there are positive correlations between land use area and most of the travel time measures. Furthermore, for single-family residential type land uses within 2 miles and 3 miles from a link, there is a positive correlation between land use area and ATT; however, for this land use type, there is a negative correlation between land use area and BTI.

During weekends, for hotels/motels and service garages within 0.5 miles from a link, there is a positive correlation between land use area and ATT. Likewise, for car washes, convenience stores, multi-family residential, parking garages, and recreational type land uses within 1 mile from a link, there are positive correlations between land use area and, both, BT and BTI. However, for attached residential, fast food restaurants, hotels/ motels, offices, and utility type land uses within 2 miles from a link, there are negative correlations between land use area and, both, BT and BTI. Furthermore, for multi-family residential, recreational, and service garages type land uses within 2 miles and 3 miles from a link, there are positive correlations between land use area and most of the travel time measures.

CORRELATION BETWEEN TRAVEL TIME MEASURES AND LAND USE DEVELOPMENT AREAS – EVENING PEAK PERIOD

Table 7 summarizes the Pearson correlation coefficient results obtained for the evening peak period. During weekdays, for car washes within 0.5 miles, 1 mile, and 2 miles from a link, there are positive correlations between land use area and, both, BT and BTI. Likewise, for convenience stores, multi-family residential, and parking garages type land uses within 1 mile from a link, there are positive correlations between land use area and most of the travel time measures. Furthermore, for multi-family residential, retail, service garages and supermarkets type land uses within 2 miles and 3 miles from a link, there are positive correlations between land use area and most of the travel time measures.

During weekends, for fast food restaurants, hotels/motels and service garages type land uses within 0.5 miles from a link, there are positive correlations between land use area and some of the travel time measures. Likewise, for fast food restaurants, multi-family residential, recreational, retail, and supermarkets type land uses within 1 mile from a link, there are positive correlations between land use area and, both, BT and BTI. For convenience stores, multi-family residential, recreational, retail, schools, service garages and supermarkets type land uses within 2 miles from a link, there are positive correlations between land use area and, both, BT and BTI. However, for attached residential, hotels/motels, and office type land uses within 2 miles from a link, there are negative correlations between land use area and, both, BT and BTI. Likewise, for banks, hotels/motels, medical, offices, and warehouse type land uses within 3 miles from a link, there are negative correlations between land use area and, both, BT and BTI.

CORRELATION BETWEEN TRAVEL TIME MEASURES AND LAND USE DEVELOPMENT AREAS – NIGHTTIME PERIOD

Table 8 summarizes the Pearson correlation coefficient results obtained for the nighttime period. During weekdays, for banks, car washes, and institutional type land uses within 0.5 miles from a link, there is a positive correlation between land use area and BTI. Likewise, for convenience stores, institutional, multi-family residential, recreational, retail, and schools type land uses within 1 mile from a link, there are positive correlations between land use area and, both, BT and BTI. Similarly, for convenience stores, multi-family residential, recreational, retail, schools, service garages, and supermarkets type land uses within 2 miles and 3 miles from a link, there are positive correlations between land use area and most of the travel time measures.

During weekends, for attached residential, banks, convenience stores, institutional, and retail stores type land uses within 0.5 miles from a link, there are positive correlations between land use area and, both, BT and BTI. Likewise, for multi-family residential, parking garages, recreational, and retail type land uses within 1 mile from a link, there are positive correlations between land use area and the majority of the travel time measures. Furthermore, for multi-family residential, recreational, schools, service garages, and supermarkets type land uses within 2 miles and 3 miles from a link, there are positive correlations between land use area and most of the travel time measures.

Table 5. Correlation between Travel Time Measures and Land Use Characteristics – Morning Peak Period

	Morning Peak Period Weekday																			
LU Category	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential											LN	LN	LN	LN				LN	LN	
Auto Dealer	LN								LP											
Bank			LP	LP																
Car Wash			LP	LP				LP	LP											
Church													LP	LP						
Commercial Service																				
Convenience Store									LP				LP	LP		LP	LP	LP	LP	LP
Daycare																				
Department Store																				
Fast Food												LN			LN	LN	LN	LN	LN	LN
Funeral Home																				
Government																				
Hospital																				
Hotel / Motel	LP	LP			LP	LP							LN	LN				LN	LN	
Industrial																				
Industrial Lg																				
Institutional																		LP	LP	
Manufactured Home Construction						LN	LN	LN	LN	LN					LP	LP		LN	LN	
Manufacturing																				
Medical																				
Multi-Family	LP	LP			LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office											LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage						LP	LP													
Recreational																LP	LP	LP	LP	LP
Restaurant																				
Retail			LP	LP				LP	LP		LP	LP	LP	LP	LP					
School													LP	LP				LP	LP	
Service Garage											LP	LP			LP	LP	LP			
Shopping Mall																				
Single-Family Residential								LN	LN		LP							LN	LN	
Stadium /Arena																				
Supermarket											LP	LP	LP	LP		LP	LP	LP	LP	LP
Truck Terminal																				
Utility						LN	LN				LN	LN	LN	LN	LN					
Warehouse																		LN	LN	

	Morning Peak Period Weekend																			
LU Category	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential						LN		LN	LN		LN	LN	LN	LN	LN	LN		LN	LN	
Auto Dealer																				
Bank			LP	LP														LN	LN	LN
Car Wash													LP	LP				LP	LP	
Church																				
Commercial Service																				
Convenience Store								LP	LP				LP	LP		LP	LP	LP	LP	LP
Daycare																				
Department Store																				
Fast Food												LN	LN	LN	LN	LN	LN	LN	LN	LN
Funeral Home																				
Government											LN		LN					LN	LN	
Hospital													LN	LN		LN	LN	LN	LN	LN
Hotel / Motel	LP	LP	LP		LP	LP	LP			LP			LN	LN				LN	LN	
Industrial																				
Industrial Lg																				
Institutional																				
Manufactured Home Construction						LN	LN	LN	LN			LP			LP	LP	LP		LN	LP
Manufacturing																				
Medical																		LN	LN	
Multi-Family						LP	LP	LP		LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office											LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage								LP	LP											
Recreational												LP	LP	LP	LP	LP	LP	LP	LP	LP
Restaurant																				
Retail			LP	LP				LP	LP		LP	LP	LP	LP			LP	LP	LP	
School													LP	LP				LP	LP	
Service Garage											LP	LP	LP	LP	LP					
Shopping Mall																				
Single-Family Residential								LN	LN		LP							LN	LN	
Stadium /Arena																				
Supermarket			LP	LP												LP	LP	LP	LP	LP
Truck Terminal																				
Utility																				
Warehouse																		LN	LN	

Table 6. Correlation between Travel Time Measures and Land Use Characteristics – Afternoon Peak Period

Parameters	Afternoon Off-Peak Period Weekday																			
	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential											LN	LN	LN	LN	LN			LN	LN	
Auto Dealer	LN																			
Bank			LP	LP																
Car Wash			LP	LP				LP	LP				LP	LP				LP	LP	
Church														LP						
Commercial Service																				
Convenience Store							LP	LP	LP	LP			LP	LP		LP	LP	LP	LP	LP
Daycare																				
Department Store																				
Fast Food									LN		LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Funeral Home																				
Government																				
Hospital																LN				
Hotel / Motel	LP	LP			LP	LP	LP			LP			LN	LN				LN	LN	
Industrial																				
Industrial Lg																				
Institutional																		LP	LP	
Manufactured Home Construction						LN	LN	LN	LN	LN					LP	LP		LN	LN	LP
Manufacturing																				
Medical																				
Multi-Family						LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office												LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage	LN																			
Recreational																LP	LP	LP	LP	LP
Restaurant																				
Retail			LP	LP				LP	LP		LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
School									LP				LP	LP	LP			LP	LP	
Service Garage	LP										LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Shopping Mall																				
Single-Family Residential	LP							LN	LN		LP	LP		LN		LP		LN	LN	
Stadium /Arena																				
Supermarket											LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Truck Terminal																				
Utility						LN	LN				LN	LN			LN					
Warehouse																		LN	LN	

Parameters	Afternoon Off-Peak Period Weekend																			
	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential											LN	LN	LN	LN	LN			LN	LN	
Auto Dealer																				
Bank																		LN	LN	LN
Car Wash								LP	LP				LP	LP						
Church																				
Commercial Service																				
Convenience Store			LP	LP				LP	LP				LP	LP		LP	LP	LP	LP	LP
Daycare																				
Department Store																				
Fast Food												LN	LN	LN	LN	LN	LN	LN	LN	LN
Funeral Home																				
Government																			LN	
Hospital																LN	LN			
Hotel / Motel	LP	LP			MP	LP	LP			LP			LN	LN	LP			LN	LN	LP
Industrial																				
Industrial Lg																				
Institutional														LP				LP	LP	
Manufactured Home Construction						LN	LN	LN	LN	LN	LP	LP			MP	LP	LP		LN	LP
Manufacturing																				
Medical																		LN	LN	LN
Multi-Family						LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office											LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage								LP	LP											
Recreational								LP	LP		LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Restaurant																				
Retail											LP	LP	LP	LP				LP	LP	
School													LP	LP				LP	LP	
Service Garage	LP										LP	LP	LP	LP	LP	LP		LP	LP	
Shopping Mall																				
Single-Family Residential								LN			LP	LP			LP			LN	LN	LP
Stadium /Arena																				
Supermarket																LP	LP	LP	LP	LP
Truck Terminal																				
Utility						LN					LN	LN	LN	LN						
Warehouse																		LN	LN	

Table 7. Correlation between Travel Time Measures and Land Use Characteristics – Evening Peak Period

Evening Peak Period Weekday

Parameters	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential											LN	LN			LN	LN	LN	LN	LN	
Auto Dealer																				
Bank			LP	LP									LN	LN				LN	LN	LN
Car Wash			LP	LP				LP	LP				LP	LP					LP	
Church													LP	LP				LP	LP	
Commercial Service																				
Convenience Store							LP	LP	LP	LP			LP	LP		LP	LP	LP	LP	LP
Daycare																				
Department Store																				
Fast Food	LN					LN	LN	LN		LN	LN	LN			LN	LN	LN	LN		LN
Funeral Home																				
Government																	LN			LN
Hospital													LN	LN		LN	LN			LN
Hotel / Motel	LP				LP	LP			LN				LN	LN				LN	LN	
Industrial																				
Industrial Lg																				
Institutional																			LP	
Manufactured Home Construction						LN	LN	LN	LN	LN					LP	LP		LN	LN	
Manufacturing																				
Medical									LN									LN	LN	
Multi-Family						LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office												LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage	LN					LP	LP	LP		LP										
Recreational																		LP	LP	
Restaurant																				
Retail								LP	LP		LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
School													LP	LP				LP	LP	
Service Garage											LP	LP	LP	LP	LP	LP	LP	LP		LP
Shopping Mall																				
Single-Family Residential	LP								LN		LP					LP		LN	LN	
Stadium /Arena																				
Supermarket											LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Truck Terminal																				
Utility						LN	LN	LN	LN	LN	LN	LN	LN	LN	LN					
Warehouse																	LN	LN	LN	LN

Evening Peak Period Weekend

Parameters	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential											LN	LN	LN	LN	LN				LN	
Auto Dealer																				
Bank																		LN	LN	LN
Car Wash									LP											
Church																				
Commercial Service																				
Convenience Store													LP	LP		LP	LP	LP	LP	LP
Daycare																				
Department Store																				
Fast Food			LP	LP				LP	LP			LN			LN	LN	LN	LN		LN
Funeral Home																				
Government																				
Hospital																				
Hotel / Motel	LP	LP			LP	LP	LP			LP	LP		LN	LN				LN	LN	
Industrial																				
Industrial Lg																				
Institutional																				
Manufactured Home Construction						LN	LN	LN	LN	LN	LP	LP			LP	LP	LP		LN	LP
Manufacturing																				
Medical																		LN	LN	LN
Multi-Family						LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office											LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage																				
Recreational								LP	MP			LP	LP	LP	LP	LP	LP	LP	LP	LP
Restaurant																				
Retail								LP	LP		LP	LP	LP	LP	LP					
School									LP				LP	LP				LP	LP	
Service Garage	LP										LP	LP	LP	LP	LP			LP	LP	
Shopping Mall																				
Single-Family Residential											LP	LP		LN	LP	LP	LP		LN	LP
Stadium /Arena																				
Supermarket							LP	LP	LP	LP		LP	LP	LP	LP		LP	LP	LP	LP
Truck Terminal																				
Utility						LN	LN				LN									
Warehouse																		LN	LN	

Table 8. Correlation between Travel Time Measures and Land Use Characteristics –Nighttime Period

Nighttime Period Weekday

Parameters	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential											LN	LN	LN	LN	LN		LN	LN	LN	LN
Auto Dealer																				
Bank				LP								LN	LN	LN	LN		LN	LN	LN	LN
Car Wash				LP																
Church													LP	LP						
Commercial Service																				
Convenience Store								LP	LP			LP	LP	LP	LP	LP	LP	MP	MP	LP
Daycare																				
Department Store																				
Fast Food											LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Funeral Home																				
Government													LN				LN	LN	LN	LN
Hospital					LN		LN	LN	LN	LN		LN	LN	LN	LN	LN	LN	LN	LN	LN
Hotel / Motel	LP	LP			LP	LP	LP		LN	LP			LN	LN				LN	LN	
Industrial																				
Industrial Lg																				
Institutional			LP	LP				LP	LP				LP	LP				LP	LP	
Manufactured Home Construction						LN	LN	LN	LN	LN		LP			LP	LP		LN	LN	
Manufacturing																				
Medical								LN	LN			LN	LN	LN	LN		LN	LN	LN	LN
Multi-Family						LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office							LN	LN	LN	LN	LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage																				
Recreational								LP	LP			LP	LP	LP	LP	LP	LP	MP	MP	LP
Restaurant																				
Retail								LP	LP		LP	LP	LP	LP	LP		LP	LP	LP	
School								LP	LP		LP	LP	LP	LP	LP		LP	LP	LP	LP
Service Garage	LP										LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Shopping Mall																				
Single-Family Residential						LN	LN	LN	LN		LP			LN				LN	LN	
Stadium /Arena																	LN			LN
Supermarket	LP										LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Truck Terminal																				
Utility						LN	LN	LN			LN	LN	LN	LN	LN			LN	LN	
Warehouse																	LN	LN	LN	LN

Nighttime Period Weekend

Parameters	0.5 miles					1-mile					2 miles					3 miles				
	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI	ATT	PT	BT	BTI	PTI
Attached Residential			LP	LP				LN	LN	LN	LN	LN	LN	LN	LN			LN	LN	LN
Auto Dealer																				
Bank			LP	LP									LN	LN		LN	LN	LN	LN	LN
Car Wash																			LP	
Church														LP						
Commercial Service																				
Convenience Store			LP	LP			LP	LP	LP				LP	LP		LP	LP	LP	LP	LP
Daycare																				
Department Store																				
Fast Food											LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Funeral Home																				
Government		LN			LN								LN	LN	LN			LN	LN	LN
Hospital						LN	LN	LN	LN	LN		LN	LN	LN	LN				LN	LN
Hotel / Motel	LP	LP			LP	LP	LP		LN	LP			LN	LN				LN	LN	
Industrial																				
Industrial Lg																				
Institutional			LP	LP				LP	LP				LP	LP				LP	LP	
Manufactured Home Construction						LN	LN	LN	LN	LN	LP	LP			LP	LP		LN	LN	
Manufacturing																				
Medical													LN	LN			LN	LN	LN	LN
Multi-Family						LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP
Office								LN	LN		LN	LN	LN	LN	LN	LN	LN	LN	LN	LN
Parking Garage						LP	LP	LP	LP	LP										
Recreational							LP	LP	LP	LP		LP	LP	LP	LP	LP	LP	MP	MP	LP
Restaurant																				
Retail			LP	LP		LP	LP	LP	LP		LP	LP	LP	LP	LP					
School								LP	LP		LP	LP	LP	LP	LP		LP	LP	LP	LP
Service Garage											LP	LP	LP	LP	LP			LP	LP	LP
Shopping Mall																				
Single-Family Residential	LP										LP	LP		LN		LP		LN	LN	
Stadium /Arena																LN				
Supermarket												LP		LP	LP	LP	LP	LP	LP	LP
Truck Terminal																				
Utility											LN	LN	LN	LN	LN		LN	LN	LN	LN
Warehouse																		LN	LN	LN

VI. STATISTICAL MODELS BY BUFFER WIDTH

This chapter presents the results obtained from the developed statistical models to examine the relationship between ATT and land use characteristics by buffer width.

Descriptive statistics for each of the buffer width datasets are presented in Table 9 and Table 10. The descriptive statistics consist of all the 4,944 samples considered for model development. For selecting the best-fitted function for model development, a linear model, a log-link model with a gamma distribution, a log-link model with a Poisson distribution, and a log-link model with negative binomial distribution were first developed using backward elimination method for the 0.5-mile buffer width dataset (Table 11 and Table 12). Log-link models with Poisson distributions and log-link models with negative binomial distributions are typically used to estimate counts. Therefore, the dependent variable (ATT) was considered in seconds (rounded off to the nearest integer) to develop the count model.

The computed QIC and QICC indicate that a log-link model with a gamma distribution was observed to be a better fit compared to the other models. The general expression for the best-fitted models is presented as Equation 9.

$$\text{Ln}\ (\text{ATT}) = f(\text{land use developments}, \text{onnetwork characteristics}, \text{DOW}, \text{TOD}) \qquad (9)$$

Twelve statistical models were developed using buffer width dataset to examine the relationship between proximal land use developments and ATT (Table 14 to Table 17). For each of the buffer width datasets, the model was developed using the backward elimination method by considering all the predictor variables, irrespective of the correlations between the predictor variables. These models are best suitable for predicting ATT, rather than for quantifying the influence of predictor variables on ATT. The influence of the predictor variables on the ATT is interpreted using Model 1 and Model 2 in each of the buffer widths. Model 1 and Model 2 were developed by first checking the multicollinearity between the predictor variables and then by selecting the predictor variables which were not correlated to each other (at a 95% confidence level). The Pearson correlation matrices for different buffer width datasets are presented in Appendix A (Table A2 to Table A5). The selection of predictor variables by buffer width is summarized in Table 13.

Per Gujarti (2012), if the objective of the regression analysis is to forecast/predict the dependent variable, then multicollinearity is not a serious problem.[85] The developed backward elimination model helps to forecast/predict the dependent variable (ATT). However, due to the multicollinearity between the predictor variables, the influence of predictor variables on the dependent variable can be questionable. In other words, if there exists a high correlation between the predictor variables, then the estimated regression coefficient of predictor variables will possess large standard errors and the estimated regression coefficients were not estimated with great accuracy. In case of Model 1 and Model 2, the developed models not only help to accurately forecast the dependent variable but also, by removing the highly correlated predictor variables, help to quantify the influence of critical predictor variables on the dependent variable while minimizing the effect of multicollinearity.

In all the developed models (Table 14 to Table 17), the coefficients of TOD and DOW are consistent with each other. In all the developed models, the results obtained indicate that, compared to weekends, the ATT is higher on weekdays, when all the other variables are held constant. In addition, when all other variables are held constant, the ATT is higher during the evening peak period when compared to the morning peak period and the afternoon off-peak period. Also, the coefficients of the network characteristics were observed to be consistent with each other in almost all the developed models. The results obtained indicate that the number of lanes and the speed limit of the selected link have a negative influence on the ATT.

DEVELOPED MODELS – 0.5 MILES

The Model 1 and Model 2 developed with the 0.5-mile buffer width dataset indicate that with the presence of convenience store, department store, multi-family residential, car wash, fast food, funeral home, hospital, office, and supermarket type land uses have a positive influence on the ATT (Table 14). However, the presence of auto dealer, daycare, industrial, manufactured home construction, manufacturing, and single-family residential type land uses have a negative influence on the ATT. In addition, the speed limit of the downstream cross street has a positive influence on the ATT. However, the speed limit of the upstream cross street has a negative influence on the ATT.

DEVELOPED MODELS – 1 MILE

The Model 1 and Model 2 developed with the 1-mile buffer width dataset indicate that the presence of auto dealer, fast food, office, department store, multi-family and utility type land uses have a positive influence on the ATT (Table 15). However, the presence of hospital, industrial, service garage, large industrial, manufactured home construction, and single-family residential type land uses have a negative influence on the ATT. In addition, the speed limit of the downstream cross street has a positive influence on the ATT. However, the speed limit of the upstream cross street has a negative influence on the ATT.

DEVELOPED MODELS – 2 MILES

The Model 1 and Model 2 developed with the 2-mile buffer width dataset indicate that with the presence of retail, single-family residential, office, and supermarket type land uses have a positive influence on the ATT (Table 16). However, the presence of daycare and large industrial type land uses have a negative influence on the ATT.

DEVELOPED MODELS – 3 MILES

Lastly, Model 1 and Model 2 developed with the 3-mile buffer width dataset indicate that with the presence of retail, single-family residential, stadium/arena, and supermarket type land uses have a positive influence on the ATT (Table 17). However, the presence of daycare type land uses and the speed limit of the upstream cross street link have a negative influence on the ATT.

Each of the developed models was validated using data for 53 selected links which were not considered for model development. A summary of all the developed models by buffer width is presented in Table 18. The computed MAPE and RMSE closer to zero indicate the better-fitted models for the data used in this research. All the developed models are acceptable (the lower the QIC and QICC, the better the model—typically, MAPE and MPE lower than 20% are considered acceptable models). However, the models for 0.5 miles and 1-mile buffer widths outperformed all the other models based on QIC, QICC, MAPE, and RMSE. Also, in all the developed models, the predicted ATT was higher compared to the actual ATT (negative MPE).

Table 9. Descriptive Statistics for 0.5-mile and 1-mile Buffer Widths

Parameters	0.5 miles				1-mile			
	Min.	Max.	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.
ATT (minutes)	0.85	6.45	1.97	0.72	0.85	6.45	1.97	0.72
Attached Residential	0.00	1,853.72	426.49	420.52	0.00	3,621.39	1,073.37	835.38
Auto Dealer	0.00	702.80	27.97	97.62	0.00	961.00	46.22	132.80
Bank	0.00	292.47	29.81	64.18	0.00	382.34	78.08	115.26
Car Wash	0.00	23.54	3.20	4.19	0.00	28.89	7.33	6.41
Church	0.00	780.41	192.55	166.80	25.25	1,425.72	474.16	326.85
Commercial Service	0.00	966.39	88.40	164.11	0.00	1,072.46	208.95	262.73
Convenience Store	0.00	29.73	7.02	5.81	0.00	38.89	15.88	8.60
Daycare	0.00	123.06	13.11	17.12	0.00	143.57	31.31	20.92
Department Store	0.00	1,058.43	35.13	144.43	0.00	1,120.80	83.74	238.41
Fast Food	0.00	31.37	7.85	7.68	0.00	43.04	16.26	10.21
Funeral Home	0.00	63.13	4.39	11.91	0.00	71.44	9.06	15.71
Government	0.00	4,657.18	480.23	1,060.53	0.00	4,753.02	1,047.50	1,624.82
Hospital	0.00	3,670.49	172.82	614.32	0.00	4,400.51	489.08	1,197.39
Hotel / Motel	0.00	3,314.05	324.49	662.77	0.00	3,325.79	762.57	1,012.48
Industrial	0.00	50.92	2.47	7.68	0.00	81.14	7.25	14.92
Industrial Lg	0.00	103.37	1.51	12.38	0.00	103.37	6.02	24.21
Institutional	0.00	1,683.84	185.09	379.85	0.00	2,674.65	449.37	706.02
Manufactured Home Construction	0.00	30.50	1.16	3.50	0.00	93.80	3.42	10.12
Manufacturing	0.00	911.92	103.51	158.70	0.00	1,461.16	283.65	294.37
Medical	0.00	1,598.78	71.21	188.07	0.00	2,310.76	216.52	432.60
Multi-Family	0.00	5,444.90	1,351.24	1,226.09	74.44	10,329.40	3,329.75	2,334.62
Office	0.00	20,128.58	1,964.29	4,366.76	5.06	23,462.55	4,834.41	7,334.00
Parking Garage	0.00	9,458.15	1,054.09	2,058.28	0.00	16,873.53	2,752.49	4,127.55
Recreational	0.00	269.43	56.29	60.62	4.09	339.68	140.63	95.55
Restaurant	0.00	172.90	34.14	37.43	0.00	316.09	86.28	76.73
Retail	0.00	819.85	151.63	139.54	1.62	1,855.88	372.91	287.45
School	0.00	830.08	263.77	211.89	0.00	1,837.61	648.44	336.52
Service Garage	0.00	669.60	57.77	82.55	0.00	993.62	140.81	136.13
Shopping Mall	0.00	978.93	148.45	190.26	0.00	1,538.93	319.28	301.87

Parameters	0.5 miles				1-mile			
	Min.	**Max.**	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**Mean**	**Std. Dev.**
Single-Family Residential	21.03	8,861.19	1,825.75	1,562.72	553.84	17,085.75	5,726.78	3,596.05
Stadium /Arena	0.00	2,999.96	220.36	627.34	0.00	3,022.60	537.95	1,016.00
Supermarket	0.00	164.03	24.31	34.50	0.00	266.06	47.33	49.59
Truck Terminal	0.00	627.72	15.91	60.68	0.00	757.17	60.08	126.63
Utility	0.00	96.10	8.78	21.29	0.00	130.24	18.78	29.23
Warehouse	0.00	5,107.52	857.31	963.53	4.49	9,097.35	2,409.42	2,103.91
Link_# of Lanes	1.00	4.00	2.12	0.77	1.00	4.00	2.12	0.77
Link_SL (mph)	35.00	65.00	42.73	7.40	35.00	65.00	42.73	7.40
DS_# of Lanes	0.00	5.00	1.88	1.04	0.00	5.00	1.88	1.04
DS_SL (mph)	0.00	65.00	38.20	15.77	0.00	65.00	38.20	15.77
US_# of Lanes	0.00	5.00	2.09	1.02	0.00	5.00	2.09	1.02
US_SL (mph)	0.00	65.00	39.05	14.18	0.00	65.00	39.05	14.18
DS_Cross street_# of Lanes	0.00	6.00	2.83	1.55	0.00	6.00	2.83	1.55
DS_Cross street_ SL (mph)	0.00	55.00	39.22	10.93	0.00	55.00	39.22	10.93
US_Cross street_# of Lanes	0.00	6.00	2.81	1.43	0.00	6.00	2.81	1.43
US_Cross street_ SL (mph)	0.00	55.00	40.23	10.22	0.00	55.00	40.23	10.22
Intersection_# of Lanes	0.00	4.00	1.65	1.01	0.00	4.00	1.65	1.01
Intersection_SL (mph)	0.00	45.00	22.61	13.46	0.00	45.00	22.61	13.46

Note: Land use categories’ areas were considered in per 1,000 square feet.

Table 10. Descriptive Statistics for 2-mile and 3-mile Buffer Widths

Parameters	2 miles				3 miles			
	Min.	Max.	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.
ATT (minutes)	0.85	6.45	1.97	0.72	0.85	6.45	1.97	0.72
Attached Residential	86.68	7,304.24	3,009.71	1,876.94	424.08	12,261.02	5,687.30	2,634.71
Auto Dealer	0.00	1,048.54	110.16	201.75	0.00	1,059.45	222.25	278.72
Bank	5.20	621.68	168.52	158.58	25.03	699.42	269.97	187.73
Car Wash	0.78	59.02	21.57	11.98	5.15	86.34	40.07	14.55
Church	377.60	3,340.75	1,430.52	684.32	749.89	4,786.49	2,656.29	981.48
Commercial Service	4.18	1,337.35	527.08	397.52	88.06	2,294.77	913.54	503.56
Convenience Store	2.96	115.00	50.03	18.20	17.54	163.14	103.47	29.32
Daycare	17.32	197.41	92.06	37.03	77.60	285.08	179.51	45.97
Department Store	0.00	1,187.91	186.35	321.40	42.44	1,764.40	314.73	391.39
Fast Food	9.75	94.63	49.55	17.98	30.67	149.32	99.49	25.60
Funeral Home	0.00	80.39	25.66	24.71	0.00	126.89	44.73	29.46
Government	15.41	6,357.07	2,097.26	2,277.42	67.28	8,701.26	3,209.20	2,836.02
Hospital	0.00	4,449.36	1,237.69	1,812.11	0.00	4,753.27	2,084.27	2,037.00
Hotel / Motel	0.00	4,254.03	1,537.91	1,301.50	0.00	6,586.00	2,508.22	1,698.82
Industrial	0.00	155.06	22.21	29.16	0.00	167.60	50.02	46.19
Industrial Lg	0.00	103.37	12.04	33.17	0.00	192.10	24.09	49.00
Institutional	0.00	2,907.05	986.35	1,117.85	10.49	3,158.92	1,531.06	1,208.12
Manufactured Home Construction	0.00	145.94	12.55	25.38	0.00	162.07	27.06	40.15
Manufacturing	0.00	2,474.60	914.36	643.01	0.00	4,102.97	1,700.20	1,041.36
Medical	21.89	2,540.03	636.13	749.68	81.25	2,778.70	1,204.72	944.40
Multi-Family	630.95	19,499.66	9,457.88	4,681.57	2,971.33	35,593.55	17,187.54	6,127.92
Office	137.17	26,598.16	10,191.78	10,234.17	963.32	36,427.48	15,756.53	11,460.63
Parking Garage	0.00	18,357.74	5,822.62	6,713.78	0.00	24,024.77	8,864.04	7,444.86
Recreational	39.80	849.86	394.06	173.73	210.14	1,303.78	749.80	267.21
Restaurant	6.96	527.83	230.93	146.06	29.01	789.39	407.59	184.90
Retail	88.29	2,696.49	1,064.52	548.74	500.62	3,400.25	1,966.88	689.23
School	412.83	3,449.01	1,841.53	702.57	911.96	6,333.30	3,558.12	1,206.73
Service Garage	5.74	1,387.35	421.61	285.13	36.25	2,193.43	838.78	469.70
Shopping Mall	45.51	2,528.31	927.91	481.47	486.94	4,404.26	1,911.36	622.53
Single-Family Residential	3,830.96	42,184.47	19,574.86	8,290.43	12,876.72	80,529.15	40,618.63	14,233.54
Stadium / Arena	0.00	3,283.42	1,022.62	1,370.60	0.00	3,283.42	1,479.39	1,480.66
Supermarket	0.00	434.79	156.96	92.47	71.31	628.76	305.28	127.37
Truck Terminal	0.00	1,105.95	181.59	252.98	0.00	1,615.07	398.14	394.35
Utility	0.12	176.94	48.70	51.35	0.99	248.76	90.27	72.87
Warehouse	74.82	20,097.45	7,323.59	4,876.16	145.20	31,850.10	14,774.29	8,320.04

Parameters	2 miles				3 miles			
	Min.	**Max.**	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**Mean**	**Std. Dev.**
Link_# of Lanes	1.00	4.00	2.12	0.77	1.00	4.00	2.12	0.77
Link_SL (mph)	35.00	65.00	42.73	7.40	35.00	65.00	42.73	7.40
DS_# of Lanes	0.00	5.00	1.88	1.04	0.00	5.00	1.88	1.04
DS_SL (mph)	0.00	65.00	38.20	15.77	0.00	65.00	38.20	15.77
US_# of Lanes	0.00	5.00	2.09	1.02	0.00	5.00	2.09	1.02
US_SL (mph)	0.00	65.00	39.05	14.18	0.00	65.00	39.05	14.18
DS_Cross street_# of Lanes	0.00	6.00	2.83	1.55	0.00	6.00	2.83	1.55
DS_Cross street_SL (mph)	0.00	55.00	39.22	10.93	0.00	55.00	39.22	10.93
US_Cross street_# of Lanes	0.00	6.00	2.81	1.43	0.00	6.00	2.81	1.43
US_Cross street_SL (mph)	0.00	55.00	40.23	10.22	0.00	55.00	40.23	10.22
Intersection_# of Lanes	0.00	4.00	1.65	1.01	0.00	4.00	1.65	1.01
Intersection_ SL (mph)	0.00	45.00	22.61	13.46	0.00	45.00	22.61	13.46

Note: Land use categories' areas were considered in in per 1,000 square feet.

Table 11.   Developed Linear and Log-link Models for 0.5-mile Buffer Width

Parameters	Linear			Log-Link Gamma Distribution		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	2.721	0.061	<0.05	1.324	0.028	<0.05
[Weekday=1]	0.131	0.011	<0.05	0.071	0.005	<0.05
[MPP=1]	0.053	0.014	<0.05	0.028	0.006	<0.05
[OPP=1]	0.077	0.014	<0.05	0.039	0.006	<0.05
[EPP=1]	0.204	0.016	<0.05	0.104	0.007	<0.05
Attached Residential	-1.31E-04	<0.001	<0.05	-4.94E-05	<0.001	<0.05
Auto Dealer	-5.05E-04	<0.001	<0.05	-2.67E-04	<0.001	<0.05
Bank	-1.40E-03	<0.001	<0.05	-4.76E-04	<0.001	<0.05
Car Wash	8.76E-03	0.002	<0.05	5.16E-03	<0.001	<0.05
Church	-	-	-	-	-	-
Commercial Service	-4.79E-04	<0.001	<0.05	-2.14E-04	<0.001	<0.05
Convenience Store	6.02E-03	0.001	<0.05	3.50E-03	<0.001	<0.05
Daycare	-3.61E-03	<0.001	<0.05	-1.75E-03	<0.001	<0.05
Department Store	-9.21E-04	<0.001	<0.05	-3.65E-04	<0.001	<0.05
Fast Food	-	-	-	-	-	-
Funeral Home	2.41E-03	<0.001	<0.05	1.06E-03	<0.001	<0.05
Government	1.02E-04	<0.001	<0.05	4.65E-05	<0.001	<0.05
Hospital	-2.54E-04	<0.001	<0.05	-9.45E-05	<0.001	<0.05
Hotel / Motel	5.92E-05	<0.001	0.033	-	-	-
Industrial	-4.69E-03	<0.001	<0.05	-2.61E-03	<0.001	<0.05
Industrial Lg	-	-	-	-	-	-
Institutional	-3.29E-04	<0.001	<0.05	-1.30E-04	<0.001	<0.05
Manufactured Home Construction	-8.44E-03	<0.001	<0.05	-3.90E-03	<0.001	<0.05
Manufacturing	-	-	-	-	-	-
Medical	1.32E-04	<0.001	0.024	5.89E-05	<0.001	0.009
Multi-Family	-	-	-	-	-	-
Office	-1.06E-04	<0.001	<0.05	-3.21E-05	<0.001	<0.05
Parking Garage	3.88E-04	<0.001	<0.05	1.26E-04	<0.001	<0.05
Recreational	-	-	-	-1.36E-04	<0.001	0.043
Restaurant	3.73E-03	<0.001	<0.05	1.39E-03	<0.001	<0.05
Retail	2.46E-04	<0.001	<0.05	1.63E-04	<0.001	<0.05
School	8.13E-05	<0.001	0.006	-	-	-
Service Garage	-	-	-	-	-	-
Shopping Mall	-	-	-	6.16E-05	<0.001	0.006
Single-Family Residential	-9.07E-05	<0.001	<0.05	-4.44E-05	<0.001	<0.05
Stadium /Arena	-	-	-	-	-	-
Supermarket	1.46E-03	<0.001	<0.05	8.12E-04	<0.001	<0.05
Truck Terminal	4.26E-04	<0.001	<0.05	3.61E-04	<0.001	<0.05
Utility	-3.86E-03	<0.001	<0.05	-1.26E-03	<0.001	<0.05
Warehouse	-7.04E-05	<0.001	<0.05	-4.92E-05	<0.001	<0.05
Link_# of Lanes	-0.055	0.017	0.001	-0.041	0.007	<0.05
Link_SL (mph)	-0.025	0.001	<0.05	-0.017	<0.001	<0.05
DS_# of Lanes	-0.058	0.008	<0.05	-0.040	0.005	<0.05

Parameters	Linear			Log-Link Gamma Distribution		
	Coeff.	**Std. Error**	**p-value**	**Coeff.**	**Std. Error**	**p-value**
DS_SL (mph)	-	-	-	0.001	<0.001	<0.05
US_# of Lanes	-0.062	0.016	<0.05	-0.031	0.006	<0.05
US_SL (mph)	0.005	<0.001	<0.05	0.002	<0.001	<0.05
DS_Cross street_# of Lanes	0.066	0.005	<0.05	0.032	0.002	<0.05
DS_Cross street_SL (mph)	0.003	<0.001	<0.05	0.001	<0.001	0.002
US_Cross street_# of Lanes	0.019	0.006	0.002	0.014	0.003	<0.05
US_Cross street_SL (mph)	-0.004	<0.001	<0.05	-0.003	<0.001	<0.05
Intersection_# of Lanes	-0.061	0.018	<0.05	-0.037	0.008	<0.05
Intersection_SL (mph)	0.010	0.001	<0.05	0.006	<0.001	<0.05
QIC		793.326			217.019	
QICC		788.683			207.885	

Note: To develop the count models, ATT (dependent variable) was considered in seconds, and land use categories' areas were considered in per 1,000 square feet.

Table 12. Developed Log-Link Models for 0.5-mile Buffer Width

Parameters	Log-link Poisson Distribution			Log-Link Negative Binomial Distribution		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	5.314	0.034	<0.05	5.397	0.030	<0.05
[Weekday=1]	0.067	0.005	<0.05	0.071	0.005	<0.05
[MPP=1]	0.028	0.007	<0.05	0.028	0.006	<0.05
[OPP=1]	0.040	0.007	<0.05	0.039	0.006	<0.05
[EPP=1]	0.103	0.008	<0.05	0.104	0.007	<0.05
Attached Residential	-5.74E-05	<0.001	<0.05	-5.34E-05	<0.001	<0.05
Auto Dealer	-2.64E-04	<0.001	<0.05	-2.57E-04	<0.001	<0.05
Bank	-4.03E-04	<0.001	<0.05	-4.66E-04	<0.001	<0.05
Car Wash	5.29E-03	<0.001	<0.05	4.95E-03	<0.001	<0.05
Church	-	-	-	-	-	-
Commercial Service	-2.13E-04	<0.001	<0.05	-1.97E-04	<0.001	<0.05
Convenience Store	3.78E-03	<0.001	<0.05	3.66E-03	<0.001	<0.05
Daycare	-2.05E-03	<0.001	<0.05	-1.91E-03	<0.001	<0.05
Department Store	-4.25E-04	<0.001	<0.05	-3.64E-04	<0.001	<0.05
Fast Food	-	-	-	-	-	-
Funeral Home	1.15E-03	<0.001	<0.05	1.12E-03	<0.001	<0.05
Government	4.24E-05	<0.001	<0.05	4.39E-05	<0.001	<0.05
Hospital	-9.82E-05	<0.001	<0.05	-9.40E-05	<0.001	<0.05
Hotel / Motel	-	-	-	-	-	-
Industrial	-3.27E-03	<0.001	<0.05	-2.70E-03	<0.001	<0.05
Industrial Lg	-	-	-	-	-	-
Institutional	-1.39E-04	<0.001	<0.05	-1.27E-04	<0.001	<0.05
Manufactured Home Construction	-3.92E-03	<0.001	<0.05	-3.81E-03	<0.001	<0.05
Manufacturing	7.22E-05	<0.001	<0.05	3.63E-05	<0.001	0.049
Medical	5.79E-05	<0.001	0.021	5.95E-05	<0.001	0.009
Multi-Family	-	-	-	-	-	-
Office	-4.10E-05	<0.001	<0.05	-3.34E-05	<0.001	<0.05
Parking Garage	1.50E-04	<0.001	<0.05	1.29E-04	<0.001	<0.05
Recreational	-	-	-	-	-	-
Restaurant	1.35E-03	<0.001	<0.05	1.30E-03	<0.001	<0.05
Retail	1.64E-04	<0.001	<0.05	1.60E-04	<0.001	<0.05
School	-	-	-	-	-	-
Service Garage	-	-	-	-	-	-
Shopping Mall	5.34E-05	<0.001	0.025	6.34E-05	<0.001	0.005
Single-Family Residential	-4.69E-05	<0.001	<0.05	-4.45E-05	<0.001	<0.05
Stadium /Arena	-	-	-	-	-	-
Supermarket	8.86E-04	<0.001	<0.05	8.32E-04	<0.001	<0.05
Truck Terminal	3.61E-04	<0.001	<0.05	3.75E-04	<0.001	<0.05
Utility	-1.58E-03	<0.001	<0.05	-1.29E-03	<0.001	<0.05
Warehouse	-5.32E-05	<0.001	<0.05	-5.34E-05	<0.001	<0.05
Link_# of Lanes	-0.035	0.008	<0.05	-0.039	0.007	<0.05
Link_SL (mph)	-0.016	<0.001	<0.05	-0.017	<0.001	<0.05

Parameters	Log-link Poisson Distribution			Log-Link Negative Binomial Distribution		
	Coeff.	**Std. Error**	**p-value**	**Coeff.**	**Std. Error**	**p-value**
DS_# of Lanes	-0.046	0.006	<0.05	-0.043	0.005	<0.05
DS_SL (mph)	0.001	<0.001	<0.05	0.001	<0.001	<0.05
US_# of Lanes	-0.032	0.006	<0.05	-0.030	0.006	<0.05
US_SL (mph)	0.002	<0.001	<0.05	0.002	<0.001	<0.05
DS_Cross street_# of Lanes	0.035	0.002	<0.05	0.032	0.002	<0.05
DS_Cross street_SL (mph)	0.001	<0.001	0.003	0.001	<0.001	0.002
US_Cross street_# of Lanes	0.013	0.003	<0.05	0.014	0.003	<0.05
US_Cross street_SL (mph)	-0.003	<0.001	<0.05	-0.003	<0.001	<0.05
Intersection_# of Lanes	-0.043	0.008	<0.05	-0.036	0.008	<0.05
Intersection_SL (mph)	0.006	<0.001	<0.05	0.006	<0.001	<0.05
QIC		16,601.197			123.207	
QICC		16,352.311			206.903	

Note: To develop the count models, ATT (dependent variable) was considered in seconds, and land use categories' areas were considered in per 1,000 square feet.

Table 13. Predictor Variables Selected to Develop Models by Buffer Width

Parameters	0.5 Miles		1 Mile		2 Miles		3 Miles	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
[Weekday=1]	√	√	√	√	√	√	√	√
[MPP=1]	√	√	√	√	√	√	√	√
[OPP=1]	√	√	√	√	√	√	√	√
[EPP=1]	√	√	√	√	√	√	√	√
Attached Residential								
Auto Dealer	√		√	√	√			
Bank								
Car Wash		√						
Church								
Commercial Service	√							
Convenience Store	√							
Daycare	√	√				√		√
Department Store	√		√	√				
Fast Food		√	√	√				
Funeral Home		√						
Government								
Hospital		√	√					
Hotel / Motel								
Industrial	√	√	√					
Industrial Lg				√		√		
Institutional				√				
Manufactured Home Construction	√	√	√	√				
Manufacturing	√							
Medical								
Multi-Family	√			√				
Office		√	√			√		
Parking Garage								
Recreational								
Restaurant								
Retail					√		√	
School	√	√						
Service Garage			√					
Shopping Mall								
Single-Family Residential	√			√	√		√	
Stadium /Arena								√
Supermarket		√				√		√
Truck Terminal								
Utility	√			√				
Warehouse		√						
Link_# of Lanes		√		√		√	√	√
Link_SL (mph)	√		√					
DS_# of Lanes								
DS_SL (mph)								

Parameters	0.5 Miles		1 Mile		2 Miles		3 Miles	
	Model 1	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**
US_# of Lanes								
US_SL (mph)								
DS_Cross street_# of Lanes								
DS_Cross street_SL (mph)	√	√		√			√	√
US_Cross street_# of Lanes								
US_Cross street_SL (mph)		√		√			√	
Intersection_# of Lanes								
Intersection_SL (mph)								

Table 14. Developed Models for 0.5-mile Buffer Width

Parameters_0.5 miles	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.324	0.028	<0.05	1.875	0.024	<0.05	1.130	0.021	<0.05
[Weekday=1]	0.071	0.005	<0.05	0.072	0.006	<0.05	0.071	0.007	<0.05
[MPP=1]	0.028	0.006	<0.05	0.029	0.008	<0.05	0.028	0.009	0.001
[OPP=1]	0.039	0.006	<0.05	0.040	0.008	<0.05	0.040	0.009	<0.05
[EPP=1]	0.104	0.007	<0.05	0.106	0.009	<0.05	0.106	0.010	<0.05
Attached Residential	-4.94E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-2.67E-04	<0.001	<0.05	-8.43E-05	<0.001	<0.05	-	-	-
Bank	-4.76E-04	<0.001	<0.05	-	-	-	-	-	-
Car Wash	5.16E-03	0.001	<0.05	-	-	-	6.14E-03	0.001	<0.05
Church	-	-	-	-	-	-	-	-	-
Commercial Service	-2.14E-04	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	3.50E-03	0.001	<0.05	3.18E-03	0.001	<0.05	-	-	-
Daycare	-1.75E-03	<0.001	<0.05	-1.05E-03	<0.001	<0.05	-2.43E-03	<0.001	<0.05
Department Store	-3.65E-04	<0.001	<0.05	1.07E-04	<0.001	<0.05	-	-	-
Fast Food	-	-	-	-	-	-	3.88E-03	<0.001	<0.05
Funeral Home	1.06E-03	<0.001	<0.05	-	-	-	1.81E-03	<0.001	<0.05
Government	4.65E-05	<0.001	<0.05	-	-	-	-	-	-
Hospital	-9.45E-05	<0.001	<0.05	-	-	-	2.49E-05	<0.001	<0.05
Hotel / Motel	-	-	-	-	-	-	-	-	-
Industrial	-2.61E-03	<0.001	<0.05	-3.84E-03	<0.001	<0.05	-3.26E-03	<0.001	<0.05
Industrial Lg	-	-	-	-	-	-	-	-	-
Institutional	-1.30E-04	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-3.90E-03	<0.001	<0.05	-1.75E-03	<0.001	<0.05	-1.07E-02	0.001	<0.05
Manufacturing	-	-	-	-2.27E-04	<0.001	<0.05	-	-	-
Medical	5.89E-05	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	-	-	-	7.32E-05	<0.001	<0.05	-	-	-
Office	-3.21E-05	<0.001	<0.05	-	-	-	3.88E-05	<0.001	<0.05
Parking Garage	1.26E-04	<0.001	<0.05	-	-	-	-	-	-
Recreational	-1.36E-04	<0.001	0.043	-	-	-	-	-	-

Parameters_0.5 miles	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
Restaurant	1.39E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	1.63E-04	<0.001	<0.05	-	-	-	-	-	-
School	-	-	-	-	-	-	-	-	-
Service Garage	-	-	-	-	-	-	-	-	-
Shopping Mall	6.16E-05	<0.001	<0.05	-	-	-	-	-	-
Single-Family Residential	-4.44E-05	<0.001	<0.05	-3.31E-05	<0.001	<0.05	-	-	-
Stadium /Arena	-	-	-	-	-	-	-	-	-
Supermarket	8.12E-04	<0.001	<0.05	-	-	-	1.12E-03	<0.001	<0.05
Truck Terminal	3.61E-04	<0.001	<0.05	-	-	-	-	-	-
Utility	-1.26E-03	<0.001	<0.05	-	-	-	-	-	-
Warehouse	-4.92E-05	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-0.041	0.007	<0.05	-	-	-	-0.217	0.004	<0.05
Link_SL (mph)	-0.017	0.001	<0.05	-0.034	<0.001	<0.05	-	-	-
DS_# of Lanes	-0.040	0.005	<0.05	-	-	-	-	-	-
DS_SL (mph)	0.001	<0.001	<0.05	-	-	-	-	-	-
US_# of Lanes	-0.031	0.006	<0.05	-	-	-	-	-	-
US_SL (mph)	0.002	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.032	0.002	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	0.001	<0.001	<0.05	0.003	<0.001	<0.05	0.001	<0.001	<0.05
US_Cross street_# of Lanes	0.014	0.003	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.003	<0.001	<0.05	-	-	-	-0.007	<0.001	<0.05
Intersection_# of Lanes	-0.037	0.008	<0.05	-	-	-	-	-	-
Intersection_SL (mph)	0.006	0.001	<0.05	-	-	-	-	-	-
QIC	217.019			238.032			280.148		
QICC	207.885			237.882			276.906		
RMSE	0.467			0.469			0.552		
MAPE	17%			16%			20%		
MPE		-6%			-6%			-7%	

Note: Land use categories were considered in per 1,000 square feet.

Table 15. Developed Models for 1-mile Buffer Width

Parameters_1-mile	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.345	0.035	<0.05	1.950	0.019	<0.05	1.155	0.025	<0.05
[Weekday=1]	0.071	0.005	<0.05	0.071	0.007	<0.05	0.071	0.007	<0.05
[MPP=1]	0.028	0.007	<0.05	0.029	0.009	<0.05	0.028	0.010	<0.05
[OPP=1]	0.038	0.006	<0.05	0.040	0.009	<0.05	0.040	0.010	<0.05
[EPP=1]	0.104	0.008	<0.05	0.106	0.010	<0.05	0.105	0.010	<0.05
Attached Residential	4.61E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-	-	-	1.47E-04	<0.001	<0.05	-	-	-
Bank	-	-	-	-	-	-	-	-	-
Car Wash	-6.29E-03	<0.001	<0.05	-	-	-	-	-	-
Church	-3.79E-05	<0.001	<0.05	-	-	-	-	-	-
Commercial Service	6.11E-05	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	5.73E-03	<0.001	<0.05	-	-	-	-	-	-
Daycare	-1.34E-03	<0.001	<0.05	-	-	-	-	-	-
Department Store	-2.16E-04	<0.001	<0.05	-	-	-	1.56E-04	<0.001	<0.05
Fast Food	2.13E-03	<0.001	<0.05	3.53E-03	<0.001	<0.05	1.12E-03	<0.001	<0.05
Funeral Home	-8.12E-04	<0.001	<0.05	-	-	-	-	-	-
Government	3.63E-05	<0.001	<0.05	-	-	-	-	-	-
Hospital	-1.21E-04	<0.001	<0.05	-2.87E-05	<0.001	<0.05	-	-	-
Hotel / Motel	4.05E-05	<0.001	<0.05	-	-	-	-	-	-
Industrial	-1.95E-03	<0.001	<0.05	-1.84E-03	<0.001	<0.05	-	-	-
Industrial Lg	-	-	-	-	-	-	-1.12E-03	<0.001	<0.05
Institutional	-4.39E-05	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-9.91E-04	<0.001	<0.05	-	-	-	-9.76E-04	<0.001	<0.05
Manufacturing	-	-	-	-	-	-	-	-	-
Medical	-3.33E-05	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	1.08E-05	<0.001	<0.05	-	-	-	5.19E-05	<0.001	<0.05
Office	-2.81E-05	<0.001	<0.05	1.03E-05	<0.001	<0.05	-	-	-
Parking Garage	6.45E-05	<0.001	<0.05	-	-	-	-	-	-
Recreational	-1.96E-04	<0.001	<0.05	-	-	-	-	-	-

Parameters_1-mile	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
Restaurant	3.90E-04	<0.001	<0.05	-	-	-	-	-	-
Retail	-	-	-	-	-	-	-	-	-
School	5.82E-05	<0.001	<0.05	-	-	-	-	-	-
Service Garage	-	-	-	-1.90E-04	<0.001	<0.05	-	-	-
Shopping Mall	-	-	-	-	-	-	-	-	-
Single-Family Residential	-2.41E-05	<0.001	<0.05	-	-	-	-1.40E-05	<0.001	<0.05
Stadium /Arena	-7.20E-05	<0.001	<0.05	-	-	-	-	-	-
Supermarket	-	-	-	-	-	-	-	-	-
Truck Terminal	7.55E-05	<0.001	<0.05	-	-	-	-	-	-
Utility	7.54E-04	<0.001	<0.05	-	-	-	6.46E-04	<0.001	<0.05
Warehouse	-3.59E-05	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-	-	-	-	-	-	-0.227	0.005	<0.05
Link_SL (mph)	-0.019	<0.001	<0.05	-0.034	<0.001	<0.05	-	-	-
DS_# of Lanes	-0.025	0.003	<0.05	-	-	-	-	-	-
DS_SL (mph)	-	-	-	-	-	-	-	-	-
US_# of Lanes	-0.052	0.005	<0.05	-	-	-	-	-	-
US_SL (mph)	0.004	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.039	0.002	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	0.001	<0.001	<0.05	-	-	-	0.002	<0.001	<0.05
US_Cross street_# of Lanes	0.017	0.003	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.005	<0.001	<0.05	-	-	-	-0.007	<0.001	<0.05
Intersection_# of Lanes	-	-	-	-	-	-	-	-	-
Intersection_SL (mph)	0.005	<0.001	<0.05	-	-	-	-	-	-
QIC	225.219			256.858			322.564		
QICC	220.152			254.810			321.199		
RMSE	0.459			0.521			0.591		
MAPE	16%			18%			21%		
MPE	-5%			-7%			-6%		

Note: Land use categories were considered in per 1,000 square feet.

Table 16. Developed Models for 2-mile Buffer Width

Parameters_2 miles	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.449	0.0378	<0.05	1.910	0.0238	<0.05	0.849	0.0182	<0.05
[Weekday=1]	0.070	0.0048	<0.05	0.071	0.0072	<0.05	0.069	0.0081	<0.05
[MPP=1]	0.028	0.0063	<0.05	0.028	0.0096	<0.05	0.028	0.0111	<0.05
[OPP=1]	0.038	0.0061	<0.05	0.039	0.0096	<0.05	0.040	0.0111	<0.05
[EPP=1]	0.103	0.0072	<0.05	0.106	0.0105	<0.05	0.105	0.0119	<0.05
Attached Residential	-4.93E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-2.67E-04	<0.001	<0.05	-	-	-	-	-	-
Bank	6.11E-04	<0.001	<0.05	-	-	-	-	-	-
Car Wash	-3.25E-03	<0.001	<0.05	-	-	-	-	-	-
Church	-1.25E-04	<0.001	<0.05	-	-	-	-	-	-
Commercial Service	-4.82E-05	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	9.63E-04	<0.001	<0.05	-	-	-	-	-	-
Daycare	-1.49E-03	<0.001	<0.05	-	-	-	-2.90E-04	<0.001	<0.05
Department Store	-1.32E-04	<0.001	<0.05	-	-	-	-	-	-
Fast Food	-	-	-	-	-	-	-	-	-
Funeral Home	2.15E-03	<0.001	<0.05	-	-	-	-	-	-
Government	-5.37E-05	<0.001	<0.05	-	-	-	-	-	-
Hospital	-4.60E-05	<0.001	<0.05	-	-	-	-	-	-
Hotel / Motel	-3.52E-05	<0.001	<0.05	-	-	-	-	-	-
Industrial	3.25E-04	<0.001	<0.05	-	-	-	-	-	-
Industrial Lg	-	-	-	-	-	-	-4.98E-04	<0.001	<0.05
Institutional	-1.10E-04	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	9.47E-04	<0.001	<0.05	-	-	-	-	-	-
Manufacturing	-3.00E-05	<0.001	<0.05	-	-	-	-	-	-
Medical	-	-	-	-	-	-	-	-	-
Multi-Family	1.93E-05	<0.001	<0.05	-	-	-	-	-	-
Office	-2.68E-05	<0.001	<0.05	-	-	-	1.21E-05	<0.001	<0.05
Parking Garage	8.00E-05	<0.001	<0.05	-	-	-	-	-	-
Recreational	-	-	-	-	-	-	-	-	-

Parameters_2 miles	Backward Elimination			Model 1			Model 2		
	Coeff.	**Std. Error**	**p-value**	**Coeff.**	**Std. Error**	**p-value**	**Coeff.**	**Std. Error**	**p-value**
Restaurant	5.86E-04	<0.001	<0.05	-	-	-	-	-	-
Retail	1.24E-04	<0.001	<0.05	7.87E-05	<0.001	<0.05	-	-	-
School	-	-	-	-	-	-	-	-	-
Service Garage	1.33E-04	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	-	-	-	-	-	-	-	-	-
Single-Family Residential	-1.52E-05	<0.001	<0.05	1.44E-06	<0.001	<0.05	-	-	-
Stadium /Arena	-4.38E-05	<0.001	<0.05	-	-	-	-	-	-
Supermarket	-	-	-	-	-	-	5.18E-04	<0.001	<0.05
Truck Terminal	-2.57E-04	<0.001	<0.05	-	-	-	-	-	-
Utility	1.09E-03	<0.001	<0.05	-	-	-	-	-	-
Warehouse	-	-	-	-	-	-	-	-	-
Link_# of Lanes	0.016	0.0077	<0.05	-	-	-	-0.211	0.0049	<0.05
Link_SL (mph)	-0.017	<0.001	<0.05	-0.034	<0.001	<0.05	-	-	-
DS_# of Lanes	-0.054	0.0056	<0.05	-	-	-	-	-	-
DS_SL (mph)	0.001	<0.001	<0.05	-	-	-	-	-	-
US_# of Lanes	-0.060	0.0065	<0.05	-	-	-	-	-	-
US_SL (mph)	0.003	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.043	0.0024	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	0.002	<0.001	<0.05	-	-	-	-	-	-
US_Cross street_# of Lanes	0.025	0.0028	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.003	<0.001	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	-	-	-	-	-	-	-	-	-
Intersection_SL (mph)	0.005	<0.001	<0.05	-	-	-	-	-	-
QIC	221.091			279.365			379.973		
QICC	214.686			277.281			378.232		
RMSE	0.477			0.569			0.700		
MAPE	18%			19%			24%		
MPE		-7%			-5%			-7%	

Note: Land use categories were considered in per 1,000 square feet.

Table 17. Developed Models for 3-mile Buffer Width

Parameters_3 miles	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.685	0.042	<0.05	1.071	0.028	<0.05	0.822	0.022	<0.05
[Weekday=1]	0.070	0.005	<0.05	0.069	0.009	<0.05	0.069	0.009	<0.05
[MPP=1]	0.028	0.006	<0.05	0.027	0.012	<0.05	0.027	0.012	<0.05
[OPP=1]	0.038	0.006	<0.05	0.039	0.012	<0.05	0.040	0.012	<0.05
[EPP=1]	0.103	0.007	<0.05	0.103	0.013	<0.05	0.104	0.013	<0.05
Attached Residential	2.48E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-1.73E-04	<0.001	<0.05	-	-	-	-	-	-
Bank	-1.05E-03	<0.001	<0.05	-	-	-	-	-	-
Car Wash	-	-	-	-	-	-	-	-	-
Church	-1.17E-04	<0.001	<0.05	-	-	-	-	-	-
Commercial Service	-3.51E-04	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	1.18E-03	<0.001	<0.05	-	-	-	-	-	-
Daycare	-6.49E-04	<0.001	<0.05	-	-	-	-3.19E-04	<0.001	<0.05
Department Store	1.66E-04	<0.001	<0.05	-	-	-	-	-	-
Fast Food	-	-	-	-	-	-	-	-	-
Funeral Home	6.51E-04	<0.001	<0.05	-	-	-	-	-	-
Government	9.78E-05	<0.001	<0.05	-	-	-	-	-	-
Hospital	-	-	-	-	-	-	-	-	-
Hotel / Motel	6.72E-05	<0.001	<0.05	-	-	-	-	-	-
Industrial	-1.85E-03	<0.001	<0.05	-	-	-	-	-	-
Industrial Lg	5.72E-04	<0.001	<0.05	-	-	-	-	-	-
Institutional	-5.77E-05	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-2.37E-04	<0.001	<0.05	-	-	-	-	-	-
Manufacturing	-	-	-	-	-	-	-	-	-
Medical	1.41E-04	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	5.58E-06	<0.001	<0.05	-	-	-	-	-	-
Office	-2.47E-05	<0.001	<0.05	-	-	-	-	-	-
Parking Garage	3.60E-05	<0.001	<0.05	-	-	-	-	-	-
Recreational	5.57E-04	<0.001	<0.05	-	-	-	-	-	-

Parameters_3 miles	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
Restaurant	-1.42E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	1.85E-04	<0.001	<0.05	1.11E-04	<0.001	<0.05	-	-	-
School	1.14E-04	<0.001	<0.05	-	-	-	-	-	-
Service Garage	-1.67E-04	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	-	-	-	-	-	-	-	-	-
Single-Family Residential	-1.81E-05	<0.001	<0.05	1.74E-06	<0.001	<0.05	-	-	-
Stadium /Arena	-4.07E-05	<0.001	<0.05	-	-	-	7.54E-05	<0.001	<0.05
Supermarket	5.31E-04	<0.001	<0.05	-	-	-	5.02E-04	<0.001	<0.05
Truck Terminal	1.80E-04	<0.001	<0.05	-	-	-	-	-	-
Utility	-6.78E-04	<0.001	<0.05	-	-	-	-	-	-
Warehouse	-	-	-	-	-	-	-	-	-
Link_# of Lanes	0.016	0.008	<0.05	-0.186	0.005	<0.05	-0.214	0.005	<0.05
Link_SL (mph)	-0.021	<0.001	<0.05	-	-	-	-	-	-
DS_# of Lanes	-0.047	0.006	<0.05	-	-	-	-	-	-
DS_SL (mph)	0.002	<0.001	<0.05	-	-	-	-	-	-
US_# of Lanes	-0.043	0.007	<0.05	-	-	-	-	-	-
US_SL (mph)	0.002	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.042	0.002	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	0.001	<0.001	<0.05	-	-	-	-	-	-
US_Cross street_# of Lanes	-	-	-	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.003	<0.001	<0.05	-0.010	<0.001	<0.05	-	-	-
Intersection_# of Lanes	-0.039	0.008	<0.05	-	-	-	-	-	-
Intersection_SL (mph)	0.007	<0.001	<0.05	-	-	-	-	-	-
QIC	231.277			391.852			407.383		
QICC	225.114			388.527			405.383		
RMSE	0.429			0.716			0.733		
MAPE	16%			23%			24%		
MPE		-5%			-6%			-7%	

Note: Land use categories were considered in per 1,000 square feet.

Table 18. Performance of Developed Models by Buffer Width – Summary

Buffer Width	Performance Parameters	Backward Elimination	Model 1	Model 2
0.5 Miles	QIC	217.019	238.032	280.148
	QICC	207.885	237.882	276.906
	RMSE	0.467	0.469	0.552
	MAPE	17%	16%	20%
	MPE	-6%	-6%	-7%
1 mile	QIC	225.219	256.858	322.564
	QICC	220.152	254.810	321.199
	RMSE	0.459	0.521	0.591
	MAPE	16%	18%	21%
	MPE	-5%	-7%	-6%
2 Miles	QIC	221.091	279.365	379.973
	QICC	214.686	277.281	378.232
	RMSE	0.477	0.569	0.700
	MAPE	18%	19%	24%
	MPE	-7%	-5%	-7%
3 Miles	QIC	231.277	391.852	407.383
	QICC	225.114	388.527	405.383
	RMSE	0.429	0.716	0.733
	MAPE	16%	23%	24%
	MPE	-5%	-6%	-7%

DISCUSSION RELATED TO THE DEVELOPED MODELS BY BUFFER WIDTH

The models for 0.5 miles and 1-mile buffer widths were found to be better-fit models for examining the relationship between land use developments and ATT. A positive sign for the coefficient of GEE indicates that the predictor variable contributes more to ATT when compared to a predictor variable with the negative sign. An increase in the area occupied by a department store, fast food, multi-family residential, or office type land uses within 0.5 miles and within 1 mile from a link increases the ATT. However, an increase in the area occupied by industrial, manufactured home construction, or single-family residential type land uses within 0.5 miles and within 1 mile from a link decreases the ATT (Table 19). Interestingly, an increase in the area occupied by hospitals within 0.5 miles from a link increases the ATT, but an increase in the area occupied by hospitals within 1 mile from a link decreases the ATT. Also, an increase in the area occupied by single-family residential type land uses within 0.5 miles and within 1 mile from a link decreases the ATT, whereas an increase in the area occupied by such single-family residential type land uses within 2 miles and 3 miles from a link increases the ATT (Table 19 and Table 20). Likewise, an increase in the area occupied by supermarkets within 1 mile, 2 miles and 3 miles from a link, and in the area occupied by offices within 0.5 miles, 1 mile and 2 miles from a link, increase the ATT. However, an increase in the area occupied by daycare land uses within 0.5 miles, 2 miles and 3-miles from a link decrease the ATT.

Table 19. Comparison of Developed Models by Buffer Width – 0.5-mile and 1-mile Buffer Widths

Parameters	0.5 miles			1-mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	P	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	P	P	P	P	P	P
[EPP=1]	P	P	P	P	P	P
Attached Residential	N			P		
Auto Dealer	N	N			P	
Bank	N					
Car Wash	P		P	N		
Church				N		
Commercial Service	N			P		
Convenience Store	P	P		P		
Daycare	N	N	N	N		
Department Store	N	P		N		P
Fast Food			P	P	P	P
Funeral Home	P		P	N		
Government	P			P		
Hospital	N		P	N	N	
Hotel / Motel				P		
Industrial	N	N	N	N	N	
Industrial Lg						N
Institutional	N			N		
Manufactured Home Construction	N	N	N	N		N
Manufacturing		N				
Medical	P			N		
Multi-Family		P		P		P
Office	N		P	N	P	
Parking Garage	P			P		
Recreational	N			N		
Restaurant	P			P		
Retail	P					
School				P		
Service Garage					N	
Shopping Mall	P					
Single-Family Residential	N	N		N		N
Stadium /Arena				N		
Supermarket	P		P			
Truck Terminal	P			P		
Utility	N			P		P
Warehouse	N			N		
Link_# of Lanes	N		N			N
Link_SL (mph)	N	N		N	N	

Parameters	0.5 miles			1-mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
DS_# of Lanes	N			N		
DS_SL (mph)	P					
US_# of Lanes	N			N		
US_SL (mph)	P			P		
DS_Cross street_# of Lanes	P			P		
DS_Cross street_SL (mph)	P	P	P	P		P
US_Cross street_# of Lanes	P			P		
US_Cross street_SL (mph)	N		N	N		N
Intersection_# of Lanes	N					
Intersection_SL (mph)	P			P		

Table 20. Comparison of Developed Models by Buffer Width – 2-mile and 3-mile Buffer Widths

Parameters	2 miles			3 miles		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	P	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	P	P	P	P	P	P
[EPP=1]	P	P	P	P	P	P
Attached Residential	N			P		
Auto Dealer	N			N		
Bank	P			N		
Car Wash	N					
Church	N			N		
Commercial Service	N			N		
Convenience Store	P			P		
Daycare	N		N	N		N
Department Store	N			P		
Fast Food						
Funeral Home	P			P		
Government	N			P		
Hospital	N					
Hotel / Motel	N			P		
Industrial	P			N		
Industrial Lg			N	P		
Institutional	N			N		
Manufactured Home Construction	P			N		
Manufacturing	N					
Medical				P		
Multi-Family	P			P		

Parameters	2 miles			3 miles		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
Office	N		P	N		
Parking Garage	P			P		
Recreational				P		
Restaurant	P			N		
Retail	P	P		P	P	
School				P		
Service Garage	P			N		
Shopping Mall						
Single-Family Residential	N	P		N	P	
Stadium /Arena	N			N		P
Supermarket			P	P		P
Truck Terminal	N			P		
Utility	P			N		
Warehouse						
Link_# of Lanes	P		N	P	N	N
Link_SL (mph)	N	N		N		
DS_# of Lanes	N			N		
DS_SL (mph)	P			P		
US_# of Lanes	N			N		
US_SL (mph)	P			P		
DS_Cross street_# of Lanes	P			P		
DS_Cross street_SL (mph)	P			P		
US_Cross street_# of Lanes	P					
US_Cross street_SL (mph)	N			N	N	
Intersection_# of Lanes				N		
Intersection_SL (mph)	P			P		

VII. STATISTICAL MODELS BY AREA TYPE

This chapter presents the results obtained from the statistical models developed to examine the relationship between ATT and land use characteristics by area type.

Eighteen models were developed using the area type datasets. As 0.5-mile and 1-mile buffer widths were observed to be suitable to analyze the influence of proximal land use developments on ATT, the models were developed only using 0.5 miles and 1-mile buffer width datasets. Similarly, to the earlier procedure, for each of the buffer width and area type data, a model is developed using the backward elimination method. Model 1 and Model 2 were developed by avoiding the multicollinearity between the predictor variables. Pearson correlation matrices by area type dataset are presented in Appendix A (Table A6 to Table A11). The selection of predictor variables by buffer widths and area types are summarized in Table 21 and Table 22. The backward elimination models can be used for estimating the ATT. However, the influence of predictor variables on the ATT is interpreted using Model 1 and Model 2. Each of the developed models by area types is discussed next.

CBD AREA

In all the developed models (with 0.5 miles and 1-mile buffer widths), the coefficients of TOD and DOW are consistent with each other (Table 23 and Table 24). In all the developed models, the results obtained indicate that, compared to the weekend, ATT is higher on weekdays, when all the other variables are held constant. In addition, ATT is higher during the evening peak period when compared to the morning peak period and the afternoon off-peak period, when all other variables are held constant. The results obtained indicate that the number of lanes and the speed limit of the selected link, both, have a negative influence on ATT. However, the number of lanes of the upstream cross street and of the intersecting link both have a positive influence on ATT.

The Model 1 and Model 2 developed with the 0.5-mile buffer width dataset for the CBD area indicate that office or multi-family type land uses have a positive influence on the ATT (Table 23). However, industrial, supermarket, or warehouse type land uses have a negative influence on ATT.

Model 1 and Model 2 developed with the 1-mile buffer width dataset for CBD area both indicate that department store, government, or multi-family type land uses have a positive influence on ATT (Table 24). However, convenience store, funeral home, or supermarket type land uses have a negative influence on ATT.

CBD FRINGE / OBD AREA

Similarly, to the models developed for the CBD area, the coefficients of TOD and DOW are consistent with each other in all the CBD Fringe / OBD area models (Table 25 and Table 26). In all the developed models, the results obtained indicate that, compared to the weekend, ATT is higher on weekdays, when all the other variables are held constant. In addition, ATT is higher during the evening peak period when compared to the morning peak period and the afternoon off-peak period, when all other variables are held constant.

The results obtained indicate that the number of lanes and the speed limit of the selected link have a negative influence on ATT. However, the speed limit of the downstream cross street has a positive influence on ATT.

The Model 1 and Model 2 developed with the 0.5-mile buffer width dataset for CBD fringe / OBD area indicates that multi-family, office, fast food, or supermarket type land uses have a positive influence on ATT (Table 25). However, commercial service, industrial, recreational, school, church, government, hotel/motel, and stadium/ arena type land uses have a negative influence on ATT.

The Model 1 and Model 2 developed with the 1-mile buffer width data for CBD fringe / OBD area indicate that daycare, multi-family, shopping mall, or supermarket land uses have a positive influence on ATT (Table 26). However, industrial, truck terminal, convenience store, large industrial, recreational, or utility type land uses have a negative influence on ATT.

URBAN AREA

Similarly, to the models developed for the CBD area, the coefficients of TOD and DOW are consistent with each other in all the urban area models (Table 27 and Table 28). In all the developed models, the results obtained indicate that, compared to the weekend, ATT is higher on weekdays, when all the other variables are held constant. In addition, ATT is higher during the evening peak period when compared to the morning peak period and the afternoon off-peak period, when all other variables are held constant. The results obtained indicate that the speed limit of the selected link has a negative influence on ATT.

The Model 1 and Model 2 developed with the 0.5-mile buffer width dataset, for the urban area, indicate that bank, convenience store, hospital, large industrial, retail, stadium/ arena, fast food, funeral home, government, medical, multi-family, and truck terminal type land uses have a positive influence on ATT (Table 27). However, hotel/motel, industrial, institutional, manufactured home construction, manufacturing, recreational, school, and single-family residential type land uses have a negative influence on the ATT.

The Model 1 and Model 2 developed with 1-mile buffer width dataset, for the urban area, indicate that fast food, multi-family, convenience store, department store, funeral home, recreational, retail, and supermarket type land uses have a positive influence on ATT (Table 28). However, large industrial, manufacturing, parking garage, school, manufactured home construction, and office type land uses have a negative influence on ATT.

Each of the developed models was validated by randomly selecting 10 links in the CBD area, 13 links in the CBD fringe / OBD area, and 29 links in the urban area. These links were not considered for model development. A summary of all the developed models by the buffer width is presented in Table 29. The computed MAPE and RMSE values closer to zero indicate the best-fitted model for the data used in this research. The backward elimination models for CBD area underperformed when compared to models developed by checking the multicollinearity, based on the QIC, QICC, RMSE, and MAPE. Also, in almost all the developed models (except the backward elimination and Model 2 for the CBD fringe area with the 0.5 mile buffer width dataset, and the backward elimination model for the CBD fringe area with the 1 mile buffer width dataset), the predicted ATT was higher compared to the actual ATT (negative MPE).

Table 21. Predictor Variables Selected to Develop Models by Area Type – 0.5-mile Buffer Width

Parameters_0.5 miles	CBD		CBD Fringe / OBD		Urban	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
[Weekday=1]	√	√	√	√	√	√
[MPP=1]	√	√	√	√	√	√
[OPP=1]	√	√	√	√	√	√
[EPP=1]	√	√	√	√	√	√
Attached Residential					√	
Auto Dealer						
Bank					√	
Car Wash						
Church				√		
Commercial Service		√	√			
Convenience Store			√		√	
Daycare				√		
Department Store					√	√
Fast Food				√		√
Funeral Home						√
Government				√		√
Hospital			√		√	√
Hotel / Motel				√	√	
Industrial		√	√	√	√	√
Industrial Lg					√	
Institutional			√	√	√	√
Manufactured Home Construction			√		√	√
Manufacturing						√
Medical						√
Multi-Family		√	√			√
Office	√		√			
Parking Garage						√
Recreational			√		√	
Restaurant						
Retail					√	
School		√	√		√	
Service Garage						
Shopping Mall						
Single-Family Residential						√
Stadium /Arena				√	√	√
Supermarket	√			√		
Truck Terminal					√	√
Utility		√			√	√

Parameters_0.5 miles	CBD		CBD Fringe / OBD		Urban	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Warehouse	√					
Link_# of Lanes		√		√		
Link_SL (mph)	√		√		√	√
DS_# of Lanes						
DS_SL (mph)						
US_# of Lanes						
US_SL (mph)						
DS_Cross street_# of Lanes						
DS_Cross street_SL (mph)	√		√		√	√
US_Cross street_# of Lanes		√				
US_Cross street_SL (mph)						
Intersection_# of Lanes		√				
Intersection_SL (mph)						

Table 22. Predictor Variables Selected to Develop Models by Area Type – 1 mile Buffer Width

Parameters_1-mile	CBD		CBD Fringe / OBD		Urban	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
[Weekday=1]	√	√	√	√	√	√
[MPP=1]	√	√	√	√	√	√
[OPP=1]	√	√	√	√	√	√
[EPP=1]	√	√	√	√	√	√
Attached Residential						
Auto Dealer						
Bank						
Car Wash						
Church						
Commercial Service		√				√
Convenience Store	√	√		√		√
Daycare			√			
Department Store	√					√
Fast Food			√		√	
Funeral Home	√					√
Government	√					
Hospital						√
Hotel / Motel						
Industrial			√			
Industrial Lg				√	√	
Institutional						
Manufactured Home Construction					√	√
Manufacturing					√	
Medical			√			

Parameters_1-mile	CBD		CBD Fringe / OBD		Urban	
	Model 1	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**
Multi-Family		√	√		√	
Office				√		√
Parking Garage					√	
Recreational				√		√
Restaurant						
Retail				√		√
School					√	
Service Garage						
Shopping Mall			√	√		
Single-Family Residential						
Stadium /Arena						
Supermarket	√			√		√
Truck Terminal			√			
Utility				√		
Warehouse						
Link_# of Lanes		√		√		√
Link_SL (mph)	√		√		√	
DS_# of Lanes						
DS_SL (mph)						
US_# of Lanes						
US_SL (mph)						
DS_Cross street_# of Lanes						
DS_Cross street_SL (mph)			√	√	√	√
US_Cross street_# of Lanes		√				
US_Cross street_SL (mph)						
Intersection_# of Lanes		√				
Intersection_SL (mph)						

Table 23. Developed Models for 0.5-mile Buffer Width – CBD Area

Parameters_0.5 miles_CBD	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	-6.149	0.490	<0.05	2.151	0.054	<0.05	0.591	0.041	<0.05
[Weekday=1]	0.044	0.007	<0.05	0.043	0.017	<0.05	0.042	0.016	<0.05
[MPP=1]	0.007	0.010	0.465	0.003	0.024	0.894	0.003	0.023	0.880
[OPP=1]	0.016	0.009	0.084	0.015	0.024	0.533	0.016	0.023	0.483
[EPP=1]	0.067	0.011	<0.05	0.070	0.026	<0.05	0.066	0.024	<0.05
Attached Residential	3.21E-03	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-	-	-	-	-	-	-	-	-
Bank	1.04E-02	0.002	<0.05	-	-	-	-	-	-
Car Wash	2.72E-01	0.016	<0.05	-	-	-	-	-	-
Church	5.11E-03	<0.001	<0.05	-	-	-	-	-	-
Commercial Service	-8.89E-03	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	7.45E-02	0.007	<0.05	-	-	-	-	-	-
Daycare	1.19E-01	0.015	<0.05	-	-	-	-	-	-
Department Store	-4.99E-02	0.006	<0.05	-	-	-	-	-	-
Fast Food	6.05E-02	0.010	<0.05	-	-	-	-	-	-
Funeral Home	-6.88E-02	0.007	<0.05	-	-	-	-	-	-
Government	-5.50E-04	<0.001	<0.05	-	-	-	-	-	-
Hospital	3.21E-03	<0.001	<0.05	-	-	-	-	-	-
Hotel / Motel	7.91E-04	<0.001	<0.05	-	-	-	-	-	-
Industrial	2.74E-01	0.044	<0.05	-	-	-	-2.38E-02	0.003	<0.05
Industrial Lg	-	-	-	-	-	-	-	-	-
Institutional	-4.80E-04	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-	-	-	-	-	-	-	-	-
Manufacturing	5.66E-03	<0.001	<0.05	-	-	-	-	-	-
Medical	-6.67E-03	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	5.95E-05	<0.001	<0.05	-	-	-	8.67E-05	<0.001	-
Office	1.69E-04	<0.001	<0.05	1.73E-05	<0.001	<0.05	-	-	-
Parking Garage	-	-	-	-	-	-	-	-	-
Recreational	-1.47E-02	0.001	<0.05	-	-	-	-	-	-

Parameters_0.5 miles_CBD	Backward Elimination			Model 1			Model 2		
	Coeff.	**Std. Error**	**p-value**	**Coeff.**	**Std. Error**	**p-value**	**Coeff.**	**Std. Error**	**p-value**
Restaurant	-2.85E-02	0.003	<0.05	-	-	-	-	-	-
Retail	3.71E-03	<0.001	<0.05	-	-	-	-	-	-
School	-4.90E-03	<0.001	<0.05	-	-	-	-	-	-
Service Garage	2.08E-02	0.002	<0.05	-	-	-	-	-	-
Shopping Mall	1.21E-02	0.002	<0.05	-	-	-	-	-	-
Single-Family Residential	2.57E-03	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-	-	-	-	-	-	-	-	-
Supermarket	-1.46E-01	0.009	<0.05	-2.39E-03	0.001	<0.05	-	-	-
Truck Terminal	-4.17E-02	0.002	<0.05	-	-	-	-	-	-
Utility	6.93E-03	0.002	<0.05	-	-	-	-	-	-
Warehouse	-5.01E-04	<0.001	<0.05	-4.37E-05	<0.001	<0.05	-	-	-
Link_# of Lanes	0.918	0.043	<0.05	-	-	-	-0.199	0.014	<0.05
Link_SL (mph)	-0.158	0.014	<0.05	-0.040	0.001	<0.05	-	-	-
DS_# of Lanes	0.326	0.043	<0.05	-	-	-	-	-	-
DS_SL (mph)	-0.064	0.004	<0.05	-	-	-	-	-	-
US_# of Lanes	-0.805	0.039	<0.05	-	-	-	-	-	-
US_SL (mph)	0.245	0.018	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.635	0.034	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	-0.068	0.004	<0.05	0.005	<0.001	<0.05	-	-	-
US_Cross street_# of Lanes	-	-	-	-	-	-	0.080	0.006	<0.05
US_Cross street_SL (mph)	-0.022	0.002	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	0.583	0.035	<0.05	-	-	-	0.157	0.008	<0.05
Intersection_SL (mph)	-	-	-	-	-	-	-	-	-
QIC		105.259			72.510			71.574	
QICC		100.079			72.348			70.484	
RMSE		178.202			0.754			1.113	
MAPE		4324%			22%			27%	
MPE		-4228%			-14%			-6%	

Note: Land use categories were considered in per 1,000 square feet.

Table 24. Developed Models for 1-mile Buffer Width – CBD Area

Parameters_1-mile_CBD	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.130	0.104	<0.05	2.241	0.057	<0.05	0.543	0.073	<0.05
[Weekday=1]	0.044	0.007	<0.05	0.041	0.017	<0.05	0.043	0.016	<0.05
[MPP=1]	0.007	0.010	0.497	0.002	0.024	0.928	0.003	0.022	0.878
[OPP=1]	0.016	0.010	0.105	0.014	0.024	0.573	0.017	0.023	0.459
[EPP=1]	0.067	0.012	<0.05	0.067	0.025	<0.05	0.068	0.024	<0.05
Attached Residential	-4.888E-04	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-	-	-	-	-	-	-	-	-
Bank	4.889E-03	<0.001	<0.05	-	-	-	-	-	-
Car Wash	-5.485E-02	0.007	<0.05	-	-	-	-	-	-
Church	-	-	-	-	-	-	-	-	-
Commercial Service	1.458E-03	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	1.918E-02	0.004	<0.05	-	-	-	-8.955E-03	0.003	<0.05
Daycare	1.143E-02	0.002	<0.05	-	-	-	-	-	-
Department Store	-	-	-	2.113E-03	<0.001	<0.05	-	-	-
Fast Food	-	-	-	-	-	-	-	-	-
Funeral Home	2.212E-02	0.003	<0.05	-3.515E-03	0.001	<0.05	-	-	-
Government	3.131E-04	<0.001	<0.05	1.103E-04	<0.001	<0.05	-	-	-
Hospital	-2.173E-04	<0.001	<0.05	-	-	-	-	-	-
Hotel / Motel	7.082E-04	<0.001	<0.05	-	-	-	-	-	-
Industrial	1.074E-01	0.008	<0.05	-	-	-	-	-	-
Industrial Lg	-	-	-	-	-	-	-	-	-
Institutional	-	-	-	-	-	-	-	-	-
Manufactured Home Construction	-	-	-	-	-	-	-	-	-
Manufacturing	-	-	-	-	-	-	-	-	-
Medical	-	-	-	-	-	-	-	-	-
Multi-Family	1.207E-04	<0.001	<0.05	-	-	-	7.344E-05	<0.001	<0.05
Office	-	-	-	-	-	-	-	-	-
Parking Garage	-1.732E-04	<0.001	<0.05	-	-	-	-	-	-
Recreational	-7.025E-03	<0.001	<0.05	-	-	-	-	-	-

Parameters_1-mile_CBD	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
Restaurant	-5.216E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	3.210E-03	<0.001	<0.05	-	-	-	-	-	-
School	-3.445E-04	<0.001	<0.05	-	-	-	-	-	-
Service Garage	1.933E-03	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	2.207E-03	<0.001	<0.05	-	-	-	-	-	-
Single-Family Residential	-2.245E-04	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-3.414E-04	<0.001	<0.05	-	-	-	-	-	-
Supermarket	-2.276E-03	<0.001	<0.05	-1.952E-03	<0.001	<0.05	-	-	-
Truck Terminal	-1.020E-02	0.001	<0.05	-	-	-	-	-	-
Utility	1.443E-03	<0.001	<0.05	-	-	-	-	-	-
Warehouse	-1.798E-04	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	0.236	0.038	<0.05	-	-	-	-0.248	0.017	<0.05
Link_SL (mph)	-	-	-	-0.047	0.001	<0.05	-	-	-
DS_# of Lanes	0.147	0.014	<0.05	-	-	-	-	-	-
DS_SL (mph)	-0.016	0.001	<0.05	-	-	-	-	-	-
US_# of Lanes	0.055	0.010	<0.05	-	-	-	-	-	-
US_SL (mph)	-0.019	0.002	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.112	0.011	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	-0.004	0.001	<0.05	-	-	-	-	-	-
US_Cross street_# of Lanes	-0.092	0.007	<0.05	-	-	-	0.075	0.006	<0.05
US_Cross street_SL (mph)	-0.012	0.002	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	-0.568	0.035	<0.05	-	-	-	0.162	0.008	<0.05
Intersection_SL (mph)	0.051	0.002	<0.05	-	-	-	-	-	-
QIC		97.341			75.244			72.109	
QICC		92.921			73.983			69.645	
RMSE		12.153			0.822			1.119	
MAPE		343%			21%			29%	
MPE		-305%			-9%			-2%	

Note: Land use categories were considered in per 1,000 square feet.

Table 25. Developed Models for 0.5-mile Buffer Width – CBD Fringe Area

Parameters_0.5 miles_OBD	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.412	0.073	<0.05	1.782	0.037	<0.05	0.966	0.027	<0.05
[Weekday=1]	0.083	0.007	<0.05	0.083	0.011	<0.05	0.084	0.012	<0.05
[MPP=1]	0.033	0.008	<0.05	0.034	0.014	<0.05	0.035	0.015	<0.05
[OPP=1]	0.059	0.008	<0.05	0.064	0.015	<0.05	0.064	0.016	<0.05
[EPP=1]	0.139	0.011	<0.05	0.142	0.017	<0.05	0.142	0.018	<0.05
Attached Residential	-3.027E-04	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-	-	-	-	-	-	-	-	-
Bank	2.752E-03	<0.001	<0.05	-	-	-	-	-	-
Car Wash	-2.841E-02	0.003	<0.05	-	-	-	-	-	-
Church	5.105E-04	<0.001	<0.05	-	-	-	-2.012E-04	<0.001	<0.05
Commercial Service	-2.973E-04	<0.001	<0.05	-1.333E-04	<0.001	<0.05	-	-	-
Convenience Store	-9.374E-03	0.002	<0.05	-	-	-	-	-	-
Daycare	-5.286E-03	<0.001	<0.05	-	-	-	-	-	-
Department Store	-1.244E-03	<0.001	<0.05	-	-	-	-	-	-
Fast Food	1.084E-02	0.002	<0.05	-	-	-	9.483E-03	<0.001	<0.05
Funeral Home	-2.060E-02	0.001	<0.05	-	-	-	-	-	-
Government	-3.908E-04	<0.001	<0.05	-	-	-	-1.056E-04	<0.001	<0.05
Hospital	-1.657E-04	<0.001	<0.05	-	-	-	-	-	-
Hotel / Motel	-2.739E-04	<0.001	<0.05	-	-	-	-1.530E-04	<0.001	<0.05
Industrial	-	-	-	-3.171E-02	0.002	<0.05	-6.130E-03	0.002	<0.05
Industrial Lg	8.769E-03	<0.001	<0.05	-	-	-	-	-	-
Institutional	-	-	-	-	-	-	-	-	-
Manufactured Home Construction	-	-	-	-	-	-	-	-	-
Manufacturing	-2.671E-04	<0.001	<0.05	-	-	-	-	-	-
Medical	3.372E-04	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	6.185E-05	<0.001	<0.05	4.328E-05	<0.001	<0.05	-	-	-
Office	-	-	-	3.782E-05	<0.001	<0.05	-	-	-
Parking Garage	1.196E-04	<0.001	<0.05	-	-	-	-	-	-
Recreational	-1.171E-03	<0.001	<0.05	-2.635E-04	<0.001	<0.05	-	-	-

Parameters_0.5 miles_OBD	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
Restaurant	-1.228E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	-2.275E-04	<0.001	<0.05	-	-	-	-	-	-
School	-1.215E-04	<0.001	<0.05	-1.385E-04	<0.001	<0.05	-	-	-
Service Garage	-	-	-	-	-	-	-	-	-
Shopping Mall	7.255E-04	<0.001	<0.05	-	-	-	-	-	-
Single-Family Residential	-6.995E-05	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-1.080E-03	<0.001	<0.05	-	-	-	-9.672E-04	<0.001	<0.05
Supermarket	2.606E-03	<0.001	<0.05	-	-	-	3.260E-03	<0.001	<0.05
Truck Terminal	-7.758E-03	<0.001	<0.05	-	-	-	-	-	-
Utility	-	-	-	-	-	-	-	-	-
Warehouse	2.303E-04	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-0.042	0.014	<0.05	-	-	-	-0.240	0.008	<0.05
Link_SL (mph)	-0.008	0.002	<0.05	-0.033	<0.001	<0.05	-	-	-
DS_# of Lanes	-	-	-	-	-	-	-	-	-
DS_SL (mph)	-	-	-	-	-	-	-	-	-
US_# of Lanes	-	-	-	-	-	-	-	-	-
US_SL (mph)	-0.004	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.098	0.006	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	-0.010	<0.001	<0.05	0.003	<0.001	<0.05	-	-	-
US_Cross street_# of Lanes	-0.054	0.005	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	0.002	<0.001	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	-0.074	0.016	<0.05	-	-	-	-	-	-
Intersection_SL (mph)	0.010	0.001	<0.05	-	-	-	-	-	-
QIC		106.254			74.978			84.415	
QICC		101.985			77.523			83.744	
RMSE		0.642			0.454			0.518	
MAPE		27%			18%			18%	
MPE		2%			-4%			1%	

Note: Land use categories were considered in per 1,000 square feet.

Table 26. Developed Models for 1-mile Buffer Width – CBD Fringe Area

Parameters_1-mile_OBD	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	0.578	0.033	<0.05	1.699	0.038	<0.05	1.129	0.040	<0.05
[Weekday=1]	0.083	0.007	<0.05	0.084	0.011	<0.05	0.085	0.013	<0.05
[MPP=1]	0.034	0.008	<0.05	0.035	0.014	<0.05	0.036	0.017	<0.05
[OPP=1]	0.060	0.008	<0.05	0.065	0.015	<0.05	0.067	0.018	<0.05
[EPP=1]	0.138	0.011	<0.05	0.143	0.016	<0.05	0.144	0.019	<0.05
Attached Residential	-	-	-	-	-	-	-	-	-
Auto Dealer	1.018E-03	<0.001	<0.05	-	-	-	-	-	-
Bank	1.650E-03	<0.001	<0.05	-	-	-	-	-	-
Car Wash	-1.682E-02	0.002	<0.05	-	-	-	-	-	-
Church	5.847E-04	<0.001	<0.05	-	-	-	-	-	-
Commercial Service	-1.061E-03	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	-	-	-	-	-	-	-5.351E-03	<0.001	<0.05
Daycare	-1.796E-03	<0.001	<0.05	7.079E-04	<0.001	<0.05	-	-	-
Department Store	-3.408E-04	<0.001	<0.05	-	-	-	-	-	-
Fast Food	1.239E-02	0.001	<0.05	-	-	-	-	-	-
Funeral Home	-1.947E-02	0.001	<0.05	-	-	-	-	-	-
Government	-2.005E-04	<0.001	<0.05	-	-	-	-	-	-
Hospital	2.359E-04	<0.001	<0.05	-	-	-	-	-	-
Hotel / Motel	-1.415E-04	<0.001	<0.05	-	-	-	-	-	-
Industrial	-9.380E-03	0.001	<0.05	-3.380E-03	<0.001	<0.05	-	-	-
Industrial Lg	1.404E-02	<0.001	<0.05	-	-	-	-4.904E-03	<0.001	<0.05
Institutional	1.152E-04	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-	-	-	-	-	-	-	-	-
Manufacturing	-	-	-	-	-	-	-	-	-
Medical	-5.084E-04	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	5.112E-05	<0.001	<0.05	8.724E-06	<0.001	<0.05	-	-	-
Office	-	-	-	-	-	-	-	-	-
Parking Garage	1.024E-04	<0.001	<0.05	-	-	-	-	-	-
Recreational	-8.340E-04	<0.001	<0.05	-	-	-	-2.167E-04	<0.001	<0.05

Parameters_1-mile_OBD	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
Restaurant	-2.656E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	2.966E-04	<0.001	<0.05	-	-	-	-	-	-
School	-1.560E-04	<0.001	<0.05	-	-	-	-	-	-
Service Garage	1.258E-03	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	-	-	-	1.574E-04	<0.001	<0.05	5.868E-05	<0.001	<0.05
Single-Family Residential	-5.411E-05	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	1.653E-04	<0.001	<0.05	-	-	-	-	-	-
Supermarket	-	-	-	-	-	-	1.397E-03	<0.001	<0.05
Truck Terminal	-1.136E-03	<0.001	<0.05	-6.758E-04	<0.001	<0.05	-	-	-
Utility	-	-	-	-	-	-	-5.860E-04	<0.001	<0.05
Warehouse	-	-	-	-	-	-	-	-	-
Link_# of Lanes	-0.138	0.016	<0.05	-	-	-	-0.272	0.010	<0.05
Link_SL (mph)	-	-	-	-0.033	<0.001	<0.05	-	-	-
DS_# of Lanes	0.067	0.017	<0.05	-	-	-	-	-	-
DS_SL (mph)	-0.007	<0.001	<0.05	-	-	-	-	-	-
US_# of Lanes	-0.163	0.014	<0.05	-	-	-	-	-	-
US_SL (mph)	0.018	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.089	0.006	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	-0.005	<0.001	<0.05	0.003	<0.001	<0.05	-	-	-
US_Cross street_# of Lanes	-0.062	0.005	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-	-	-	-	-	-	-	-	-
Intersection_# of Lanes	-0.142	0.022	<0.05	-	-	-	-	-	-
Intersection_SL (mph)	0.030	0.002	<0.05	-	-	-	-	-	-
QIC		98.804			74.339			94.452	
QICC		100.599			75.255			94.629	
RMSE		0.736			0.507			0.466	
MAPE		26%			22%			18%	
MPE		8%			-8%			-2%	

Note: Land use categories were considered in per 1,000 square feet.

Table 27. Developed Models for 0.5-mile Buffer Width – Urban Area

Parameters_0.5 miles_Urban	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.245	0.043	<0.05	1.859	0.028	<0.05	1.941	0.028	<0.05
[Weekday=1]	0.073	0.005	<0.05	0.074	0.007	<0.05	0.075	0.007	<0.05
[MPP=1]	0.032	0.007	<0.05	0.034	0.009	<0.05	0.034	0.009	<0.05
[OPP=1]	0.035	0.006	<0.05	0.037	0.008	<0.05	0.036	0.008	<0.05
[EPP=1]	0.098	0.008	<0.05	0.100	0.010	<0.05	0.101	0.010	<0.05
Attached Residential	2.569E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-	-	-	-	-	-	-	-	-
Bank	3.634E-03	<0.001	<0.05	2.464E-03	<0.001	<0.05	-	-	-
Car Wash	8.058E-03	0.001	<0.05	-	-	-	-	-	-
Church	-	-	-	-	-	-	-	-	-
Commercial Service	-3.580E-04	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	5.623E-03	<0.001	<0.05	7.484E-03	<0.001	<0.05	-	-	-
Daycare	-1.576E-03	<0.001	<0.05	-	-	-	-	-	-
Department Store	-6.908E-04	<0.001	<0.05	-	-	-	-	-	-
Fast Food	2.636E-03	<0.001	<0.05	-	-	-	2.635E-03	<0.001	<0.05
Funeral Home	1.304E-03	<0.001	<0.05	-	-	-	1.178E-03	<0.001	<0.05
Government	2.019E-04	<0.001	<0.05	-	-	-	1.055E-04	<0.001	<0.05
Hospital	2.879E-04	<0.001	<0.05	2.848E-04	<0.001	<0.05	2.265E-04	<0.001	<0.05
Hotel / Motel	-	-	-	-5.114E-05	<0.001	<0.05	-	-	-
Industrial	-1.086E-03	<0.001	<0.05	-2.524E-03	<0.001	<0.05	-3.738E-03	<0.001	<0.05
Industrial Lg	-9.646E-04	<0.001	<0.05	2.010E-03	<0.001	<0.05	-	-	-
Institutional	-1.010E-04	<0.001	<0.05	-5.418E-04	<0.001	<0.05	-5.090E-04	<0.001	<0.05
Manufactured Home Construction	-3.696E-03	<0.001	<0.05	-5.155E-03	<0.001	<0.05	-3.607E-03	<0.001	<0.05
Manufacturing	-	-	-	-2.884E-04	<0.001	<0.05	-3.023E-04	<0.001	<0.05
Medical	-	-	-	-	-	-	5.603E-04	<0.001	<0.05
Multi-Family	-5.117E-05	<0.001	<0.05	-	-	-	1.098E-05	<0.001	<0.05
Office	-4.696E-05	<0.001	<0.05	-	-	-	-	-	-
Parking Garage	1.190E-04	<0.001	<0.05	-	-	-	-	-	-
Recreational	-	-	-	-2.156E-04	<0.001	<0.05	-	-	-

Parameters_0.5 miles_Urban	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
Restaurant	2.623E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	-	-	-	1.860E-04	<0.001	<0.05	-	-	-
School	-	-	-	-1.083E-04	<0.001	<0.05	-	-	-
Service Garage	-	-	-	-	-	-	-	-	-
Shopping Mall	-1.771E-04	<0.001	<0.05	-	-	-	-	-	-
Single-Family Residential	-4.473E-05	<0.001	<0.05	-	-	-	-2.909E-05	<0.001	<0.05
Stadium /Arena	1.670E-04	<0.001	<0.05	4.065E-05	<0.001	<0.05	5.243E-05	<0.001	<0.05
Supermarket	3.705E-04	<0.001	<0.05	-	-	-	-	-	-
Truck Terminal	4.777E-04	<0.001	<0.05	-	-	-	8.314E-05	<0.001	<0.05
Utility	-1.917E-03	<0.001	<0.05	-	-	-	-	-	-
Warehouse	-8.469E-05	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-0.056	0.008	<0.05	-	-	-	-	-	-
Link_SL (mph)	-0.014	<0.001	<0.05	-0.032	<0.001	<0.05	-0.032	<0.001	<0.05
DS_# of Lanes	-	-	-	-	-	-	-	-	-
DS_SL (mph)	-	-	-	-	-	-	-	-	-
US_# of Lanes	-0.063	0.009	<0.05	-	-	-	-	-	-
US_SL (mph)	0.004	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.025	0.003	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	-	-	-	-	-	-	-	-	-
US_Cross street_# of Lanes	0.027	0.003	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.005	<0.001	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	-	-	-	-	-	-	-	-	-
Intersection_SL (mph)	0.003	<0.001	<0.05	-	-	-	-	-	-
QIC		127.621			112.092			114.028	
QICC		122.710			117.490			115.414	
RMSE		0.336			0.459			0.352	
MAPE		15%			16%			15%	
MPE		-5%			-6%			-4%	

Note: Land use categories were considered in per 1,000 square feet.

Table 28. Developed Models for 1-mile Buffer Width – Urban Area

Parameters_1-mile_Urban	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.267	0.044	<0.05	1.848	0.030	<0.05	0.741	0.021	<0.05
[Weekday=1]	0.073	0.005	<0.05	0.076	0.008	<0.05	0.076	0.008	<0.05
[MPP=1]	0.033	0.007	<0.05	0.035	0.010	<0.05	0.035	0.010	<0.05
[OPP=1]	0.035	0.006	<0.05	0.037	0.009	<0.05	0.038	0.010	<0.05
[EPP=1]	0.097	0.008	<0.05	0.103	0.011	<0.05	0.103	0.012	<0.05
Attached Residential	1.977E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-1.077E-04	<0.001	<0.05	-	-	-	-	-	-
Bank	2.113E-03	<0.001	<0.05	-	-	-	-	-	-
Car Wash	-	-	-	-	-	-	-	-	-
Church	-	-	-	-	-	-	-	-	-
Commercial Service	-3.590E-04	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	6.054E-03	<0.001	<0.05	-	-	-	4.988E-03	<0.001	<0.05
Daycare	-2.526E-03	<0.001	<0.05	-	-	-	-	-	-
Department Store	-3.346E-04	<0.001	<0.05	-	-	-	6.520E-05	<0.001	<0.05
Fast Food	-	-	-	2.821E-03	<0.001	<0.05	-	-	-
Funeral Home	-	-	-	-	-	-	1.255E-03	<0.001	<0.05
Government	2.516E-04	<0.001	<0.05	-	-	-	-	-	-
Hospital	3.393E-05	<0.001	<0.05	-	-	-	-	-	-
Hotel / Motel	-7.994E-05	<0.001	<0.05	-	-	-	-	-	-
Industrial	-1.741E-03	<0.001	<0.05	-	-	-	-	-	-
Industrial Lg	4.788E-04	<0.001	<0.05	-3.708E-04	<0.001	<0.05	-	-	-
Institutional	-3.557E-04	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-1.636E-03	<0.001	<0.05	-	-	-	-2.067E-03	<0.001	<0.05
Manufacturing	1.348E-04	<0.001	<0.05	-4.670E-05	<0.001	<0.05	-	-	-
Medical	-	-	-	-	-	-	-	-	-
Multi-Family	-1.934E-05	<0.001	<0.05	7.699E-06	<0.001	<0.05	-	-	-
Office	5.017E-05	<0.001	<0.05	-	-	-	-1.724E-05	<0.001	<0.05
Parking Garage	-	-	-	-7.257E-06	<0.001	<0.05	-	-	-
Recreational	-	-	-	-	-	-	4.215E-04	<0.001	<0.05

Parameters_1-mile_Urban	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
Restaurant	-8.503E-04	<0.001	<0.05	-	-	-	-	-	-
Retail	1.958E-04	<0.001	<0.05	-	-	-	3.705E-05	<0.001	<0.05
School	1.380E-04	<0.001	<0.05	-1.126E-04	<0.001	<0.05	-	-	-
Service Garage	2.125E-04	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	-	-	-	-	-	-	-	-	-
Single-Family Residential	-2.886E-05	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-6.633E-05	<0.001	<0.05	-	-	-	-	-	-
Supermarket	4.608E-04	<0.001	<0.05	-	-	-	5.028E-04	<0.001	<0.05
Truck Terminal	2.451E-04	<0.001	<0.05	-	-	-	-	-	-
Utility	-3.566E-03	<0.001	<0.05	-	-	-	-	-	-
Warehouse	-6.173E-05	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-0.037	0.008	<0.05	-	-	-	-0.223	0.005	<0.05
Link_SL (mph)	-0.015	<0.001	<0.05	-0.031	<0.001	<0.05	-	-	-
DS_# of Lanes	-	-	-	-	-	-	-	-	-
DS_SL (mph)	-	-	-	-	-	-	-	-	-
US_# of Lanes	-0.089	0.009	<0.05	-	-	-	-	-	-
US_SL (mph)	0.004	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.033	0.003	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	-	-	-	-	-	-	0.001	<0.001	<0.05
US_Cross street_# of Lanes	0.026	0.003	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.004	<0.001	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	-	-	-	-	-	-	-	-	-
Intersection_SL (mph)	0.005	<0.001	<0.05	-	-	-	-	-	-
QIC		119.963			118.939			133.508	
QICC		125.287			118.226			132.035	
RMSE		0.318			0.317			0.366	
MAPE		14%			14%			18%	
MPE		-5%			-5%			-7%	

Note: Land use categories were considered in per 1,000 square feet.

Table 29. Performance of Developed Models by Area Type – Summary

Buffer Width	Models	Parameters	Backward Elimination	Model 1	Model 2
0.5 Miles	CBD	QIC	105.259	72.510	71.574
		QICC	100.079	72.348	70.484
		RMSE	178.202	0.754	1.113
		MAPE	4324%	22%	27%
		MPE	-4228%	-14%	-6%
	CBD Fringe / OBD	QIC	106.254	74.978	84.415
		QICC	101.985	77.523	83.744
		RMSE	0.642	0.454	0.518
		MAPE	27%	18%	18%
		MPE	2%	-4%	1%
	Urban	QIC	127.621	112.092	114.028
		QICC	122.710	117.490	115.414
		RMSE	0.336	0.459	0.352
		MAPE	15%	16%	15%
		MPE	-5%	-6%	-4%
1 mile	CBD	QIC	97.341	75.244	72.109
		QICC	92.921	73.983	69.645
		RMSE	12.153	0.822	1.119
		MAPE	343%	21%	29%
		MPE	-305%	-9%	-2%
	CBD Fringe / OBD	QIC	98.804	74.339	94.452
		QICC	100.599	75.255	94.629
		RMSE	0.736	0.507	0.466
		MAPE	26%	22%	18%
		MPE	8%	-8%	-2%
	Urban	QIC	119.963	118.939	133.508
		QICC	125.287	118.226	132.035
		RMSE	0.318	0.317	0.366
		MAPE	14%	14%	18%
		MPE	-5%	-5%	-7%

DISCUSSION RELATED TO THE DEVELOPED MODELS BY AREA TYPE

In all the developed models by area type, an increase in the speed limit of the selected link decreases ATT. In the CBD area, an increase in the area occupied by multi-family residential type land use within 0.5 miles and within 1 mile from a link increases ATT (Table 30). However, in the CBD area, an increase in the area occupied by supermarkets within 0.5 miles and within 1 mile from a link decreases ATT.

Likewise, in the CBD Fringe / OBD area, an increase in the area occupied by multi-family or supermarket type land uses within 0.5 miles and within 1 mile from a link increases ATT (Table 31). However, in the CBD Fringe / OBD area, an increase in the area occupied by industrial or recreational type land uses within 0.5 miles and within 1 mile from a link decreases ATT.

Similarly, in the urban area, an increase in the area occupied by a convenience store, fast food, funeral home, multi-family, and retail type land uses within 0.5 miles and within 1 mile from a link increases ATT (Table 32). However, in the urban area, an increase in with the area occupied by manufactured home construction, manufacturing, and school type land uses within 0.5 miles and within 1 mile from a link decreases ATT. Furthermore, in the urban area, an increase in the area occupied by recreational type land use within 0.5 miles from a link decreases ATT; however, within 1 mile from a link, an increase in the area occupied by recreational type land use increases ATT. Likewise, an increase in the area occupied by large industrial type land use within 0.5 miles from a link increases ATT; however, within 1 mile from a link, an increase in the area occupied by large industrial type land use decreases ATT.

Furthermore, the developed backward elimination model for the CBD area should not be used for estimating the ATT due to high errors in the validation results. Based on QIC, QICC, RMSE and MAPE, for models by area type, the 1 mile buffer model was observed to be a better fit than the 0.5 mile buffer width model (lower QIC and QICC, lower difference between QIC to QICC, lower RMSE and MAPE), for explaining the relationship between the land use developments and the ATT. Furthermore, for each of the area type, Model 1 was observed to be the better fit to estimate the ATT compared to other models (Table 29).

Table 30. Comparison of Developed Models for the CBD Area

Parameters_CBD	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	N	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	P	P	P	P	P	P
[EPP=1]	P	P	P	P	P	P
Attached Residential	P			N		
Auto Dealer						
Bank	P			P		
Car Wash	P			N		
Church	P					
Commercial Service	N			P		
Convenience Store	P			P		N
Daycare	P			P		
Department Store	N				P	
Fast Food	P					
Funeral Home	N			P	N	
Government	N			P	P	
Hospital	P			N		
Hotel / Motel	P			P		
Industrial	P		N	P		
Industrial Lg						
Institutional	N					

Parameters_CBD	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
Manufactured Home Construction						
Manufacturing	P					
Medical	N					
Multi-Family	P		P	P		P
Office	P	P				
Parking Garage				N		
Recreational	N			N		
Restaurant	N			N		
Retail	P			P		
School	N			N		
Service Garage	P			P		
Shopping Mall	P			P		
Single-Family Residential	P			N		
Stadium /Arena				N		
Supermarket	N	N		N	N	
Truck Terminal	N			N		
Utility	P			P		
Warehouse	N	N		N		
Link_# of Lanes	P		N	P		N
Link_SL (mph)	N	N			N	
DS_# of Lanes	P			P		
DS_SL (mph)	N			N		
US_# of Lanes	N			P		
US_SL (mph)	P			N		
DS_Cross street_# of Lanes	P			P		
DS_Cross street_SL (mph)	N	P		N		
US_Cross street_# of Lanes			P	N		P
US_Cross street_SL (mph)	N			N		
Intersection_# of Lanes	P		P	N		P
Intersection_SL (mph)				P		

Table 31. Comparison of Developed Models for the CBD Fringe / OBD Area

Parameters_OBD	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	P	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	P	P	P	P	P	P
[EPP=1]	P	P	P	P	P	P
Attached Residential	N					
Auto Dealer				P		
Bank	P			P		
Car Wash	N			N		
Church	P		N	P		
Commercial Service	N	N		N		
Convenience Store	N					N
Daycare	N			N	P	
Department Store	N			N		
Fast Food	P		P	P		
Funeral Home	N			N		
Government	N		N	N		
Hospital	N			P		
Hotel / Motel	N		N	N		
Industrial		N	N	N	N	
Industrial Lg	P			P		N
Institutional				P		
Manufactured Home Construction						
Manufacturing	N					
Medical	P			N		
Multi-Family	P	P		P	P	
Office		P				
Parking Garage	P			P		
Recreational	N	N		N		N
Restaurant	N			N		
Retail	N			P		
School	N	N		N		
Service Garage				P		
Shopping Mall	P				P	P
Single-Family Residential	N			N		
Stadium /Arena	N		N	P		
Supermarket	P		P			P
Truck Terminal	N			N	N	
Utility						N
Warehouse	P					
Link_# of Lanes	N		N	N		N
Link_SL (mph)	N	N			N	
DS_# of Lanes				P		

Parameters_OBD	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
DS_SL (mph)				N		
US_# of Lanes				N		
US_SL (mph)	N			P		
DS_Cross street_# of Lanes	P			P		
DS_Cross street_SL (mph)	N	P		N	P	
US_Cross street_# of Lanes	N			N		
US_Cross street_SL (mph)	P					
Intersection_# of Lanes	N			N		
Intersection_SL (mph)	P			P		

Table 32. Comparison of Developed Models for the Urban Area

Parameters_Urban	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	P	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	P	P	P	P	P	P
[EPP=1]	P	P	P	P	P	P
Attached Residential	P			P		
Auto Dealer				N		
Bank	P	P		P		
Car Wash	P					
Church						
Commercial Service	N			N		
Convenience Store	P	P		P		P
Daycare	N			N		
Department Store	N			N		P
Fast Food	P		P		P	
Funeral Home	P		P			P
Government	P		P	P		
Hospital	P	P	P	P		
Hotel / Motel		N		N		
Industrial	N	N	N	N		
Industrial Lg	N	P		P	N	
Institutional	N	N	N	N		
Manufactured Home Construction	N	N	N	N		N
Manufacturing		N	N	P	N	
Medical			P			
Multi-Family	N		P	N	P	
Office	N			P		N
Parking Garage	P				N	

Parameters_Urban	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
Recreational		N				P
Restaurant	P			N		
Retail		P		P		P
School		N		P	N	
Service Garage				P		
Shopping Mall	N					
Single-Family Residential	N		N	N		
Stadium /Arena	P	P	P	N		
Supermarket	P			P		P
Truck Terminal	P		P	P		
Utility	N			N		
Warehouse	N			N		
Link_# of Lanes	N			N		N
Link_SL (mph)	N	N	N	N	N	
DS_# of Lanes						
DS_SL (mph)						
US_# of Lanes	N			N		
US_SL (mph)	P			P		
DS_Cross street_# of Lanes	P			P		
DS_Cross street_SL (mph)						P
US_Cross street_# of Lanes	P			P		
US_Cross street_SL (mph)	N			N		
Intersection_# of Lanes						
Intersection_SL (mph)	P			P		

VIII. STATISTICAL MODELS BY SPEED LIMIT

This chapter presents the results obtained from the statistical models developed to examine the relationship between ATT and land use characteristics by the speed limit.

In this step, the selected links were classified into three categories (less than 45 mph, between 45 to 50 mph and greater than 50 mph) based on the speed limit. Eighteen models were developed based on the speed limit datasets. As 0.5 miles and 1-mile buffer widths were observed to be suitable for analyzing the influence of proximal land use developments on ATT, the models were developed using only 0.5-mile and 1-mile buffer width datasets. Similarly, to the earlier procedure, for each buffer width and speed limit classification, a model is developed using the backward elimination method. Model 1 and Model 2 were then developed by avoiding the multicollinearity between the predictor variables. Pearson correlation matrices by the speed limit dataset are presented in Appendix A (Table A12 to Table A17). The selection of predictor variables by buffer width and speed limit categories are summarized in Table 33 and Table 34. The backward elimination models can be used for estimating ATT. However, the influence of critical predictor variables on ATT is interpreted using Model 1 and Model 2. Each of the developed models by the speed limit is discussed in turn, next.

SPEED LIMIT < 45 MPH

In all the developed models (0.5 miles and 1-mile buffer widths), the coefficients of TOD and DOW are consistent with each other (Table 35 and Table 36). The results obtained indicate that, compared to the weekend, ATT is higher on weekdays when all the other variables are held constant. In addition, ATT is higher during the evening peak period when compared to the morning peak period and the afternoon off-peak period, when all the other variables are held constant. The results obtained indicate that the speed limit of the selected link has a negative influence on ATT. However, the number of lanes of the downstream cross street and the intersecting links, and the speed limit of intersecting links have a positive influence on ATT.

The Model 1 and Model 2 developed with the 0.5-mile buffer width dataset, for the speed limit less than 45 mph category, indicate that commercial service, multi-family, school, hospital, or stadium/arena type land uses have a positive influence on ATT (Table 35). However, auto dealer, daycare, funeral home, industrial, manufactured home construction, supermarket, or shopping mall type land uses have a negative influence on the ATT.

The Model 1 and Model 2 developed with the 1-mile buffer width dataset, for the speed limit less than 45 mph category, indicate that multi-family, school, fast food, office, or warehouse type land uses have a positive influence on ATT (Table 36). However, convenience store, department store, funeral home, auto dealer, or daycare type land uses have a negative influence on ATT.

SPEED LIMIT BETWEEN 45 TO 50 MPH

Similarly, to the models developed by selecting the links with a speed limit less than 45 mph, the coefficients of TOD and DOW are consistent with each other in all the models developed by selecting the links with a speed limit between 45 to 50 mph (Table 37 and Table 38). Also, DOW and TOD interpretations are similar to the models developed by selecting the links with a speed limit less than 45 mph. The results obtained indicate that the speed limits of the selected link and of the upstream link have a negative influence on ATT. However, the speed limit of the downstream link has a positive influence on ATT.

The Model 1 and Model 2 developed with the 0.5 mile buffer width dataset, for the speed limit between 45 to 50 mph category, indicate that fast food, hotel/motel, medical, utility, convenience store, or department store type land uses have a positive influence on ATT (Table 37). However, church, government, industrial, manufacturing, recreational, commercial store, hospital, manufactured home construction, multi-family, or school type land uses have a negative influence on ATT.

The Model 1 and Model 2 developed with the 1-mile buffer width dataset, for the speed limit between 45 to 50 mph category, indicate that medical store, shopping mall, convenience store, department store, or supermarket type land uses have a positive influence on ATT (Table 38). However, daycare, industrial, manufactured home construction, recreational, government, hospital, or multi-family type land uses have a negative influence on ATT.

SPEED LIMIT GREATER THAN 50 MPH

Similarly, to the models developed by selecting the links with the speed limit less than 45 mph, the coefficients of TOD and DOW are consistent with each other in all the models developed by selecting the links with the speed limit greater than 50 mph category (Table 39 and Table 40). Also, DOW and TOD interpretations are similar to the models developed by selecting the links with the speed limit less than 45 mph category. The results obtained indicate that the number of lanes and the speed limit of the selected link have a negative influence on ATT.

The Model 1 and Model 2 developed with the 0.5-mile buffer width dataset, for the speed limit greater than 50 mph category, indicates that institutional, commercial service, hospital, and manufacturing type land uses have a positive influence on ATT (Table 39). However, auto dealer, manufactured home construction, shopping mall, or supermarket type land uses have a negative influence on ATT.

The Model 1 and Model 2 developed with the 1-mile buffer width dataset, for the speed limit greater than 50 mph category, indicates that commercial service or industrial type land uses have a positive influence on the ATT (Table 40). However, manufactured home construction, shopping mall, or supermarket type land uses have a negative influence on ATT.

Each of the developed models was validated by randomly selecting 23 links with a speed limit less than 45 mph, 23 links with a speed limit between 45 to 50 mph, and 7 links with a speed limit greater than 50 mph. These links were not considered for model development.

A summary of all the developed models by buffer width and a speed limit is presented in Table 41. The backward elimination models for speed limit greater than 50 mph underperformed, compared to the models developed by checking the multicollinearity, based on the QIC, QICC, RMSE, and MAPE. Also, in all the developed models, the predicted ATT was higher than the actual ATT (negative MPE).

Table 33. Predictor Variables Selected to Develop Models by Speed Limit – 0.5-mile Buffer Width

Parameters_0.5 miles	< 45 mph		45 - 50 mph		> 50 mph	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
[Weekday=1]	√	√	√	√	√	√
[MPP=1]	√	√	√	√	√	√
[OPP=1]	√	√	√	√	√	√
[EPP=1]	√	√	√	√	√	√
Attached Residential						
Auto Dealer	√		√			√
Bank						
Car Wash						
Church		√	√			
Commercial Service	√			√		√
Convenience Store	√			√		
Daycare	√	√				
Department Store				√		
Fast Food			√			
Funeral Home	√					
Government			√			
Hospital		√		√		√
Hotel / Motel			√			
Industrial	√		√	√	√	
Industrial Lg						
Institutional					√	
Manufactured Home Construction	√	√		√		√
Manufacturing	√		√	√		√
Medical			√			√
Multi-Family	√			√		
Office						
Parking Garage						
Recreational			√			
Restaurant						
Retail						
School	√	√		√		
Service Garage						
Shopping Mall		√			√	√
Single-Family Residential						
Stadium /Arena		√		√		

Parameters_0.5 miles	< 45 mph		45 - 50 mph		> 50 mph	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Supermarket	√			√	√	
Truck Terminal				√	√	
Utility			√	√		
Warehouse		√				
Link_# of Lanes				√	√	
Link_SL (mph)	√	√	√			√
DS_# of Lanes						
DS_SL (mph)	√	√	√			
US_# of Lanes						
US_SL (mph)			√			
DS_Cross street_# of Lanes	√			√		
DS_Cross street_SL (mph)						
US_Cross street_# of Lanes	√			√	√	
US_Cross street_SL (mph)		√				
Intersection_# of Lanes	√					
Intersection_SL (mph)		√				

Table 34. Predictor Variables Selected to Develop Models by Speed Limit – 1-mile Buffer Width

Parameters_1-mile	< 45 mph		45 - 50 mph		> 50 mph	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
[Weekday=1]	√	√	√	√	√	√
[MPP=1]	√	√	√	√	√	√
[OPP=1]	√	√	√	√	√	√
[EPP=1]	√	√	√	√	√	√
Attached Residential						
Auto Dealer		√	√			√
Bank						
Car Wash						
Church						
Commercial Service					√	
Convenience Store	√			√		
Daycare		√	√			
Department Store	√			√		
Fast Food		√				
Funeral Home	√					
Government				√		
Hospital				√		
Hotel / Motel						
Industrial			√	√	√	√
Industrial Lg	√	√				
Institutional						√

Parameters_1-mile	< 45 mph		45 - 50 mph		> 50 mph	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Manufactured Home Construction			√	√	√	
Manufacturing						
Medical			√			
Multi-Family	√			√		
Office		√				
Parking Garage						
Recreational			√			
Restaurant						
Retail						
School	√	√				
Service Garage			√		√	
Shopping Mall			√		√	√
Single-Family Residential						
Stadium /Arena						
Supermarket			√	√		√
Truck Terminal	√					
Utility						
Warehouse		√				
Link_# of Lanes						√
Link_SL (mph)	√	√	√		√	
DS_# of Lanes		√				
DS_SL (mph)			√	√		
US_# of Lanes						
US_SL (mph)			√	√		
DS_Cross street_# of Lanes	√	√				√
DS_Cross street_SL (mph)					√	
US_Cross street_# of Lanes		√				
US_Cross street_SL (mph)				√		
Intersection_# of Lanes		√				
Intersection_SL (mph)	√					

Table 35. Developed Models for 0.5-mile Buffer Width – Speed Limit < 45 mph

Parameters_0.5 miles_< 45 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	-0.121	0.121	0.319	0.896	0.102	<0.05	1.254	0.083	<0.05
[Weekday=1]	0.040	0.006	<0.05	0.040	0.008	<0.05	0.040	0.008	<0.05
[MPP=1]	0.019	0.008	<0.05	0.018	0.011	0.096	0.019	0.012	0.105
[OPP=1]	0.034	0.008	<0.05	0.034	0.011	<0.05	0.035	0.012	<0.05
[EPP=1]	0.068	0.009	<0.05	0.069	0.012	<0.05	0.069	0.012	<0.05
Attached Residential	-2.010E-04	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-3.269E-03	<0.001	<0.05	-9.374E-04	<0.001	<0.05	-	-	-
Bank	2.219E-04	<0.001	<0.05	-	-	-	-	-	-
Car Wash	1.333E-02	0.002	<0.05	-	-	-	-	-	-
Church	1.286E-04	<0.001	<0.05	-	-	-	-	-	-
Commercial Service	-2.524E-04	<0.001	<0.05	3.028E-04	<0.001	<0.05	-	-	-
Convenience Store	-	-	-	-	-	-	-	-	-
Daycare	-4.381E-03	<0.001	<0.05	-2.607E-03	<0.001	<0.05	-	-	-
Department Store	-3.051E-04	<0.001	<0.05	-	-	-	-	-	-
Fast Food	-	-	-	-	-	-	-	-	-
Funeral Home	-1.484E-03	<0.001	<0.05	-4.843E-03	<0.001	<0.05	-	-	-
Government	-	-	-	-	-	-	-	-	-
Hospital	8.641E-05	<0.001	<0.05	-	-	-	5.914E-05	<0.001	<0.05
Hotel / Motel	-5.230E-05	<0.001	<0.05	-	-	-	-	-	-
Industrial	-2.009E-03	<0.001	<0.05	-1.804E-03	<0.001	<0.05	-	-	-
Industrial Lg	-	-	-	-	-	-	-	-	-
Institutional	-7.359E-05	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-5.389E-02	0.005	<0.05	-3.709E-02	0.005	<0.05	-4.537E-02	0.005	<0.05
Manufacturing	-	-	-	-	-	-	-	-	-
Medical	-1.476E-04	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	7.454E-05	<0.001	<0.05	1.067E-04	<0.001	<0.05	-	-	-
Office	-	-	-	-	-	-	-	-	-
Parking Garage	8.831E-05	<0.001	<0.05	-	-	-	-	-	-
Recreational	-7.121E-04	<0.001	<0.05	-	-	-	-	-	-

Parameters_0.5 miles_< 45 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
Restaurant	1.290E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	-4.374E-04	<0.001	<0.05	-	-	-	-	-	-
School	1.578E-04	<0.001	<0.05	1.277E-04	<0.001	<0.05	7.742E-05	<0.001	<0.05
Service Garage	-9.013E-04	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	-2.454E-04	<0.001	<0.05	-	-	-	-4.409E-05	<0.001	<0.05
Single-Family Residential	-5.397E-05	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-	-	-	-	-	-	1.805E-04	<0.001	<0.05
Supermarket	2.511E-03	<0.001	<0.05	-7.077E-04	<0.001	<0.05	-	-	-
Truck Terminal	9.218E-04	<0.001	<0.05	-	-	-	-	-	-
Utility	-3.797E-03	<0.001	<0.05	-	-	-	-	-	-
Warehouse	2.788E-05	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-	-	-	-	-	-	-	-	-
Link_SL (mph)	0.021	0.003	<0.05	-0.010	0.003	<0.05	-0.018	0.002	<0.05
DS_# of Lanes	-	-	-	-	-	-	-	-	-
DS_SL (mph)	-0.004	<0.001	<0.05	-0.002	<0.001	<0.05	-0.002	<0.001	<0.05
US_# of Lanes	-0.025	0.004	<0.05	-	-	-	-	-	-
US_SL (mph)	-	-	-	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.030	0.003	<0.05	0.028	0.003	<0.05	-	-	-
DS_Cross street_SL (mph)	0.004	<0.001	<0.05	-	-	-	-	-	-
US_Cross street_# of Lanes	-0.023	0.003	<0.05	-0.009	0.004	<0.05	-	-	-
US_Cross street_SL (mph)	0.003	<0.001	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	-	-	-	0.039	0.006	<0.05	-	-	-
Intersection_SL (mph)	0.004	<0.001	<0.05	-	-	-	0.006	<0.001	<0.05
QIC		122.583			102.280			102.412	
QICC		118.660			101.107			98.832	
RMSE		0.657			0.584			0.644	
MAPE		19%			16%			17%	
MPE		-6%			-4%			-2%	

Note: Land use categories were considered in per 1,000 square feet.

Table 36. Developed Models for 1-mile Buffer Width – Speed Limit < 45 mph

Parameters_1-mile_ < 45 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	1.087	0.088	<0.05	1.278	0.098	<0.05	1.298	0.088	<0.05
[Weekday=1]	0.040	0.006	<0.05	0.040	0.009	<0.05	0.039	0.009	<0.05
[MPP=1]	0.018	0.008	<0.05	0.019	0.012	0.108	0.017	0.012	0.159
[OPP=1]	0.034	0.008	<0.05	0.035	0.012	<0.05	0.034	0.012	<0.05
[EPP=1]	0.067	0.009	<0.05	0.070	0.012	<0.05	0.069	0.013	<0.05
Attached Residential	8.398E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-7.447E-04	<0.001	<0.05	-	-	-	-1.107E-03	<0.001	<0.05
Bank	-3.273E-04	<0.001	<0.05	-	-	-	-	-	-
Car Wash	-1.417E-02	0.001	<0.05	-	-	-	-	-	-
Church	-1.627E-04	<0.001	<0.05	-	-	-	-	-	-
Commercial Service	-	-	-	-	-	-	-	-	-
Convenience Store	1.113E-02	<0.001	<0.05	-1.523E-03	<0.001	<0.05	-	-	-
Daycare	-	-	-	-	-	-	-4.639E-04	<0.001	<0.05
Department Store	-1.364E-04	<0.001	<0.05	-9.646E-05	<0.001	<0.05	-	-	-
Fast Food	-2.076E-03	<0.001	<0.05	-	-	-	5.372E-03	<0.001	<0.05
Funeral Home	-8.373E-03	<0.001	<0.05	-3.131E-03	<0.001	<0.05	-	-	-
Government	3.871E-05	<0.001	<0.05	-	-	-	-	-	-
Hospital	-1.412E-04	<0.001	<0.05	-	-	-	-	-	-
Hotel / Motel	1.664E-04	<0.001	<0.05	-	-	-	-	-	-
Industrial	-1.706E-03	<0.001	<0.05	-	-	-	-	-	-
Industrial Lg	-1.525E-03	<0.001	<0.05	-	-	-	-	-	-
Institutional	-	-	-	-	-	-	-	-	-
Manufactured Home Construction	-	-	-	-	-	-	-	-	-
Manufacturing	-2.977E-04	<0.001	<0.05	-	-	-	-	-	-
Medical	-	-	-	-	-	-	-	-	-
Multi-Family	5.092E-05	<0.001	<0.05	6.420E-05	<0.001	<0.05	-	-	-
Office	-4.158E-05	<0.001	<0.05	-	-	-	1.879E-05	<0.001	<0.05
Parking Garage	6.300E-05	<0.001	<0.05	-	-	-	-	-	-
Recreational	-5.772E-04	<0.001	<0.05	-	-	-	-	-	-

Parameters_1-mile_ < 45 mph	**Backward Elimination**			**Model 1**			**Model 2**		
	Coeff.	**Std. Error**	**p-value**	**Coeff.**	**Std. Error**	**p-value**	**Coeff.**	**Std. Error**	**p-value**
Restaurant	3.010E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	-3.356E-04	<0.001	<0.05	-	-	-	-	-	-
School	1.417E-04	<0.001	<0.05	8.063E-05	<0.001	<0.05	3.367E-05	<0.001	<0.05
Service Garage	-1.970E-04	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	-2.629E-04	<0.001	<0.05	-	-	-	-	-	-
Single-Family Residential	-2.446E-05	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-1.893E-04	<0.001	<0.05	-	-	-	-	-	-
Supermarket	6.830E-04	<0.001	<0.05	-	-	-	-	-	-
Truck Terminal	-	-	-	-	-	-	-	-	-
Utility	2.226E-03	<0.001	<0.05	-	-	-	-	-	-
Warehouse	1.701E-05	<0.001	<0.05	-	-	-	4.768E-06	<0.001	<0.05
Link_# of Lanes	0.024	0.010	<0.05	-	-	-	-	-	-
Link_SL (mph)	-0.020	0.002	<0.05	-0.030	0.003	<0.05	-0.026	0.002	<0.05
DS_# of Lanes	0.034	0.008	<0.05	-	-	-	-0.033	0.006	<0.05
DS_SL (mph)	-0.007	<0.001	<0.05	-	-	-	-	-	-
US_# of Lanes	-0.029	0.007	<0.05	-	-	-	-	-	-
US_SL (mph)	0.003	<0.001	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	0.018	0.003	<0.05	0.043	0.003	<0.05	0.022	0.003	<0.05
DS_Cross street_SL (mph)	0.006	<0.001	<0.05	-	-	-	-	-	-
US_Cross street_# of Lanes	-0.015	0.003	<0.05	-	-	-	0.010	0.004	<0.05
US_Cross street_SL (mph)	-	-	-	-	-	-	-	-	-
Intersection_# of Lanes	-	-	-	-	-	-	0.062	0.007	<0.05
Intersection_SL (mph)	0.006	<0.001	<0.05	0.006	<0.001	<0.05	-	-	-
QIC		124.583			100.831			111.057	
QICC		124.024			98.406			109.730	
RMSE		0.747			0.585			0.685	
MAPE		23%			17%			19%	
MPE		-5%			-2%			-4%	

Note: Land use categories were considered in per 1,000 square feet.

Table 37. Developed Models for 0.5-mile Buffer Width – Speed Limit 45 to 50 mph

Parameters_0.5 miles_45to50 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	2.596	0.194	<0.05	3.985	0.127	<0.05	0.459	0.025	<0.05
[Weekday=1]	0.095	0.006	<0.05	0.096	0.008	<0.05	0.095	0.008	<0.05
[MPP=1]	0.041	0.008	<0.05	0.042	0.010	<0.05	0.043	0.010	<0.05
[OPP=1]	0.052	0.007	<0.05	0.054	0.010	<0.05	0.054	0.009	<0.05
[EPP=1]	0.135	0.010	<0.05	0.138	0.012	<0.05	0.136	0.011	<0.05
Attached Residential	-8.183E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-	-	-	-	-	-	-	-	-
Bank	-	-	-	-	-	-	-	-	-
Car Wash	4.844E-03	0.001	<0.05	-	-	-	-	-	-
Church	-	-	-	-1.823E-04	<0.001	<0.05	-	-	-
Commercial Service	-3.005E-04	<0.001	<0.05	-	-	-	-3.346E-04	<0.001	<0.05
Convenience Store	5.967E-03	<0.001	<0.05	-	-	-	8.581E-03	<0.001	<0.05
Daycare	-1.850E-03	<0.001	<0.05	-	-	-	-	-	-
Department Store	-5.769E-04	<0.001	<0.05	-	-	-	1.706E-04	<0.001	<0.05
Fast Food	-	-	-	1.992E-03	<0.001	<0.05	-	-	-
Funeral Home	1.182E-03	<0.001	<0.05	-	-	-	-	-	-
Government	-	-	-	-2.687E-04	<0.001	<0.05	-	-	-
Hospital	-7.725E-05	<0.001	<0.05	-	-	-	-4.213E-05	<0.001	<0.05
Hotel / Motel	9.494E-05	<0.001	<0.05	1.228E-04	<0.001	<0.05	-	-	-
Industrial	-3.983E-03	<0.001	<0.05	-6.207E-03	<0.001	<0.05	-2.666E-03	<0.001	<0.05
Industrial Lg	-2.118E-03	<0.001	<0.05	-	-	-	-	-	-
Institutional	-2.386E-04	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-2.775E-03	<0.001	<0.05	-	-	-	-1.204E-03	<0.001	<0.05
Manufacturing	-1.923E-04	<0.001	<0.05	-1.188E-04	<0.001	<0.05	-1.399E-04	<0.001	<0.05
Medical	1.224E-04	<0.001	<0.05	2.644E-04	<0.001	<0.05	-	-	-
Multi-Family	-2.076E-05	<0.001	<0.05	-	-	-	-3.215E-05	<0.001	<0.05
Office	-2.312E-05	<0.001	<0.05	-	-	-	-	-	-
Parking Garage	1.912E-04	<0.001	<0.05	-	-	-	-	-	-
Recreational	-	-	-	-1.119E-03	<0.001	<0.05	-	-	-

Parameters_0.5 miles_45to50 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	**Std. Error**	**p-value**	**Coeff.**	**Std. Error**	**p-value**	**Coeff.**	**Std. Error**	**p-value**
Restaurant	2.068E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	1.379E-04	<0.001	<0.05	-	-	-	-	-	-
School	-5.822E-05	<0.001	<0.05	-	-	-	-3.096E-04	<0.001	<0.05
Service Garage	-6.061E-04	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	-	-	-	-	-	-	-	-	-
Single-Family Residential	-4.850E-05	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-4.725E-04	<0.001	<0.05	-	-	-	-	-	-
Supermarket	5.492E-04	<0.001	<0.05	-	-	-	-	-	-
Truck Terminal	4.166E-04	<0.001	<0.05	-	-	-	-	-	-
Utility	-	-	-	2.774E-03	<0.001	<0.05	-	-	-
Warehouse	-	-	-	-	-	-	-	-	-
Link_# of Lanes	-0.090	0.011	<0.05	-	-	-	-0.064	0.007	<0.05
Link_SL (mph)	-0.043	0.004	<0.05	-0.076	0.003	<0.05	-	-	-
DS_# of Lanes	0.023	0.006	<0.05	-	-	-	-	-	-
DS_SL (mph)	-	-	-	0.003	<0.001	<0.05	-	-	-
US_# of Lanes	-0.028	0.009	<0.05	-	-	-	-	-	-
US_SL (mph)	0.002	<0.001	<0.05	-0.002	<0.001	<0.05	-	-	-
DS_Cross street_# of Lanes	0.032	0.004	<0.05	-	-	-	0.066	0.003	<0.05
DS_Cross street_SL (mph)	-	-	-	-	-	-	-	-	-
US_Cross street_# of Lanes	0.011	0.004	<0.05	-	-	-	0.008	0.004	<0.05
US_Cross street_SL (mph)	-0.002	<0.001	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	-	-	-	-	-	-	-	-	-
Intersection_SL (mph)	0.002	<0.001	<0.05	-	-	-	-	-	-
QIC		126.200			101.475			95.937	
QICC		121.106			101.518			96.071	
RMSE		0.443			0.381			0.403	
MAPE		20%			18%			20%	
MPE		-12%			-12%			-12%	

Note: Land use categories were considered in per 1,000 square feet.

Table 38. Developed Models for 1-mile Buffer Width – Speed Limit 45 to 50mph

Parameters_1-mile_ 45 to 50 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	3.123	0.203	<0.05	4.307	0.138	<0.05	0.687	0.032	<0.05
[Weekday=1]	0.095	0.007	<0.05	0.096	0.008	<0.05	0.096	0.009	<0.05
[MPP=1]	0.042	0.008	<0.05	0.043	0.010	<0.05	0.043	0.011	<0.05
[OPP=1]	0.052	0.007	<0.05	0.054	0.010	<0.05	0.055	0.011	<0.05
[EPP=1]	0.135	0.010	<0.05	0.138	0.012	<0.05	0.137	0.013	<0.05
Attached Residential	7.902E-05	<0.001	<0.05	-	-	-	-	-	-
Auto Dealer	-	-	-	-	-	-	-	-	-
Bank	-	-	-	-	-	-	-	-	-
Car Wash	-	-	-	-	-	-	-	-	-
Church	-	-	-	-	-	-	-	-	-
Commercial Service	-3.487E-04	<0.001	<0.05	-	-	-	-	-	-
Convenience Store	5.324E-03	<0.001	<0.05	-	-	-	5.076E-03	<0.001	<0.05
Daycare	-1.647E-03	<0.001	<0.05	-7.602E-04	<0.001	<0.05	-	-	-
Department Store	-2.817E-04	<0.001	<0.05	-	-	-	1.222E-04	<0.001	<0.05
Fast Food	2.652E-03	<0.001	<0.05	-	-	-	-	-	-
Funeral Home	1.225E-03	<0.001	<0.05	-	-	-	-	-	-
Government	-4.150E-05	<0.001	<0.05	-	-	-	-9.464E-05	<0.001	<0.05
Hospital	-2.006E-04	<0.001	<0.05	-	-	-	-4.470E-05	<0.001	<0.05
Hotel / Motel	1.378E-04	<0.001	<0.05	-	-	-	-	-	-
Industrial	-2.914E-03	<0.001	<0.05	-2.862E-03	<0.001	<0.05	-2.757E-03	<0.001	<0.05
Industrial Lg	9.249E-04	<0.001	<0.05	-	-	-	-	-	-
Institutional	-1.122E-04	<0.001	<0.05	-	-	-	-	-	-
Manufactured Home Construction	-1.019E-03	<0.001	<0.05	-7.212E-04	<0.001	<0.05	-1.298E-03	<0.001	<0.05
Manufacturing	-6.089E-05	<0.001	<0.05	-	-	-	-	-	-
Medical	1.419E-04	<0.001	<0.05	5.987E-05	<0.001	<0.05	-	-	-
Multi-Family	-3.379E-05	<0.001	<0.05	-	-	-	-2.959E-05	<0.001	<0.05
Office	-2.756E-05	<0.001	<0.05	-	-	-	-	-	-
Parking Garage	1.227E-04	<0.001	<0.05	-	-	-	-	-	-
Recreational	-	-	-	-3.350E-04	<0.001	<0.05	-	-	-

Parameters_1-mile_ 45 to 50 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
Restaurant	1.027E-03	<0.001	<0.05	-	-	-	-	-	-
Retail	-	-	-	-	-	-	-	-	-
School	1.244E-04	<0.001	<0.05	-	-	-	-	-	-
Service Garage	-	-	-	-	-	-	-	-	-
Shopping Mall	-1.723E-04	<0.001	<0.05	1.879E-04	<0.001	<0.05	-	-	-
Single-Family Residential	-3.523E-05	<0.001	<0.05	-	-	-	-	-	-
Stadium /Arena	-2.141E-04	<0.001	<0.05	-	-	-	-	-	-
Supermarket	-	-	-	-	-	-	5.068E-04	<0.001	<0.05
Truck Terminal	-2.766E-04	<0.001	<0.05	-	-	-	-	-	-
Utility	-	-	-	-	-	-	-	-	-
Warehouse	-1.511E-05	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	0.021	0.010	<0.05	-	-	-	-	-	-
Link_SL (mph)	-0.053	0.004	<0.05	-0.085	0.003	<0.05	-	-	-
DS_# of Lanes	-	-	-	-	-	-	-	-	-
DS_SL (mph)	-	-	-	0.002	<0.001	<0.05	0.001	<0.001	<0.05
US_# of Lanes	-0.071	0.010	<0.05	-	-	-	-	-	-
US_SL (mph)	0.002	<0.001	<0.05	-0.001	<0.001	<0.05	-0.002	<0.001	<0.05
DS_Cross street_# of Lanes	0.027	0.004	<0.05	-	-	-	-	-	-
DS_Cross street_SL (mph)	-	-	-	-	-	-	-	-	-
US_Cross street_# of Lanes	0.016	0.004	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.005	<0.001	<0.05	-	-	-	-0.004	<0.001	<0.05
Intersection_# of Lanes	-	-	-	-	-	-	-	-	-
Intersection_SL (mph)	0.003	<0.001	<0.05	-	-	-	-	-	-
QIC		126.092			99.465			111.585	
QICC		122.468			99.605			112.141	
RMSE		0.361			0.357			0.377	
MAPE		16%			17%			17%	
MPE		-8%			-10%			-10%	

Note: Land use categories were considered in per 1,000 square feet.

Table 39. Developed Models for 0.5-mile Buffer Width – Speed Limit > 50 mph

Parameters_0.5 miles_ >50 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	0.959	0.116	<0.05	0.586	0.026	<0.05	1.233	0.076	<0.05
[Weekday=1]	0.082	0.008	<0.05	0.084	0.009	<0.05	0.083	0.009	<0.05
[MPP=1]	0.006	0.007	0.386	0.006	0.008	0.432	0.007	0.009	0.451
[OPP=1]	-0.003	0.006	0.600	-0.002	0.007	0.729	-0.002	0.008	0.780
[EPP=1]	0.108	0.015	<0.05	0.111	0.017	<0.05	0.109	0.016	<0.05
Attached Residential	-	-	-	-	-	-	-	-	-
Auto Dealer	3.414E-03	<0.001	<0.05	-	-	-	-3.281E-04	<0.001	<0.05
Bank	-	-	-	-	-	-	-	-	-
Car Wash	-	-	-	-	-	-	-	-	-
Church	-	-	-	-	-	-	-	-	-
Commercial Service	6.152E-04	<0.001	<0.05	-	-	-	2.658E-04	<0.001	<0.05
Convenience Store	-	-	-	-	-	-	-	-	-
Daycare	1.184E-02	0.003	<0.05	-	-	-	-	-	-
Department Store	-	-	-	-	-	-	-	-	-
Fast Food	-	-	-	-	-	-	-	-	-
Funeral Home	-	-	-	-	-	-	-	-	-
Government	-	-	-	-	-	-	-	-	-
Hospital	2.199E-04	<0.001	<0.05	-	-	-	5.923E-04	<0.001	<0.05
Hotel / Motel	-	-	-	-	-	-	-	-	-
Industrial	1.724E-02	0.004	<0.05	-	-	-	-	-	-
Industrial Lg	5.829E-03	<0.001	<0.05	-	-	-	-	-	-
Institutional	1.568E-04	<0.001	<0.05	3.733E-05	<0.001	<0.05	-	-	-
Manufactured Home Construction	-	-	-	-	-	-	-1.711E-02	0.003	<0.05
Manufacturing	3.197E-04	<0.001	<0.05	-	-	-	3.919E-04	<0.001	<0.05
Medical	-	-	-	-	-	-	-	-	-
Multi-Family	-	-	-	-	-	-	-	-	-
Office	8.967E-05	<0.001	<0.05	-	-	-	-	-	-
Parking Garage	-	-	-	-	-	-	-	-	-
Recreational	-	-	-	-	-	-	-	-	-

Parameters_0.5 miles_ >50 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	**Std. Error**	**p-value**	**Coeff.**	**Std. Error**	**p-value**	**Coeff.**	**Std. Error**	**p-value**
Restaurant	-1.730E-02	0.004	<0.05	-	-	-	-	-	-
Retail	1.083E-03	<0.001	<0.05	-	-	-	-	-	-
School	-1.719E-04	<0.001	<0.05	-	-	-	-	-	-
Service Garage	-3.596E-03	<0.001	<0.05	-	-	-	-	-	-
Shopping Mall	1.159E-03	<0.001	<0.05	-	-	-	-2.135E-04	<0.001	<0.05
Single-Family Residential	-	-	-	-	-	-	-	-	-
Stadium /Arena	6.088E-04	<0.001	<0.05	-	-	-	-	-	-
Supermarket	-1.391E-03	<0.001	<0.05	-2.069E-03	<0.001	<0.05	-	-	-
Truck Terminal	3.538E-03	<0.001	<0.05	-	-	-	-	-	-
Utility	-	-	-	-	-	-	-	-	-
Warehouse	2.004E-04	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-	-	-	-0.154	0.007	<0.05	-	-	-
Link_SL (mph)	-0.068	0.015	<0.05	-	-	-	-0.023	0.001	<0.05
DS_# of Lanes	0.508	0.109	<0.05	-	-	-	-	-	-
DS_SL (mph)	0.020	0.008	<0.05	-	-	-	-	-	-
US_# of Lanes	-0.116	0.018	<0.05	-	-	-	-	-	-
US_SL (mph)	-	-	-	-	-	-	-	-	-
DS_Cross street_# of Lanes	-	-	-	-	-	-	-	-	-
DS_Cross street_SL (mph)	-	-	-	-	-	-	-	-	-
US_Cross street_# of Lanes	-	-	-	-0.087	0.012	<0.05	-	-	-
US_Cross street_SL (mph)	-	-	-	-	-	-	-	-	-
Intersection_# of Lanes	-	-	-	-	-	-	-	-	-
Intersection_SL (mph)	-	-	-	-	-	-	-	-	-
QIC		66.436			27.248			33.227	
QICC		59.197			24.950			31.209	
RMSE		1.334			0.176			0.188	
MAPE		76%			13%			14%	
MPE		-73%			-5%			-10%	

Note: Land use categories were considered in per 1,000 square feet.

Table 40. Developed Models for 1-mile Buffer Width – Speed Limit > 50 mph

Parameters_1-mile_ > 50 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
(Intercept)	7.305	2.207	<0.05	1.237	0.071	<0.05	0.589	0.026	<0.05
[Weekday=1]	0.082	0.008	<0.05	0.083	0.009	<0.05	0.084	0.009	<0.05
[MPP=1]	0.006	0.007	0.391	0.007	0.009	0.450	0.006	0.007	0.416
[OPP=1]	-0.003	0.006	0.610	-0.002	0.008	0.756	-0.003	0.006	0.693
[EPP=1]	0.108	0.015	<0.05	0.109	0.016	<0.05	0.112	0.017	<0.05
Attached Residential	-	-	-	-	-	-	-	-	-
Auto Dealer	1.523E-02	0.005	<0.05	-	-	-	-	-	-
Bank	-	-	-	-	-	-	-	-	-
Car Wash	-1.183E-01	0.039	<0.05	-	-	-	-	-	-
Church	3.105E-03	0.001	<0.05	-	-	-	-	-	-
Commercial Service	-	-	-	2.159E-04	<0.001	<0.05	-	-	-
Convenience Store	-	-	-	-	-	-	-	-	-
Daycare	-	-	-	-	-	-	-	-	-
Department Store	1.320E-02	0.004	<0.05	-	-	-	-	-	-
Fast Food	-1.704E-02	0.005	<0.05	-	-	-	-	-	-
Funeral Home	-2.621E-02	0.009	<0.05	-	-	-	-	-	-
Government	-	-	-	-	-	-	-	-	-
Hospital	-	-	-	-	-	-	-	-	-
Hotel / Motel	-	-	-	-	-	-	-	-	-
Industrial	-	-	-	2.220E-03	<0.001	<0.05	1.701E-03	<0.001	<0.05
Industrial Lg	-6.184E-02	0.022	<0.05	-	-	-	-	-	-
Institutional	-	-	-	-	-	-	-	-	-
Manufactured Home Construction	-	-	-	-1.066E-02	0.001	<0.05	-	-	-
Manufacturing	-	-	-	-	-	-	-	-	-
Medical	1.236E-03	<0.001	<0.05	-	-	-	-	-	-
Multi-Family	5.239E-05	<0.001	<0.05	-	-	-	-	-	-
Office	-	-	-	-	-	-	-	-	-
Parking Garage	-8.664E-05	<0.001	<0.05	-	-	-	-	-	-
Recreational	2.485E-03	<0.001	<0.05	-	-	-	-	-	-

Parameters_1-mile_ > 50 mph	Backward Elimination			Model 1			Model 2		
	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value	Coeff.	Std. Error	p-value
Restaurant	-7.077E-03	0.002	<0.05	-	-	-	-	-	-
Retail	-	-	-	-	-	-	-	-	-
School	-	-	-	-	-	-	-	-	-
Service Garage	-6.331E-03	0.002	<0.05	-	-	-	-	-	-
Shopping Mall	8.132E-04	<0.001	<0.05	-5.095E-05	<0.001	<0.05	-7.194E-05	<0.001	<0.05
Single-Family Residential	-	-	-	-	-	-	-	-	-
Stadium /Arena	-5.838E-04	<0.001	<0.05	-	-	-	-	-	-
Supermarket	-	-	-	-	-	-	-1.113E-03	<0.001	<0.05
Truck Terminal	4.699E-03	0.002	<0.05	-	-	-	-	-	-
Utility	-	-	-	-	-	-	-	-	-
Warehouse	1.721E-04	<0.001	<0.05	-	-	-	-	-	-
Link_# of Lanes	-	-	-	-	-	-	-0.155	0.006	<0.05
Link_SL (mph)	0.677	0.232	<0.05	-0.023	0.001	<0.05	-	-	-
DS_# of Lanes	0.388	0.128	<0.05	-	-	-	-	-	-
DS_SL (mph)	-0.146	0.041	<0.05	-	-	-	-	-	-
US_# of Lanes	-	-	-	-	-	-	-	-	-
US_SL (mph)	-0.664	0.230	<0.05	-	-	-	-	-	-
DS_Cross street_# of Lanes	-	-	-	-	-	-	-0.062	0.012	<0.05
DS_Cross street_SL (mph)	0.005	0.002	<0.05	-	-	-	-	-	-
US_Cross street_# of Lanes	-0.122	0.039	<0.05	-	-	-	-	-	-
US_Cross street_SL (mph)	-0.033	0.011	<0.05	-	-	-	-	-	-
Intersection_# of Lanes	1.996	0.671	<0.05	-	-	-	-	-	-
Intersection_SL (mph)	-	-	-	-	-	-	-	-	-
QIC		74.271			27.998			29.974	
QICC		65.225			27.017			26.768	
RMSE		1.823			0.138			0.214	
MAPE		129%			10%			15%	
MPE		-101%			-6%			-9%	

Note: Land use categories were considered in per 1,000 square feet.

Table 41. Performance of Developed Models by Speed Limit – Summary

Buffer Width	Models	Parameters	Backward Elimination	Model 1	Model 2
0.5 Miles	< 45 mph	QIC	122.583	102.280	102.412
		QICC	118.660	101.107	98.832
		RMSE	0.657	0.584	0.644
		MAPE	19%	16%	17%
		MPE	-6%	-4%	-2%
	45 to 50 mph	QIC	126.200	101.475	95.937
		QICC	121.106	101.518	96.071
		RMSE	0.443	0.381	0.403
		MAPE	20%	18%	20%
		MPE	-12%	-12%	-12%
	> 50 mph	QIC	66.436	27.248	33.227
		QICC	59.197	24.950	31.209
		RMSE	1.334	0.176	0.188
		MAPE	76%	13%	14%
		MPE	-73%	-5%	-10%
1 mile	< 45 mph	QIC	124.583	100.831	111.057
		QICC	124.024	98.406	109.730
		RMSE	0.747	0.585	0.685
		MAPE	23%	17%	19%
		MPE	-5%	-2%	-4%
	45 to 50 mph	QIC	126.092	99.465	111.585
		QICC	122.468	99.605	112.141
		RMSE	0.361	0.357	0.377
		MAPE	16%	17%	17%
		MPE	-8%	-10%	-10%
	> 50 mph	QIC	74.271	27.998	29.974
		QICC	65.225	27.017	26.768
		RMSE	1.823	0.138	0.214
		MAPE	129%	10%	15%
		MPE	-101%	-6%	-9%

DISCUSSION RELATED TO THE DEVELOPED MODELS BY SPEED LIMIT

For all the models by the speed limit (Model 1 or Model 2), an increase in the speed limit of the selected link decreases ATT (Table 42 and Table 43). For links with the speed limit less than 45 mph, an increase in the area occupied by multi-family residential or school type land uses within 0.5 miles and within 1 mile from a link increases ATT (Table 42). However, an increase in the area occupied by an auto dealer or daycare type land uses within 0.5 miles and within 1 mile from a link decreases ATT.

For links with the speed limit between 45 to 50 mph, an increase in the area occupied by a convenience store, department store, or medical type land uses within 0.5 miles and within 1 mile from a link increases ATT (Table 43). However, an increase in the area occupied by an industrial, manufactured home construction, multi-family residential, or recreational type land uses within 0.5 miles and within 1 mile from a link decreases ATT.

In addition, for links with the speed limit greater than 50 mph, an increase in the area occupied by commercial service type land uses within 0.5 miles and within 1-mile increases ATT. However, an increase in the area occupied by manufactured home construction, shopping mall, or supermarkets within 1 mile from a link decreases the (Table 44).

Furthermore, the developed backward elimination model for links with the speed limit more than 50 mph with the 0.5 miles and 1-mile buffer width dataset should not be used for estimating the ATT due to the high errors in the validation results (Table 41). Based on QIC, QICC, RMSE and MAPE, for all the speed limit categories, the one-mile buffer width was observed to be a better fit than the 0.5 mile buffer width (lower QIC and QICC, lower difference between QIC to QICC, lower RMSE and MAPE), for explaining the relationship between the land use developments and the ATT. Furthermore, for each speed limit category, Model 1 was observed to be the better fit to estimate the ATT compared to other models (Table 41).

Table 42. Comparison of Developed Models for Speed Limit < 45mph

Parameters_< 45 mph	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	N	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	P	P	P	P	P	P
[EPP=1]	P	P	P	P	P	P
Attached Residential	N			P		
Auto Dealer	N	N		N		N
Bank	P			N		
Car Wash	P			N		
Church	P			N		
Commercial Service	N	P				
Convenience Store				P	N	
Daycare	N	N				N
Department Store	N			N	N	
Fast Food				N		P
Funeral Home	N	N		N	N	
Government				P		
Hospital	P		P	N		
Hotel / Motel	N			P		
Industrial	N	N		N		
Industrial Lg				N		
Institutional	N					
Manufactured Home Construction	N	N	N			
Manufacturing				N		
Medical	N					
Multi-Family	P	P		P	P	
Office				N		P

Parameters_< 45 mph	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
Parking Garage	P			P		
Recreational	N			N		
Restaurant	P			P		
Retail	N			N		
School	P	P	P	P	P	P
Service Garage	N			N		
Shopping Mall	N		N	N		
Single-Family Residential	N			N		
Stadium /Arena			P	N		
Supermarket	P	N		P		
Truck Terminal	P					
Utility	N			P		
Warehouse	P			P		P
Link_# of Lanes				P		
Link_SL (mph)	P	N	N	N	N	N
DS_# of Lanes				P		N
DS_SL (mph)	N	N	N	N		
US_# of Lanes	N			N		
US_SL (mph)				P		
DS_Cross street_# of Lanes	P	P		P	P	P
DS_Cross street_SL (mph)	P			P		
US_Cross street_# of Lanes	N	N		N		P
US_Cross street_SL (mph)	P					
Intersection_# of Lanes		P				P
Intersection_SL (mph)	P		P	P	P	

Table 43. Comparison of Developed Models for Speed Limit between 45 to 50 mph

Parameters_ 45 to 50 mph	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	P	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	P	P	P	P	P	P
[EPP=1]	P	P	P	P	P	P
Attached Residential	N			P		
Auto Dealer						
Bank						
Car Wash	P					
Church		N				
Commercial Service	N		N	N		
Convenience Store	P		P	P		P

Parameters_ 45 to 50 mph	**0.5 Miles**			**1-Mile**		
	Backward Elimination	**Model 1**	**Model 2**	**Backward Elimination**	**Model 1**	**Model 2**
Daycare	N			N	N	
Department Store	N		P	N		P
Fast Food		P		P		
Funeral Home	P			P		
Government		N		N		N
Hospital	N		N	N		N
Hotel / Motel	P	P		P		
Industrial	N	N	N	N	N	N
Industrial Lg	N			P		
Institutional	N			N		
Manufactured Home Construction	N		N	N	N	N
Manufacturing	N	N	N	N		
Medical	P	P		P	P	
Multi-Family	N		N	N		N
Office	N			N		
Parking Garage	P			P		
Recreational		N			N	
Restaurant	P			P		
Retail	P					
School	N		N	P		
Service Garage	N					
Shopping Mall				N	P	
Single-Family Residential	N			N		
Stadium /Arena	N			N		
Supermarket	P					P
Truck Terminal	P			N		
Utility		P				
Warehouse				N		
Link_# of Lanes	N		N	P		
Link_SL (mph)	N	N		N	N	
DS_# of Lanes	P					
DS_SL (mph)		P			P	P
US_# of Lanes	N			N		
US_SL (mph)	P	N		P	N	N
DS_Cross street_# of Lanes	P		P	P		
DS_Cross street_SL (mph)						
US_Cross street_# of Lanes	P		P	P		
US_Cross street_SL (mph)	N			N		N
Intersection_# of Lanes						
Intersection_SL (mph)	P			P		

Table 44. Comparison of Developed Models for Speed Limit > 50 mph

Parameters_ > 50 mph	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
(Intercept)	P	P	P	P	P	P
[Weekday=1]	P	P	P	P	P	P
[MPP=1]	P	P	P	P	P	P
[OPP=1]	N	N	N	N	N	N
[EPP=1]	P	P	P	P	P	P
Attached Residential						
Auto Dealer	P		N	P		
Bank						
Car Wash				N		
Church				P		
Commercial Service	P		P		P	
Convenience Store						
Daycare	P					
Department Store				P		
Fast Food				N		
Funeral Home				N		
Government						
Hospital	P		P			
Hotel / Motel						
Industrial	P				P	P
Industrial Lg	P			N		
Institutional	P	P				
Manufactured Home Construction			N		N	
Manufacturing	P		P			
Medical				P		
Multi-Family				P		
Office	P					
Parking Garage				N		
Recreational				P		
Restaurant	N			N		
Retail	P					
School	N					
Service Garage	N			N		
Shopping Mall	P		N	P	N	N
Single-Family Residential						
Stadium /Arena	P			N		
Supermarket	N	N				N
Truck Terminal	P			P		
Utility						
Warehouse	P			P		
Link_# of Lanes		N				N
Link_SL (mph)	N		N	P	N	
DS_# of Lanes	P			P		

Parameters_ > 50 mph	0.5 Miles			1-Mile		
	Backward Elimination	Model 1	Model 2	Backward Elimination	Model 1	Model 2
DS_SL (mph)	P			N		
US_# of Lanes	N					
US_SL (mph)				N		
DS_Cross street_# of Lanes						N
DS_Cross street_SL (mph)				P		
US_Cross street_# of Lanes		N		N		
US_Cross street_SL (mph)				N		
Intersection_# of Lanes				P		
Intersection_SL (mph)						

IX. CONCLUSIONS

Transportation decisions and land use decisions are interconnected with each other. This research examined the influence of proximal land use developments within a selected distance from a link on travel time at the link level. In addition, the research investigated, by selecting the links by area type and by classifying the links based on the speed limit, the influence of land use developments on travel time at the link level. The broadest conclusion is that land use developments within the proximity of a link do influence travel times on that link.

Correlations between the densities of land use developments and travel time measures were examined, by considering data from before- and after-construction data. The correlation analysis investigated the question of whether or not there exists a relationship between the area occupied by land use developments and travel time measures. Statistical models were developed using data from different buffer widths to evaluate the influence of land use developments (predictor variables) on ATT (dependent variable). Furthermore, statistical models were developed by area type (CBD, CBD Fringe / OBD, and urban area) and by classifying the links based on the speed limit (< 45 mph, 45 to 50 mph, and > 50 mph) using 0.5-mile and 1-mile buffer width datasets. A total of forty-eight models were developed in this research. In addition, network characteristics of the selected, upstream, downstream, upstream and downstream cross street, and intersecting links were also considered in the model development to address spatial dependency. A log-link model with a gamma distribution was observed to be the best-fit model for the data used in this research.

Models developed using 0.5 mile and 1-mile buffer width datasets were observed to perform better than models with 2-mile or 3-mile buffer width datasets based on the QIC, QICC, RMSE, and MAPE. In addition, MPE suggested that the developed models over-predict compared to the actual ATT. Depending on the buffer width, the same land use category contributes differently to ATT. In addition, different land use categories contribute differently to the ATT, depending on the buffer width. Typically, in most of the cases, travel time on a link was observed to be higher during the evening peak period compared to the morning peak period and the afternoon off-peak period. In all the models by the buffer width, the number of lanes and the speed limit on the selected link are negatively associated with ATT. The area occupied by single-family attached residential type land uses within 0.5 miles and within 1 mile from a link contributes negatively to ATT. However, the area occupied by single-family attached residential type land uses within 2 miles and within 3 miles from a link is positively associated with the ATT. In addition, the area occupied by supermarkets within 0.5 miles, 2 miles and 3 miles from a link contribute positively to ATT. Likewise, the area occupied by office type land uses within 0.5 miles, 1 mile, and 2 miles from a link contributes positively to ATT. On the other hand, the area occupied by daycare type land uses within 0.5 miles, 2 miles and 3 miles from a link contribute negatively to ATT. Likewise, the area occupied by industrial type land uses within 0.5 miles and within 1 mile from a link contributes negatively to the ATT. Also, the area occupied by large industrial type land uses within 1 mile and 2 miles from a link contributes negatively to the ATT.

Similarly, to the models by buffer width, each land use category within 0.5 miles and 1-mile buffer width, by area type (CBD, CBD Fringe/ OBD, and urban area) and by classifying the links based on the speed limit, contribute differently to ATT. The results indicate that the influence of land use developments on ATT varies by area type and by the speed limit.

Per DeRobertis et al. (2014), the typical solution in TIS is to increase the road capacity.[13] However, the relationship examined in the present research between land use developments and ATT indicates that different land use developments have different (positive/negative) influences on ATT. In addition, DeRobertis et al. (2014)[13] have stated that trip generation rates due to future land use developments are assumed to be similar to those due to past developments, and this assumption needs to be readdressed. The proposed and adopted methodology in this research overcomes the assumption typically made in TIS.

In the CBD area, potential solutions and strategies for TIS should be evaluated on links during weekdays and during the evening peak period, and in areas with high densities of department store, government, and multi-family type land uses, within 1 mile from a link, in order to reduce congestion and improve mobility. Likewise, in the CBD fringe/ OBD area, potential solutions and strategies for TIS should be reviewed for areas with high densities of daycare, multi-family, shopping mall, and supermarket type land uses within 1 mile from a link. Similarly, in the urban area, potential solutions and strategies for TIS should be reviewed for areas with high densities of a convenience store, department store, fast food, funeral home, multi-family, recreational, retail, and supermarket type land uses within 1 mile from a link.

Based on the QIC, QICC, RMSE, and MAPE, the models by the speed limit, particularly Model 1 in each of the speed limit category for 1 mile buffer width is recommended, as the best-fitted models for forecasting / predicting the ATT. In other words, classifying the links by the speed limit, capturing the land use developments within 1 mile from a link, and then developing the models, would aid in better understanding the relationship between land use developments and ATT. However, the developed backward elimination model for 0.5-mile buffer width is recommended while examining the influence of land use developments on the ATT by the buffer width. Similarly, the developed Model 1 in each of the area types (CBD, CBD fringe / OBD, and urban), for a 1-mile buffer width, are recommended while examining the influence of land use developments on the ATT by area type.

Based on the need, the developed models can be implemented to estimate the ATT on a link based on the types of land use within its proximity. In addition, the developed models suggest that the magnitudes of connections between the land use developments and travel time vary over space and time.

The influence of land use type, network characteristics, TOD and DOW on travel times based on the statistical models' aid professionals and planners in land use planning decisions and can proactively improve the mobility. In addition to the procedure followed in the TIS, the developed relationships could be helpful for quantifying the influence of land use developments on travel times, based on the type of land use development, area type, and the speed limit of the link.

LIMITATIONS AND SCOPE FOR FUTURE WORK

The land use developments and travel time data for the city of Charlotte, NC were used in this research. Similar studies should be conducted using data for other cities to investigate the relationship between land use developments and travel time. Consideration of more data over the years merit further investigation. In addition, inter-regional motorists, who are not regular commuters (during long weekends, on game day), could also influence ATT due to the unfamiliarity of the route.

Demographic characteristics, socioeconomic characteristics, and non-recurrent events such as crashes, long weekend holidays, and adverse weather conditions could also influence ATT and should be considered in the model development procedure.

The influence of land use developments on the operational performance of transportation networks could be quantified by collecting origin and destination patterns of every individual trip (home-to-work, home-to-recreational, work-to-recreational, work to home, and so on) using navigation applications. However, collecting individual trip data have privacy-related concerns. Land use development activities and ATT should be collected over the years for such disaggregated analysis. While it is challenging to collect data at this level, the feasibility of examining the relationship between land use developments and ATT by incorporating origin and destination patterns merits an investigation.

APPENDIX A: CORRELATION TABLES

This Appendix presents Pearson correlation matrices for each of the developed models. To avoid the multicollinearity, the predictor variables were selected based on these Pearson correlation coefficients.

Table A1 illustrates reference numbers for the dependent (ATT) and all the predictor variables used in the model development procedure. Table A2 to Table A17 present the Pearson correlation matrices for buffer widths, area type, and the speed limit. Pearson correlation coefficients that were significant at a 95% confidence level were classified into six categories. They are:

- High negative correlation (less than -0.5) represented as HN
- Moderate negative correlation (-0.5 to -0.3) represented as MN
- Low negative correlation (-0.3 to 0) represented as LN
- Low positive correlation (0 to +0.3) represented as LP
- Moderate positive correlation (+0.3 to +0.5) represented as MP
- High positive correlation (greater than 0.5) represented as HP

In addition, the dash symbol ("-") indicates that Pearson correlation coefficient is not significant at a 95% confidence level between the two variables. Also, "1" indicates that the variable on the horizontal and corresponding vertical cell is the same.

Table A1 List of the Variables and Corresponding Reference Number for Correlation Analysis

Parameters	Reference Number for correlation tables	Parameters	Reference Number for correlation tables
ATT (minutes)	1	Recreational	25
Attached Residential	2	Restaurant	26
Auto Dealer	3	Retail	27
Bank	4	School	28
Car Wash	5	Service Garage	29
Church	6	Shopping Mall	30
Commercial Service	7	Single-Family Residential	31
Convenience Store	8	Stadium /Arena	32
Daycare	9	Supermarket	33
Department Store	10	Truck Terminal	34
Fast Food	11	Utility	35
Funeral Home	12	Warehouse	36
Government	13	Link_# of Lanes	37
Hospital	14	Link_SL (mph)	38
Hotel / Motel	15	DS_# of Lanes	39
Industrial	16	DS_SL (mph)	40
Industrial Lg	17	US_# of Lanes	41
Institutional	18	US_SL (mph)	42
Manufactured Home Construction	19	DS_Cross street_# of Lanes	43
Manufacturing	20	DS_Cross street_SL (mph)	44
Medical	21	US_Cross street_# of Lanes	45
Multi-Family	22	US_Cross street_SL (mph)	46
Office	23	Intersection_# of Lanes	47
Parking Garage	24	Intersection_SL (mph)	48

Table A2 Correlation Matrix – 0.5 miles Buffer Width

0.5 miles	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																													
3	LN	LP	1																																												
4	MP	MP	LN	1																																											
5	LN	LN	MP	LN	1																																										
6	MP	HP	LN	MP	LN	1																																									
7	LP	LP	LN	LP	MP	LP	1																																								
8	LN	LN	-	LN	LP	LN	LN	1																																							
9	LN	LN	-	LP	LP	LN	LP	LP	1																																						
10	LP	-	LN	LP	LN	LN	LN	LN	LN	1																																					
11	LN	LN	-	LN	LP	LN	LP	HP	LP	LN	1																																				
12	LN	-	MP	LN	LP	LN	LN	LP	LP	LN	LN	1																																			
13	HP	MP	LN	HP	-	MP	MP	LN	LP	LN	LN	LN	1																																		
14	LP	LP	LN	LP	LP	LP	MP	LN	LN	LN	LP	LP	LP	1																																	
15	MP	MP	LN	HP	LN	MP	LP	LN	LP	LP	LN	LN	HP	-	1																																
16	LN	LN	LN	LN	LP	LN	LN	LP	-	LN	LN	LN	LN	LN	LN	1																															
17	LN	LN	LN	LN	MP	LN	MP	LN	-	LN	-	LN	LP	-	-	-	1																														
18	MP	MP	LN	HP	-	MP	MP	LN	LN	LN	LN	LN	HP	LP	HP	LN	LN	1																													
19	LN	LN	-	LN	LP	LN	-	LP	LP	LN	LP	-	LN	LN	LN	-	-	LN	1																												
20	LP	LN	LN	LN	-	LN	LN	LP	LP	LN	LN	LN	LP	LN	-	LP	-	LN	LN	1																											
21	LP	LP	LN	LP	LP	LP	MP	-	LN	-	LP	LP	-	HP	LN	LN	LN	MP	LN	LN	1																										
22	MP	HP	LP	MP	-	MP	LP	LN	LP	-	LN	-	HP	LP	HP	LN	LN	MP	LN	LP	-	1																									
23	HP	HP	LN	HP	LN	HP	LP	LN	-	-	LN	LN	HP	LN	HP	LN	LN	HP	LN	LP	LN	HP	1																								
24	HP	HP	LN	HP	LN	HP	MP	MN	LN	LP	LN	LN	HP	MP	HP	LN	LN	HP	LN	-	LP	HP	HP	1																							
25	MP	MP	LN	MP	LN	LP	-	LN	LP	LN	LN	LN	HP	LN	HP	-	LN	LP	LN	LP	LN	HP	HP	HP	1																						
26	HP	HP	LN	HP	LN	MP	LP	LN	LP	LP	LP	LN	HP	LP	HP	LN	LN	HP	LN	LP	LP	HP	HP	HP	HP	1																					
27	MP	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	-	LP	LP	MP	LN	LN	MP	LP	LP	LP	MP	MP	MP	LP	HP	1																				
28	LP	LP	-	LP	-	MP	LN	LN	LP	LN	-	LN	LP	LP	LP	LN	LN	LP	LP	LN	LP	LP	LP	LP	LP	LP	LP	1																			
29	LN	LN	LP	LN	LP	LN	LP	LP	-	LN	LP	LP	LN	LN	LN	LP	LP	LN	-	MP	LN	LN	LN	LN	LN	LN	LN	LN	1																		
30	-	-	LP	LP	LP	LN	LN	LP	LP	HP	MP	LP	LN	-	LN	LN	LN	LN	-	LN	LP	-	LN	LN	LN	LP	MP	LP	LN	1																	
31	LN	LP	LP	LN	LN	LP	LN	LN	-	LP	-	LP	MN	LP	MN	LN	LN	LN	LP	LN	LP	LN	MN	LN	LN	LN	LN	LP	LN	LP	1																
32	HP	HP	LN	HP	LN	MP	LP	LN	LN	LN	LN	LN	HP	LN	HP	LN	LN	MP	LN	LP	LN	HP	HP	HP	HP	HP	LP	LP	LN	LN	LN	1															
33	LP	LP	LP	LN	LN	LP	LN	LN	LP	MP	LP	-	LN	LP	LN	LN	LN	LN	LP	LN	LP	LP	LN	LN	LN	LP	LP	-	LN	MP	MP	LN	1														
34	LN	LN	LP	LN	LN	LN	LN	LP	LN	LN	-	LN	LN	LN	LN	LP	LP	LN	-	LP	LN	LN	LN	LN	LN	LN	LN	LN	HP	LN	LN	LN	LN	1													
35	LP	LP	LN	LP	LN	MP	LP	LN	LN	LN	-	LP	LP	HP	LP	LN	LN	LP	LN	-	MP	LP	LP	MP	-	MP	LP	LP	LN	LN	LP	LP	LP	LN	1												
36	LN	MN	LN	LN	LP	LN	LP	MP	-	LN	LP	LN	LN	LN	LN	LP	LP	LN	-	HP	LN	LN	LN	LN	LN	LN	LN	LN	HP	LN	MN	LN	LN	HP	LN	1											
37	MN	LN	LP	LP	-	LN	-	LP	-	LP	LN	LP	-	LN	LP	LP	-	-	LN	LN	LN	LN	LP	-	LN	LP	-	-	LP	LN	LN	-	LN	LP	LN	LP	1										
38	HN	MN	LP	LN	LP	LN	LN	LP	LP	-	LP	LP	LN	LN	LN	LP	LP	LN	LP	LN	LN	LN	LN	MN	LN	LN	LN	LN	LP	-	LN	LN	LN	LP	LN	LP	HP	1									
39	MN	LN	LP	LP	-	LN	-	LP	LP	LP	LN	LP	-	-	LP	LP	LP	LP	LN	-	LN	LP	LP	LP	LN	LP	-	LN	LP	LN	LN	-	LN	LP	-	LP	HP	HP	1								
40	MN	LN	LP	LN	-	LN	LN	LP	LP	-	LN	LP	LN	LN	-	-	LP	LN	LN	LN	LN	-	LN	LN	LN	-	LN	LN	LP	LN	LN	LN	-	LP	LN	LP	HP	HP	HP	1							
41	MN	LN	LP	LP	LN	LP	-	LP	-	LN	-	LP	LP	-	LP	-	-	LP	-	LN	LN	-	LP	LP	LN	LP	-	LP	LP	LN	LN	LP	LN	LP	LN	LP	HP	HP	HP	MP	1						
42	MN	LN	-	-	LN	LN	-	LP	LN	LN	LP	LP	LN	LN	-	LN	LP	-	-	LN	LN	LN	LN	LN	LN	LN	LN	LP	LP	LN	LN	-	-	-	LN	-	HP	HP	HP	MP	HP	1					
43	MP	LP	LP	LP	LP	LP	-	-	LP	LP	LP	LP	-	LP	-	LN	LN	LN	LN	LN	LP	LP	-	LP	LP	LP	LP	LP	LN	MP	LP	LN	LP	LN	LP	LN	MN	MN	MN	LN	MN	MN	1				
44	LN	LN	LP	LN	LP	LN	-	LP	LP	-	LP	LP	LN	LN	LN	LP	LP	LN	LP	LN	LN	LN	LN	LN	LN	LN	LN	LN	-	LP	LP	LN	LP	LP	LN	-	LN	LP	LP	LP	-	LN	LP	1			
45	LP	LP	LP	LP	LP	LP	LN	LN	-	LP	LN	LP	-	-	-	LN	LN	LN	-	LN	-	LP	LP	LP	LP	LP	LP	LP	LN	MP	MP	-	LP	LN	LP	MN	MN	MN	LN	LN	MN	MN	MP	LP	1		
46	MN	LN	LP	LN	-	LN	LN	LP	LN	-	-	LP	LN	LN	LN	LP	LN	MN	LP	LN	LN	LN	LN	MN	LN	LN	LN	LN	LP	LP	-	LN	LN	LP	LN	LP	LP	MP	LP	LP	LP	LP	LN	LP	LP	1	
47	MP	MP	-	LP	-	LP	LN	LN	LP	LP	LP	LN	LP	LP	LP	LN	LN	LP	-	LN	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LP	LP	-	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	MN	1
48	MP	LP	LP	LP	-	LP	LN	LN	LP	LP	LP	-	LP	LP	LP	-	LN	LP	-	-	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LP	LP	-	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	LN	HP

Table A3 Correlation Matrix – 1-mile Buffer Width

1-mile	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																													
3	LN	LN	1																																												
4	MP	HP	LN	1																																											
5	LP	LN	MP	LP	1																																										
6	MP	HP	LN	HP	LN	1																																									
7	LP	MP	LN	HP	HP	MP	1																																								
8	LN	MN	LP	LN	MP	LN	LN	1																																							
9	LN	LN	LP	LN	LP	LN	LP	LP	1																																						
10	LP	LP	LN	LP	LN	LN	LN	LN	LN	1																																					
11	LP	-	LP	LP	MP	-	LP	MP	MP	LN	1																																				
12	-	LP	HP	-	LP	LP	-	LP	LN	LN	LN	1																																			
13	MP	HP	LN	HP	LP	HP	HP	LN	LN	LN	LP	LP	1																																		
14	LP	MP	LN	HP	LP	HP	MP	LN	LN	LN	LP	LP	MP	1																																	
15	MP	HP	LN	HP	LP	HP	HP	LN	LN	-	LP	-	HP	MP	1																																
16	LN	MN	LN	LN	LP	LN	LP	LP	LP	LN	LN	LN	LN	LN	LN	1																															
17	LN	LN	LN	LN	MP	LN	MP	LN	LP	LN	LN	LN	LP	LN	LN	HP	1																														
18	MP	HP	LN	HP	LP	HP	HP	LN	LP	LN	-	LP	HP	MP	HP	LN	LN	1																													
19	LN	LN	-	LN	-	LN	LN	LP	LP	LN	LP	LN	LN	LN	LN	-	-	LN	1																												
20	LP	LP	LN	LP	LP	LP	LP	LP	LP	LN	LN	LN	MP	LN	MP	LP	LP	MP	LN	1																											
21	LP	MP	LN	HP	LP	HP	MP	LN	-	LN	LP	LP	MP	HP	LP	LN	LN	MP	LN	LN	1																										
22	MP	HP	-	HP	LP	HP	MP	LN	LP	LN	LP	LP	HP	LP	HP	LN	LN	HP	LN	MP	LP	1																									
23	MP	HP	LN	HP	-	HP	MP	LN	LN	-	LN	LP	HP	LP	HP	LN	LN	HP	LN	MP	LP	HP	1																								
24	MP	HP	LN	HP	-	HP	HP	LN	LN	LP	-	LP	HP	HP	HP	LN	LN	HP	LN	LP	HP	HP	HP	1																							
25	MP	HP	LN	HP	LP	HP	MP	LN	LP	LN	-	LN	HP	LP	HP	LN	LN	HP	LN	MP	LP	HP	HP	HP	1																						
26	MP	HP	LN	HP	LP	HP	HP	LN	LP	LP	LP	LP	HP	HP	HP	LN	LN	HP	LN	LP	HP	HP	HP	HP	HP	1																					
27	LP	MP	LP	MP	LP	LP	MP	LP	LP	LP	MP	LP	MP	LP	HP	LN	LN	HP	LN	LP	LP	HP	HP	HP	MP	HP	1																				
28	LP	HP	LN	HP	-	HP	LP	-	LP	LN	LP	LP	MP	MP	MP	LN	LN	HP	LN	-	MP	MP	MP	HP	MP	MP	MP	1																			
29	LN	LN	LP	LN	LP	LN	LP	MP	LP	LN	LP	LP	LP	LN	LP	LP	LP	LN	LP	MP	LN	LN	-	LN	LN	-	LN	LN	1																		
30	LN	LP	LP	-	LP	LN	LN	LP	LP	HP	LP	-	MN	LN	LN	LN	LN	LN	LN	MN	-	LN	LN	LN	LN	-	LP	LP	LN	1																	
31	LN	LP	LP	LN	LN	LP	LN	LN	LN	LP	-	LP	MN	LP	MN	MN	LN	MN	LP	HN	LP	LN	MN	LN	LN	LN	LN	LP	MN	MP	1																
32	MP	HP	LN	HP	LN	HP	MP	LN	LN	LN	LN	LP	HP	LP	HP	LN	LN	HP	LN	MP	LP	HP	HP	HP	HP	HP	MP	MP	-	MN	MN	1															
33	-	LP	LP	LP	-	LP	-	LN	LP	LP	MP	LP	LN	MP	LN	LN	LN	LN	LP	MN	MP	-	LN	LN	LN	-	LP	LP	LN	MP	HP	LN	1														
34	LN	MN	LN	LN	LP	LN	LP	LP	-	LN	LP	LN	LN	LN	LN	MP	MP	LN	LP	MP	LN	MN	LN	LN	LN	LN	MN	MN	HP	LN	MN	LN	LN	1													
35	LP	MP	LN	HP	LP	HP	MP	LN	LN	LN	LP	LP	MP	HP	MP	LN	-	MP	LN	LP	HP	LP	MP	HP	LP	MP	LP	MP	LN	LN	LP	MP	LP	LN	1												
36	LN	MN	LN	LN	LP	LN	LP	MP	LP	LN	LP	LN	LP	MN	LP	MP	LP	LN	LP	HP	MN	LN	-	LN	LN	LN	LN	LN	HP	LN	HN	LP	MN	HP	LN	1											
37	MN	LN	LP	-	-	LN	LN	LP	LP	-	LP	LP	-	LN	LP	-	LN	LP	LN	-	-	-	LP	-	LN	LP	-	-	LP	-	LN	LP	LN	LP	LN	LP	1										
38	HN	MN	LP	MN	-	MN	LN	LP	LP	LN	LP	-	MN	LN	LN	-	-	LN	LP	LN	LN	MN	LN	MN	MN	LN	LN	LN	LP	-	LN	MN	LN	LP	LN	LP	HP	1									
39	MN	LN	LP	LP	-	-	LN	LP	LP	LP	LP	LP	-	-	LP	LN	LN	LP	LN	-	LP	LP	LP	LP	-	LP	LP	-	LP	-	LN	-	LN	LP	-	LP	HP	HP	1								
40	MN	LN	LP	LN	-	LN	LN	LP	LP	-	LP	LP	LN	LN	-	LN	LN	LN	LN	LN	-	-	LN	LN	LN	-	-	LN	LP	-	LN	LN	-	LP	-	LP	HP	HP	HP	1							
41	MN	-	-	LP	LN	LP	-	LP	LP	LN	LP	LP	LP	-	LP	LN	LN	LP	-	-	LP	LP	LP	LP	-	LP	-	LP	LP	LN	LN	LP	LN	LP	LN	LP	HP	HP	HP	MP	1						
42	MN	LN	-	-	LN	LN	LN	LP	-	-	LP	LP	LN	LN	-	LN	LN	LN	LP	LN	-	LN	LN	LN	LN	LN	LN	LN	LP	-	LN	-	LN	LP	LN	-	HP	HP	HP	MP	HP	1					
43	MP	LP	LP	LP	LP	LP	LN	LN	LP	LP	LP	LP	LN	LP	LN	LN	LN	LN	LN	LN	LP	-	LN	-	-	-	LP	LP	LN	MP	MP	LN	LP	LN	LP	MN	MN	MN	MN	LN	MN	MN	1				
44	LN	LN	LP	LN	-	LN	LN	LP	LP	LP	LP	LP	MN	LN	LN	LP	LN	LN	LP	LN	LN	LN	MN	MN	LN	LN	LN	LN	-	LP	LP	MN	LP	LP	LN	-	LN	LP	LP	LP	-	LN	LP	1			
45	LP	LP	LP	-	LP	LP	LN	LN	LN	LP	LN	LP	LN	LN	LN	LN	LN	LN	-	LN	LN	LP	LN	LN	LP	LN	LP	LP	LN	LP	MP	LN	LP	LN	-	MN	MN	MN	LN	LN	MN	MN	MP	LP	1		
46	MN	LN	LP	MN	-	LN	LN	LP	LN	-	LP	-	LN	LN	LN	-	LN	MN	LP	LN	MN	LN	LN	MN	MN	MN	LN	LN	LP	LP	-	LN	LN	LP	LN	LP	LP	MP	LP	LP	LP	LP	LN	LP	LP	1	
47	MP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LN	-	LP	LP	LP	-	-	LP	LP	LN	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LP	LP	LN	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	MN	1
48	MP	LP	LP	LP	LP	LP	-	LN	LP	LP	-	-	-	-	-	LP	-	LP	LP	LN	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LP	LP	LN	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	LN	HP

Table A4 Correlation Matrix – 2 miles Buffer Width

2 miles	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																													
3	LN	LN	1																																												
4	MP	HP	MN	1																																											
5	-	LN	MP	LN	1																																										
6	MP	HP	MN	HP	LN	1																																									
7	LP	MP	MN	HP	LP	HP	1																																								
8	LP	LP	LP	LP	MP	LP	LP	1																																							
9	LN	LN	LP	LN	MP	LN	LP	MP	1																																						
10	-	MP	LN	LP	LN	LP	LN	MN	LN	1																																					
11	LP	LP	LP	LP	MP	LP	HP	HP	MP	LN	1																																				
12	LP	LP	LP	LP	LP	MP	LP	MP	LP	LN	LP	1																																			
13	MP	HP	MN	HP	LP	HP	HP	MP	-	LN	MP	LP	1																																		
14	MP	HP	LN	HP	LP	HP	HP	LP	LN	LN	MP	MP	HP	1																																	
15	MP	HP	MN	HP	LN	HP	HP	MP	-	LN	MP	LP	HP	HP	1																																
16	LN	MN	LN	LN	LP	MN	LP	LP	LP	LN	LP	MN	LP	LN	LP	1																															
17	LN	MN	LN	LN	LP	LN	MP	-	-	LN	LP	MN	LP	LN	-	HP	1																														
18	MP	HP	MN	HP	LN	HP	HP	MP	LP	LN	LP	MP	HP	HP	HP	LN	LN	1																													
19	LN	MN	LP	MN	LN	MN	MN	LN	LN	LN	LN	LN	LN	LN	MN	-	LN	LN	1																												
20	LP	-	MN	MP	LN	MP	MP	HP	LP	MN	LP	LP	HP	MP	HP	MP	LP	HP	LN	1																											
21	MP	HP	LN	HP	LP	HP	HP	LP	-	LN	LP	MP	HP	HP	HP	MN	LN	HP	LN	LP	1																										
22	MP	HP	LN	HP	LP	HP	HP	MP	LP	LN	MP	MP	HP	HP	HP	MN	LN	HP	MN	LP	HP	1																									
23	MP	HP	MN	HP	LN	HP	HP	MP	-	LN	MP	MP	HP	HP	HP	LN	LN	HP	MN	HP	HP	HP	1																								
24	MP	HP	MN	HP	LN	HP	HP	LP	LN	LN	LP	MP	HP	HP	HP	LN	LN	HP	MN	MP	HP	HP	HP	1																							
25	MP	HP	LN	HP	LP	HP	HP	MP	LP	LP	MP	LP	HP	HP	HP	LN	LN	HP	MN	LP	HP	HP	HP	HP	1																						
26	MP	HP	LN	HP	LP	HP	HP	MP	LP	LN	MP	MP	HP	HP	HP	LN	LN	HP	MN	MP	HP	HP	HP	HP	HP	1																					
27	MP	HP	LP	HP	LP	HP	HP	MP	MP	LN	HP	MP	HP	HP	HP	LN	LN	HP	MN	LP	HP	HP	HP	HP	HP	HP	1																				
28	LP	HP	LN	HP	-	HP	MP	MP	LP	-	MP	MP	HP	HP	HP	LN	LN	HP	MN	MP	HP	HP	HP	HP	HP	HP	HP	1																			
29	LN	LN	LN	LN	LN	-	LP	HP	LP	MN	-	LP	LP	LN	LP	MP	LP	LP	LP	HP	LN	LN	LP	LP	LN	LP	LN	LP	1																		
30	-	LP	MP	LP	LP	-	LN	LN	LP	HP	MP	LN	LN	LN	LN	LN	LN	LN	MN	MN	-	LP	LN	LN	LP	LP	LP	LP	MN	1																	
31	LP	HP	LP	LP	LN	MP	LN	LN	LN	HP	LN	LP	LN	LP	LN	HN	MN	LN	LN	HN	MP	LP	LN	LP	LP	LP	LP	MP	HN	MP	1																
32	MP	HP	MN	HP	LN	HP	HP	MP	-	LN	MP	MP	HP	HP	HP	LN	LN	HP	LN	HP	HP	HP	HP	HP	HP	HP	HP	HP	LP	LN	LN	1															
33	LP	HP	LP	MP	LP	MP	LP	LN	-	MP	LP	LP	LP	MP	LP	MN	LN	LP	LN	MN	HP	MP	LP	LP	MP	MP	MP	MP	MN	MP	HP	LP	1														
34	LN	HN	LN	MN	LN	LN	LN	LP	-	LN	LN	LN	LN	MN	LN	MP	LP	LN	LP	MP	MN	MN	LN	LN	MN	LN	MN	LN	HP	MN	MN	LN	HN	1													
35	MP	HP	MN	HP	LP	HP	HP	LP	LN	LN	MP	LP	HP	HP	HP	LN	LN	HP	MN	MP	HP	HP	HP	HP	HP	HP	HP	HP	LN	-	LP	HP	MP	LN	1												
36	LN	LN	LN	-	LN	LP	LP	HP	LP	MN	LP	-	MP	-	MP	HP	LP	LP	LP	HP	LN	LN	LP	LP	-	LP	-	LP	HP	MN	HN	MP	HN	HP	LP	1											
37	MN	LN	LP	LN	-	LN	LN	LP	-	LN	LN	LP	-	LN	LN	-	-	LP	LN	LP	LN	LN	LN	LN	LN	LN	LN	LN	LP	LN	LN	-	LN	LP	LN	LP	1										
38	HN	MN	LP	MN	-	MN	LN	LN	-	LN	LN	LN	MN	MN	MN	LP	LP	MN	LP	LN	MN	MN	MN	MN	MN	MN	LN	MN	LP	-	LN	MN	LN	LP	MN	-	HP	1									
39	MN	LN	-	-	-	-	-	LP	LN	LN	-	LP	LP	-	LP	LP	-	LP	LN	LP	-	-	LP	-	LN	LP	-	-	LP	LN	LN	LP	LN	LP	-	LP	HP	HP	1								
40	MN	LN	LP	LN	-	LN	LN	LP	LN	LN	LN	LP	LN	LN	LN	-	LN	LN	-	-	LN	LN	LN	LN	LN	LN	LN	LN	LP	LN	LN	LN	LN	LP	LN	LP	HP	HP	HP	1							
41	MN	LN	LN	LP	LN	-	-	LP	LN	LN	LN	LP	LP	-	LP	LN	LN	LP	-	LP	-	-	LP	LP	LN	LP	-	-	LP	LN	LN	LP	LN	LP	-	LP	HP	HP	HP	MP	1						
42	MN	LN	-	LN	LN	LN	LN	-	LN	-	LN	LP	LN	LN	LN	-	LN	LN	LP	-	LN	LN	LN	LN	LN	LN	LN	LN	LP	LN	LN	LN	LN	LP	LN	-	HP	HP	HP	MP	HP	1					
43	MP	LP	LP	-	LP	LP	LN	LN	LP	LP	LN	-	LN	-	LN	LN	LN	LN	LN	MN	LP	LP	LN	LN	LP	-	-	LP	LN	LP	MP	LN	MP	LN	-	MN	MN	MN	MN	LN	MN	MN	1				
44	LN	LN	LP	MN	LP	LN	LN	LN	-	LP	LN	LN	MN	MN	LN	LP	LP	MN	LP	LN	LN	LN	MN	MN	LN	MN	LN	LN	-	LP	LP	MN	-	LP	LN	LN	LN	LP	LP	LP	-	LN	LP	1			
45	LP	LP	LP	-	LP	-	LN	LN	LN	LP	LN	-	LN	LN	LN	LN	LN	LN	LN	MN	-	LP	LN	LN	LP	LN	LP	-	LN	MP	MP	LN	LP	LN	LN	MN	MN	MN	LN	LN	MN	MN	MP	LP	1		
46	MN	MN	LP	MN	-	MN	MN	LN	LN	LP	LN	LN	MN	MN	LN	LP	-	MN	LP	LN	MN	MN	MN	MN	LN	MN	LN	MN	LP	-	LN	MN	LN	LP	LN	LP	LP	MP	LP	LP	LP	LP	LN	LP	LP	1	
47	MP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LN	-	LP	LP	LP	LN	LN	-	-	LN	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LP	LP	LN	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	MN	1
48	MP	LP	LP	LP	LP	LP	-	LN	LP	LP	-	-	-	LP	-	LN	LN	-	LP	LN	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LP	LP	LN	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	LN	HP

Table A5 Correlation Matrix – 3 miles Buffer Width

3 miles	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1
3	LN	LN	1
4	MP	HP	MN	1
5	LP	LP	MP	LP	1
6	MP	HP	MN	HP	LP	1
7	LP	LP	MN	HP	MP	HP	1
8	LP	LP	LN	MP	MP	HP	HP	1
9	LP	-	LP	LP	HP	LP	LP	HP	1
10	-	HP	LP	LP	LN	LP	LN	MN	MN	1
11	LP	MP	LN	HP	MP	HP	HP	HP	MP	LN	1
12	LP	LP	MP	MP	MP	MP	-	MP	LP	LN	LP	1
13	MP	MP	HN	HP	LP	HP	HP	HP	LP	LN	HP	LP	1
14	MP	HP	MN	HP	LP	HP	HP	MP	LP	LP	HP	MP	HP	1
15	LP	MP	HN	HP	LP	HP	HP	HP	LP	LN	HP	LN	HP	HP	1
16	LN	MN	MN	LN	LN	LN	MP	LP	LN	MN	LP	MN	LP	LN	MP	1
17	LN	MN	LN	LN	LN	LN	MP	LN	LN	LN	LP	LN	LP	LN	LP	HP	1
18	LP	MP	HN	HP	LP	HP	HP	HP	MP	MN	HP	LP	HP	HP	HP	LP	LN	1
19	LN	MN	LP	MN	LN	HN	MN	LN	LN	LN	LN	-	MN	MN	MN	LP	MP	LN	1
20	LP	LN	HN	MP	LN	MP	HP	HP	LP	MN	HP	LP	HP	MP	HP	HP	MP	HP	LN	1
21	MP	HP	LN	HP	LP	HP	MP	MP	LP	LP	MP	MP	HP	HP	MP	MN	MN	HP	MN	LP	1
22	MP	HP	-	HP	MP	HP	MP	HP	MP	LP	HP	MP	HP	HP	HP	MN	MN	HP	MN	LP	HP	1
23	MP	HP	MN	HP	LP	HP	HP	HP	LP	LN	HP	LP	HP	HP	HP	LP	LN	HP	MN	HP	HP	HP	1
24	MP	HP	MN	HP	LP	HP	HP	HP	LP	-	HP	MP	HP	HP	HP	LN	LN	HP	MN	HP	HP	HP	HP	1
25	MP	HP	LN	HP	LP	HP	HP	MP	LP	LP	HP	LP	HP	HP	HP	LN	LN	HP	HN	LP	HP	HP	HP	HP	1
26	MP	HP	MN	HP	LP	HP	HP	HP	MP	LN	HP	MP	HP	HP	HP	LN	LN	HP	HN	MP	HP	HP	HP	HP	HP	1
27	MP	HP	-	HP	MP	HP	HP	HP	HP	LN	HP	MP	HP	HP	HP	LN	LN	HP	MN	MP	HP	HP	HP	HP	HP	HP	1
28	MP	HP	LN	HP	LP	HP	MP	HP	LP	LP	HP	MP	HP	HP	HP	MN	MN	HP	HN	LP	HP	HP	HP	HP	HP	HP	HP	1
29	LN	LN	MN	LP	LN	LP	LP	HP	LP	MN	LP	LP	MP	LP	LP	MP	LP	MP	LP	HP	LN	-	LP	LP	-	LP	LP	LP	1
30	LP	HP	MP	MP	LP	MP	LP	LN	LP	HP	LP	-	LN	MP	LP	MN	MN	LN	MN	MN	MP	MP	LP	LP	MP	MP	MP	MP	MN	1
31	LP	HP	MP	LP	-	MP	LN	LN	LN	HP	LN	LP	LN	LP	LN	HN	MN	LN	LN	HN	MP	MP	LN	LP	MP	LP	LP	MP	HN	HP	1
32	MP	MP	MN	HP	LP	HP	HP	HP	LP	MN	HP	MP	HP	HP	HP	-	LN	HP	MN	HP	HP	HP	HP	HP	HP	HP	HP	HP	MP	LN	LN	1
33	LP	HP	MP	MP	MP	MP	LP	-	LP	MP	LP	MP	-	MP	LN	HN	MN	-	LN	MN	HP	HP	LP	LP	MP	MP	MP	MP	MN	HP	HP	LP	1
34	LN	HN	MN	LN	LN	LN	LP	MP	LP	MN	LP	LN	LP	LN	LP	HP	MP	LP	LP	HP	MN	MN	-	LN	MN	LN	LN	LN	HP	HN	HN	LP	HN	1
35	MP	HP	MN	HP	LP	HP	HP	MP	-	LP	HP	LP	HP	HP	HP	-	-	HP	HN	MP	HP	HP	HP	HP	HP	HP	HP	HP	LN	MP	LP	HP	MP	LN	1
36	-	LN	HN	LP	LN	LP	MP	HP	LP	MN	MP	-	HP	LP	HP	HP	MP	HP	LN	HP	LN	-	MP	MP	LP	MP	LP	LP	HP	MN	HN	HP	HN	HP	LP	1
37	MN	LN	-	LN	LN	LN	LN	LP	-	LN	LN	LP	LN	LN	LN	-	-	LP	LN	LP	LN	LN	LN	LN	LN	LN	LN	LN	LP	LN	LN	-	LN	LP	LN	LP	1
38	HN	MN	LP	MN	LN	MN	MN	LN	LN	LN	LN	LN	MN	MN	MN	LP	LP	MN	LP	LN	MN	MN	MN	MN	MN	MN	MN	MN	-	LN	LN	MN	LN	LP	MN	LN	HP	1
39	MN	LN	LN	-	-	LP	-	LP	LP	LN	-	LP	LP	-	LP	LP	-	LP	LN	LP	-	-	LP	LP	-	LP	-	-	LP	LN	LN	LP	LN	LP	-	LP	HP	HP	1
40	MN	LN	-	LN	-	LN	LN	-	-	LN	-	LP	LN	LN	LN	LP	LP	-	-	LP	LN	LN	LN	LN	LN	LN	LN	LN	LP	LN	LN	LN	LN	LP	LN	LP	HP	HP	HP	1
41	MN	LN	LN	-	LN	LP	LN	LP	-	LN	-	LP	LP	-	-	-	LN	LP	LN	LP	-	-	LP	LP	-	-	LN	-	LP	LN	LN	LP	LN	LP	LN	LP	HP	HP	HP	MP	1
42	MN	LN	LN	LN	LN	LN	LN	-	LN	LP	LN	LP	LN	LN	LN	-	LP	LN	LN	-	LN	LN	LN	LN	LN	LN	LN	LN	LP	LN	LN	LN	LN	-	LN	-	HP	HP	HP	MP	HP	1
43	MP	LP	LP	-	LP	-	LN	LN	-	LP	LN	-	LN	LN	LN	LN	LN	LN	LN	MN	LP	LP	LN	LN	LP	LN	-	-	LN	LP	MP	LN	MP	LN	LN	MN	MN	MN	MN	LN	MN	MN	1
44	LN	LN	LP	LN	-	MN	LN	LN	LN	LP	LN	LN	LN	LN	LN	LP	LP	LN	LP	LN	LN	LN	LN	MN	LN	LN	LN	LN	LN	LP	LP	LN	LN	-	LN	LN	LN	LP	LP	LP	-	LN	LP	1
45	LP	LP	MP	LN	LP	-	LN	LN	-	LP	LN	-	LN	LN	LN	MN	LN	MN	LN	MN	LP	LP	LN	LN	LP	LN	LP	LP	MN	MP	MP	LN	MP	MN	LN	MN	MN	MN	LN	LN	MN	MN	MP	LP	1
46	MN	LN	LP	MN	-	MN	LN	LN	LN	LP	LN	LN	MN	MN	LN	LP	LP	MN	LP	LN	MN	LN	MN	MN	MN	MN	LN	MN	-	-	LN	MN	LN	LP	LN	-	LP	MP	LP	LP	LP	LP	LN	LP	LP	1
47	MP	LP	LP	LP	LP	LP	LP	-	LP	LP	LP	LN	-	LP	-	LN	LN	-	-	LN	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	-	LP	LN	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	MN	1
48	MP	LP	LP	LP	LP	LP	LP	-	LP	LP	LP	-	-	LP	-	LN	LN	-	-	LN	LP	LP	-	LP	LP	LP	LP	LP	LN	LP	LP	-	LP	LN	LP	LN	MN	HN	MN	LN	MN	MN	MP	LP	MP	LN	HP

Table A6 Correlation Matrix for CBD Area with 0.5 miles Buffer Width

0.5 miles_CBD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																													
3	-	-	1																																												
4	LP	LP	-	1																																											
5	LN	MN	-	LP	1																																										
6	MP	HP	-	HP	LN	1																																									
7	-	LN	-	MP	MP	LP	1																																								
8	LN	LN	-	MN	MP	MN	-	1																																							
9	LP	-	-	HP	MP	HP	MP	LN	1																																						
10	MP	HP	-	-	LN	LP	MN	-	LN	1																																					
11	LN	HN	-	LP	HP	LN	HP	LP	LP	MN	1																																				
12	LN	LN	-	MN	-	LN	-	MP	MN	-	-	1																																			
13	MP	MP	-	HP	-	HP	LP	MN	HP	LP	-	MN	1																																		
14	-	MN	-	LN	MP	-	HP	LP	LN	MN	HP	LP	LN	1																																	
15	HP	HP	-	HP	LN	HP	LP	HN	HP	MP	LN	MN	HP	LN	1																																
16	LN	LN	-	LN	-	LN	LN	MP	LN	LN	LN	MP	LN	LN	LN	1																															
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1																														
18	LP	LP	-	MP	MP	LP	MP	LP	MP	LN	MP	LN	LP	LP	LP	LN	-	1																													
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1																												
20	-	-	-	MN	LN	MN	HN	-	MN	LP	MN	-	MN	MN	MN	MP	-	HN	-	1																											
21	LP	MN	-	LN	MP	LN	HP	MP	-	MN	HP	LP	LN	HP	LN	LN	-	MP	-	MN	1																										
22	HP	HP	-	LP	MN	HP	LN	MN	LP	HP	MN	LN	HP	MN	HP	LN	-	-	-	-	MN	1																									
23	HP	HP	-	HP	MN	HP	LN	MN	MP	HP	MN	MN	HP	MN	HP	LN	-	LP	-	LN	MN	HP	1																								
24	HP	HP	-	HP	LN	HP	LP	MN	MP	MP	LN	MN	HP	-	HP	LN	-	LP	-	MN	-	HP	HP	1																							
25	HP	HP	-	MP	MN	HP	LN	MN	MP	HP	HN	LN	HP	MN	HP	LN	-	LP	-	-	MN	HP	HP	HP	1																						
26	HP	HP	-	HP	LN	HP	LP	MN	MP	MP	LN	MN	HP	-	HP	LN	-	LP	-	LN	LN	HP	HP	HP	HP	1																					
27	HP	HP	-	LP	LN	HP	LN	LN	LP	HP	LN	MN	HP	LN	HP	LN	-	LP	-	-	LN	HP	HP	HP	HP	HP	1																				
28	LP	LP	-	HP	MP	MP	LP	MN	HP	LN	-	MN	HP	-	LP	LN	-	MP	-	LN	-	LP	LP	LP	MP	LP	LP	1																			
29	LN	MN	-	MN	-	HN	MN	-	MN	LP	MN	LP	MN	MN	MN	MP	-	HN	-	HP	MN	-	MN	MN	LN	LN	LN	MN	1																		
30	LN	MN	-	LN	HP	LN	HP	MP	-	MN	HP	LP	LN	HP	LN	LP	-	LP	-	LN	HP	MN	MN	LN	MN	LN	LN	LN	LN	1																	
31	LN	MN	-	MN	LP	MN	MP	MP	MN	LN	MP	MP	HN	HP	HN	-	-	LP	-	LN	HP	MN	HN	MN	HN	MN	MN	LN	LN	HP	1																
32	HP	HP	-	MP	HN	HP	LN	MN	LP	HP	MN	MN	HP	MN	HP	LN	-	-	-	-	MN	HP	HP	HP	HP	HP	HP	-	LN	HN	HN	1															
33	LN	LN	-	LN	LP	LP	HP	-	LN	LN	MP	MP	LN	HP	LN	-	-	-	-	LN	HP	LN	LN	-	LN	-	LN	LN	LN	HP	HP	LN	1														
34	-	LP	-	LN	LP	-	MN	LP	LN	-	MN	LP	LN	LN	LN	HP	-	MN	-	HP	LN	-	-	LN	LP	-	-	LP	MP	LN	LN	LN	LN	1													
35	-	LP	-	LN	LP	LP	LP	-	LN	LN	LP	MP	-	HP	LN	LP	-	LN	-	-	MP	LN	LN	LP	-	LP	LN	-	LN	HP	MP	LN	HP	LP	1												
36	LN	-	-	MN	LN	MN	HN	LP	MN	LP	HN	MP	MN	MN	MN	HP	-	HN	-	HP	MN	-	LN	MN	LN	LN	-	MN	HP	LN	LN	-	LN	HP	-	1											
37	MN	LP	-	LP	-	LP	-	LN	LP	LN	LN	LP	LP	LN	LP	-	-	LN	-	-	LN	-	-	-	-	-	LN	LP	LN	LN	LN	LN	LN	LP	LP	LP	1										
38	HN	LN	-	LP	LP	LN	LP	-	LP	LN	LP	LN	LN	LN	LN	LN	-	-	-	-	LN	LN	LN	MN	LN	LN	MN	LP	LP	-	LN	LN	LN	-	LN	-	MP	1									
39	MN	LP	-	LP	LP	LP	LP	LN	LP	-	-	LN	LP	LN	LP	MN	-	LP	-	LN	LN	LP	LP	LP	-	LP	-	LP	LN	LN	LN	LP	-	LN	-	LN	HP	HP	1								
40	MN	-	-	LP	LP	LP	LP	MN	LP	-	LP	LN	LP	LN	LP	MN	-	-	-	LN	LN	LP	-	-	-	-	-	LP	-	LN	-	-	-	LN	-	LN	HP	HP	HP	1							
41	LN	LP	-	LP	LP	LP	LP	-	LP	LP	LP	LN	LP	-	LP	MN	-	LP	-	LN	LN	LP	LP	LP	-	LP	-	LP	LN	LN	LN	-	LN	-	-	LN	HP	MP	MP	MP	1						
42	MN	-	-	LP	LP	LP	LP	MN	LP	LN	LP	LN	-	-	-	HN	-	LP	-	LN	-	-	LN	-	LN	-	LN	LP	LN	LN	-	-	-	MN	LN	MN	MP	HP	HP	HP	MP	1					
43	HP	-	-	LP	LP	LP	LP	-	LP	-	LP	LP	MP	MP	MP	LP	-	LP	-	LN	MP	-	LP	MP	LP	LP	LP	LP	LN	MP	-	LP	LP	-	LP	LN	MN	HN	MN	LN	LN	MN	1				
44	LP	LP	-	LP	LP	LP	LP	-	LP	-	LP	LN	MP	LP	LP	-	-	LP	-	LN	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	-	LP	LP	-	-	LN	MN	LN	-	-	LN	LN	HP	1			
45	MP	LP	-	LP	-	LP	-	LN	LP	LP	LN	LN	MP	-	MP	LP	-	-	-	-	-	LP	MP	MP	MP	MP	MP	LP	-	-	LN	MP	-	LP	-	-	LN	MN	LN	LN	-	LN	MP	LP	1		
46	LN	LN	-	LP	-	LN	LN	LN	LP	LN	LN	LN	-	MN	-	-	-	MN	-	LP	MN	-	-	LN	-	-	LN	LP	LP	LN	LN	-	LN	LP	LN	LP	LP	MP	LP	LP	LP	LP	LN	LN	LP	1	
47	HP	LP	-	LP	LN	MP	-	LP	LP	LP	-	LP	MP	LP	LP	-	-	LP	-	LN	LP	LP	MP	MP	MP	MP	MP	LP	LN	LP	LN	LP	-	LP	LP	LN	LN	HN	MN	LN	LN	HN	HP	MP	LP	HN	1
48	HP	MP	-	LP	LN	LP	LN	LP	-	LP	LN	-	LP	-	LP	-	-	LP	-	LN	LP	LP	MP	MP	MP	MP	MP	LP	LN	LN	LN	LP	LN	-	-	LN	MN	HN	MN	MN	MN	HN	MP	LP	LP	MN	HP

Table A7 Correlation Matrix for CBD Area with 1-mile Buffer Width

CBD_1mile	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																													
3	-	-	1																																												
4	LP	HP	-	1																																											
5	LP	LP	-	HP	1																																										
6	LP	HP	-	HP	HP	1																																									
7	MP	HP	-	HP	HP	HP	1																																								
8	LN	MN	-	LN	-	LN	LN	1																																							
9	LP	MP	-	HP	HP	HP	HP	-	1																																						
10	LP	MP	-	-	MN	LP	LP	LN	LP	1																																					
11	LP	MP	-	HP	MP	HP	HP	-	HP	MP	1																																				
12	LN	-	-	-	LN	-	LN	LP	LN	LN	LN	1																																			
13	MP	HP	-	HP	HP	HP	HP	LN	HP	LP	MP	LN	1																																		
14	LN	-	-	HP	MP	MP	HP	LP	HP	-	HP	LP	LP	1																																	
15	MP	HP	-	HP	MP	HP	HP	MN	HP	LP	MP	LN	HP	-	1																																
16	LN	MN	-	HN	LN	MN	MN	LP	MN	LN	MN	LP	HN	LN	HN	1																															
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1																														
18	MP	HP	-	MP	HP	MP	HP	LN	MP	LN	LP	-	HP	-	HP	MN	-	1																													
19	LN	MN	-	HN	MN	MN	MN	MP	MN	-	LN	LP	HN	LN	MN	MP	-	MN	1																												
20	LP	-	-	MN	LN	LN	MN	-	MN	LN	HN	LN	LN	HN	-	LP	-	LP	LP	1																											
21	LN	-	-	HP	MP	MP	HP	LP	HP	-	HP	LP	LP	HP	-	LN	-	-	LN	HN	1																										
22	MP	HP	-	LP	-	MP	LP	LN	LP	LP	-	LN	MP	LN	HP	LN	-	HP	LN	MP	MN	1																									
23	LP	HP	-	MP	LP	HP	MP	MN	MP	LP	-	LN	HP	LN	HP	MN	-	HP	MN	LP	LN	HP	1																								
24	LP	HP	-	HP	MP	HP	HP	LN	HP	MP	HP	-	HP	MP	HP	HN	-	HP	MN	LN	MP	HP	HP	1																							
25	LP	HP	-	LP	LP	MP	LP	MN	LP	LP	-	LN	HP	LN	HP	LN	-	MP	LN	MP	LN	HP	HP	MP	1																						
26	LP	HP	-	HP	MP	HP	HP	LN	HP	MP	HP	LN	HP	MP	HP	HN	-	MP	MN	LN	MP	MP	HP	HP	HP	1																					
27	LP	HP	-	MP	LP	HP	HP	LN	MP	HP	HP	MN	HP	LP	HP	MN	-	LP	LN	LN	LP	HP	HP	HP	HP	HP	1																				
28	LP	MP	-	HP	HP	HP	HP	-	HP	MN	LP	LN	HP	MP	MP	LN	-	HP	MN	-	MP	LP	LP	MP	LP	MP	-	1																			
29	LP	-	-	MN	LN	LN	LN	-	LN	LP	MN	LN	LN	HN	-	LP	-	-	MP	HP	HN	MP	LP	LN	LP	LN	LP	LN	1																		
30	LN	LN	-	MP	MP	MP	MP	LP	MP	LN	HP	MP	LP	HP	LN	-	-	LN	-	HN	HP	MN	MN	LP	MN	LP	-	LP	MN	1																	
31	LN	LN	-	MP	LP	LP	LP	LP	LP	-	HP	LP	-	HP	LN	LN	-	MN	-	HN	HP	HN	MN	LP	HN	LP	-	LP	HN	HP	1																
32	LP	HP	-	LP	LN	LP	LP	MN	LP	MP	LN	-	MP	MN	HP	MN	-	MP	LN	MP	MN	HP	HP	MP	HP	MP	MP	-	MP	MN	HN	1															
33	LN	LN	-	MP	MP	MP	MP	LP	MP	-	HP	LP	LP	HP	-	LN	-	LN	LN	HN	HP	MN	MN	LP	MN	LP	LP	LP	HN	HP	HP	MN	1														
34	LN	LN	-	-	MP	LN	LN	LP	-	MN	MN	LP	-	MN	-	MP	-	LP	LP	HP	LN	-	LP	LN	LP	LN	LN	LP	MP	LN	MN	-	MN	1													
35	-	LP	-	HP	MP	MP	MP	-	MP	LN	MP	MP	LP	HP	LP	LN	-	LP	LN	MN	HP	LN	-	MP	LN	LP	-	MP	MN	HP	HP	LN	HP	-	1												
36	LN	LN	-	HN	HN	HN	HN	LP	HN	LN	HN	-	MN	HN	LN	MP	-	LN	MP	HP	HN	LP	-	HN	LP	HN	LN	MN	HP	HN	HN	LP	HN	MP	MN	1											
37	MN	LP	-	-	LN	LP	-	LN	-	LN	LN	MP	-	-	LP	-	-	LP	LP	LP	-	LP	LP	LP	LP	-	LN	-	LP	-	LN	LP	LN	LP	LP	LP	1										
38	HN	-	-	-	-	LP	-	LP	LP	-	-	-	-	LP	-	LN	-	-	LP	-	LP	-	LP	LP	-	LP	LP	-	-	LP	-	-	-	-	-	-	MP	1									
39	MN	LP	-	LP	-	LP	-	-	LP	LN	-	-	LP	-	LP	LN	-	LP	-	LP	-	LP	LP	LP	LP	LP	LP	LP	-	-	LN	LP	-	-	LP	-	HP	HP	1								
40	MN	LP	-	LP	-	MP	LP	-	MP	LP	LP	LN	LP	LP	LP	LN	-	LP	LN	-	LP	LP	LP	MP	LP	LP	LP	LP	-	LP	-	LP	LP	LN	LP	LN	HP	HP	HP	1							
41	LN	MP	-	MP	LP	LP	LP	-	MP	-	-	LP	MP	LP	LP	LN	-	MP	LN	-	LP	LP	LP	MP	LP	LP	LP	LP	LN	-	-	LP	-	-	LP	LN	HP	MP	MP	MP	1						
42	MN	LP	-	LP	-	LP	LP	LN	LP	LP	LP	LN	LP	LP	LP	MN	-	LP	LN	LN	LP	LP	LP	MP	-	MP	MP	-	LN	LP	-	LP	-	LN	-	LN	MP	HP	HP	HP	MP	1					
43	HP	LP	-	MP	MP	LP	MP	-	MP	LP	MP	-	LP	LP	LP	LP	-	LP	LN	LN	LP	-	-	LP	-	LP	LP	LP	LN	LP	LP	LN	LP	-	LP	MN	MN	HN	MN	LN	LN	MN	1				
44	LP	LP	-	MP	LP	LP	MP	LN	LP	LP	MP	LN	LP	LP	MP	LP	-	LP	LN	LN	LP	LP	LP	LP	-	LP	LP	LP	LN	LP	LP	LP	LP	-	LP	LN	MN	LN	-	-	LN	LN	HP	1			
45	MP	MP	-	LP	MP	LP	LP	-	LP	-	LP	LN	MP	LN	LP	-	-	LP	LN	LP	-	LP	LP	LP	LP	LP	LP	MP	LP	LN	LN	LP	LN	LP	-	LN	LN	MN	LN	LN	-	LN	MP	LP	1		
46	LN	-	-	LN	-	-	-	LP	-	LP	-	LN	LN	LN	LN	LP	-	-	LP	LP	LN	LP	LN	LN	LN	-	LP	-	LP	LN	LN	-	LN	LP	MN	LP	LP	MP	LP	LP	LP	LP	LN	LN	LP	1	
47	HP	LP	-	LP	LP	LP	LP	LN	LP	-	-	LP	LP	-	LP	LP	-	MP	LN	-	-	-	-	LP	-	-	LN	LP	LN	-	-	-	-	-	LP	LN	LN	HN	MN	LN	LN	HN	HP	MP	LP	HN	1
48	HP	LP	-	-	LP	-	LP	LN	LN	LN	LN	-	LP	LN	LP	LP	-	MP	MN	LP	LN	-	LP	-	-	LN	LN	LP	LN	LN	LN	LP	LN	-	-	-	MN	HN	MN	MN	MN	HN	MP	LP	LP	MN	HP

Table A8 Correlation Matrix for CBD Fringe / OBD Area with 0.5 miles Buffer Width

0.5 miles_OBD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1
3	LN	LN	1
4	LP	MP	LN	1
5	LN	LN	LP	LN	1
6	LP	HP	LN	LN	LN	1
7	-	-	LN	LN	MP	-	1
8	-	-	LP	LN	LP	LP	-	1
9	LN	LN	-	LN	LP	LN	LP	-	1
10	LP	LP	LN	HP	LN	LN	LN	LN	LN	1
11	LP	LP	LP	-	MP	LP	MP	HP	LP	LN	1
12	-	LP	LN	LN	LN	LP	-	LP	LN	LN	LN	1
13	-	LN	LN	LN	LP	LN	MP	LP	LP	LN	LP	LN	1
14	LP	HP	LN	-	LN	MP	LP	LN	LN	LN	-	MP	LN	1
15	LN	LN	MP	LP	-	LN	LN	LP	LP	LP	LP	LN	LN	LN	1
16	LN	LN	LN	LN	LP	LN	LP	LP	-	LN	LN	LP	LP	LN	LN	1
17	LN	LN	-	-	HP	LN	HP	LN	LP	-	LP	LN	MP	LN	LN	LP	1
18	-	-	LN	-	LP	-	-	-	-	LN	LP	LP	LN	LP	LP	LN	-	1
19	LN	LN	HP	LN	LP	LN	LN	LP	LN	LN	LP	LN	LN	LN	MP	LN	LN	LP	1
20	-	LN	LP	LN	LP	LN	LN	MP	MP	LN	-	LP	-	LN	-	HP	LN	-	LN	1
21	LP	HP	LN	LP	-	LP	LP	-	LN	-	LP	MP	LN	HP	LN	LN	LN	MP	LP	LN	1
22	MP	MP	LN	LP	-	LP	LP	LP	LP	-	MP	-	LP	LP	-	LN	LN	LP	LN	LP	LP	1
23	-	LP	LP	MP	LN	LN	-	LP	MP	MP	LP	-	MN	-	HP	LN	LN	-	LN	-	LP	LP	1
24	MP	HP	LN	HP	LN	LP	LP	LN	LN	MP	-	LP	LN	HP	-	LN	LN	LP	LN	LN	HP	MP	MP	1
25	-	-	LN	-	LP	LN	LN	LP	MP	LN	LP	LN	-	LN	LN	LP	-	LN	LN	LP	LN	LP	-	LN	1
26	LP	MP	-	MP	-	LP	LP	LP	LP	MP	HP	-	MN	MP	LP	LN	LN	MP	-	LN	MP	MP	HP	HP	-	1
27	LP	-	MP	LP	LP	LN	LP	LP	LP	LP	HP	LN	LN	-	LP	LN	LN	MP	LP	LP	LP	MP	LP	LP	-	HP	1
28	LN	LP	LN	LN	LN	MP	LN	LN	LN	LN	MN	-	LN	LP	MN	LN	LN	-	LN	LN	LP	LN	LN	LP	LN	LN	LN	1
29	-	LN	LP	MN	MP	LN	LP	MP	LP	MN	LP	LP	LP	LN	LN	HP	LP	-	LN	HP	LN	LP	LN	MN	LP	LN	LP	LN	1
30	MP	LP	-	HP	LN	LN	LN	-	LN	HP	LP	LN	LN	LN	LP	LN	LN	-	LN	LN	-	LP	MP	MP	-	HP	MP	LN	LN	1
31	LP	HP	LN	LP	LN	HP	LN	-	LN	-	LN	LP	LN	MP	MN	LN	LN	LP	LN	LN	HP	LP	LN	MP	-	LP	LN	HP	MN	LP	1
32	LN	LN	LN	LN	LP	LN	-	LP	LN	LN	-	-	LN	-	LN	-	-	LP	LN	LP	-	-	-	LN	MP	LP	-	-	LP	LN	-	1
33	HP	HP	LN	HP	LN	LP	-	LN	LN	HP	LP	LP	LN	MP	LN	LN	LN	LN	MN	LN	LP	MP	LP	HP	LN	HP	LP	-	LN	MP	MP	-	1
34	LN	LN	-	LN	LP	LN	LP	LP	-	LN	-	LP	-	LN	LP	HP	LP	LN	LN	HP	LN	LN	-	LN	-	LN	LN	LN	HP	LN	LN	-	LN	1
35	LP	MP	LN	LN	LN	MP	LP	LP	LN	LN	LP	HP	LN	HP	LN	-	LN	-	LN	LN	HP	-	LP	HP	MN	LP	LN	LP	-	LN	MP	LN	MP	-	1
36	LN	MN	LP	MN	MP	LN	LP	MP	LP	MN	LP	LP	MP	MN	-	HP	LP	LN	LN	HP	MN	LP	LN	MN	LP	MN	-	MN	HP	MN	MN	-	MN	HP	LN	1
37	HN	LN	LP	LP	-	LN	-	-	LP	LP	LN	LN	LN	LN	LP	LN	-	LP	LP	-	LN	LN	LP	-	LN	-	LP	-	LN	-	MN	LP	LN	LN	LN	-	1
38	HN	MN	LP	-	-	MN	LP	LP	LP	-	-	LN	-	LN	MP	LN	-	LP	LP	LN	LN	LN	LP	LN	LN	-	-	-	LN	LN	MN	LP	MN	LN	LN	-	HP	1
39	HN	MN	-	-	LP	LN	LP	LP	LP	LP	-	LN	-	-	LP	-	LP	LP	-	LP	LN	LN	LP	-	LN	LP	LP	LN	-	-	LN	LP	LN	LP	LN	LP	HP	HP	1
40	MN	MN	LP	-	LP	LN	LP	LP	LP	-	LP	LN	LP	LN	LP	-	LP	LP	LP	-	-	LN	LP	LN	-	-	LP	LN	-	-	MN	LP	LN	-	LN	LP	HP	HP	HP	1
41	MN	LN	LN	LN	LN	LN	LP	LN	MP	LN	LN	-	-	-	-	-	-	LP	LN	LP	-	LN	LP	-	LN	-	LN	LP	-	LN	LN	LP	LN	LN	LN	-	HP	HP	HP	MP	1
42	MN	LN	LN	-	LP	LN	LP	LN	LP	-	-	LN	LP	LN	LP	-	LP	LP	LN	LN	LN	LN	LP	LN	LN	-	LN	-	LN	LN	LN	LP	LN	LN	LN	-	HP	HP	HP	MP	HP	1
43	HP	MP	-	MP	-	-	LN	-	LN	MP	LP	-	LN	LP	LP	LN	LN	LP	-	LN	LP	LP	LP	MP	-	MP	LP	LN	LN	HP	MP	LN	MP	LN	LP	LN	MN	MN	MN	MN	MN	MN	1
44	-	LN	LP	-	-	LN	LP	LN	LP	-	-	-	LP	LN	LP	-	LP	LN	LP	LN	LN	LN	LP	LN	LN	LN	-	LN	-	LP	LN	HN	LN	LP	LN	LP	-	LP	-	LP	-	-	LP	1
45	MP	MP	-	MP	LN	LP	LN	LP	LN	MP	LP	LN	LN	LP	LN	LP	LN	LN	LN	LN	-	-	-	LP	LN	LP	LP	LN	LN	HP	MP	MN	MP	-	LP	LN	MN	MN	LN	LN	MN	MN	MP	-	1
46	MN	LN	LP	LN	LP	LN	-	LP	LN	-	LN	LN	LP	LN	LP	-	LP	LN	LP	LN	LN	MN	LN	LN	LN	LN	LN	-	-	-	LN	LN	MN	LP	LN	LP	LP	MP	MP	LP	LP	LP	MN	LP	-	1
47	HP	MP	LN	MP	LN	LP	LN	-	-	LP	LP	LP	LN	LP	LN	-	LN	-	LN	LP	LP	MP	LP	MP	LP	MP	LP	LN	LP	MP	LP	LN	MP	LN	LP	LN	MN	HN	MN	LN	MN	MN	HP	-	HP	HN	1
48	HP	MP	LN	LP	-	LP	LN	LP	LP	LP	LP	LP	LN	LP	LN	LP	LN	-	LN	LP	LP	MP	LP	MP	LP	MP	LP	LN	LP	MP	LP	LN	MP	LN	LP	LN	MN	HN	MN	LN	MN	HN	HP	-	HP	HN	HP

Table A9 Correlation Matrix for CBD Fringe / OBD Area with 1-mile Buffer Width

OBD_1mile	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																													
3	LN	LN	1																																												
4	LP	MP	LN	1																																											
5	LN	LN	MP	LP	1																																										
6	LP	HP	LN	LP	-	1																																									
7	-	LP	LN	LP	MP	MP	1																																								
8	LN	LN	LP	LN	HP	-	-	1																																							
9	LN	MN	LP	LN	LP	MN	-	-	1																																						
10	LP	LP	-	MP	LN	MN	LN	MN	LN	1																																					
11	LP	LN	MP	-	HP	LP	MP	MP	LP	LN	1																																				
12	-	HP	LN	-	LN	HP	LP	LN	MN	LN	LN	1																																			
13	LP	LP	LN	MP	LP	MP	HP	-	LN	MN	MP	MP	1																																		
14	LP	HP	LN	HP	-	HP	HP	LN	LN	LN	LP	MP	MP	1																																	
15	LN	LN	MP	LP	MP	LN	LP	LP	-	LP	LP	-	-	LN	1																																
16	LN	LN	LN	LN	-	LN	LN	-	-	LN	-	-	LN	LN	LN	1																															
17	LN	LN	LN	LN	MP	LN	MP	LN	-	LN	LN	LN	LP	LN	LN	-	1																														
18	LN	LP	LN	LP	LN	MP	MP	LN	MP	LN	-	MP	MP	MP	LP	LN	LN	1																													
19	MN	MN	LP	MN	LP	LN	LP	-	MP	LN	-	-	LN	LN	LP	-	LP	LP	1																												
20	LN	MN	-	MN	LP	-	-	MP	LP	MN	-	LP	LP	MN	LP	HP	LP	-	LP	1																											
21	LP	HP	LN	HP	LP	HP	HP	LN	LN	LN	LP	MP	MP	HP	-	LN	LN	MP	-	MN	1																										
22	LP	LP	LN	-	-	LP	LP	LP	LP	LN	LP	LP	MP	-	-	-	LN	LP	LN	MP	LP	1																									
23	-	LP	LN	LP	LN	LP	-	LN	LN	LP	LN	MP	LP	LN	MP	-	LN	MP	-	LP	-	MP	1																								
24	LP	HP	MN	HP	LN	HP	MP	MN	MN	MP	LN	HP	MP	HP	LP	LN	LN	MP	LN	LN	HP	LP	HP	1																							
25	-	LP	LN	LN	LN	-	MN	LP	LP	LN	LN	LP	-	LN	LN	MP	LN	-	LN	MP	LN	MP	LP	LN	1																						
26	LP	MP	LN	HP	LP	MP	HP	-	LP	-	MP	LP	MP	MP	MP	LN	LN	HP	-	LN	HP	MP	MP	HP	-	1																					
27	-	LN	MP	-	MP	LN	LP	LP	MP	-	HP	LN	-	LN	MP	-	LN	MP	MP	-	LP	MP	LP	-	-	HP	1																				
28	LP	HP	MN	MP	LN	HP	LP	LN	LN	LN	-	HP	LP	HP	LN	LN	LN	MP	LN	LN	HP	LP	LP	MP	MP	MP	LN	1																			
29	LN	MN	-	MN	LP	LN	LP	MP	-	MN	LP	LP	LP	MN	-	MP	MP	LN	MP	HP	MN	MP	LP	MN	LP	LN	LP	LN	1																		
30	LP	LP	LP	MP	-	MN	LN	LN	-	HP	-	MN	MN	LN	MP	LN	LN	LN	LN	MN	LN	LN	LP	LP	LN	LP	LP	LN	MN	1																	
31	MP	HP	LN	MP	LN	HP	LP	LN	MN	LP	-	LP	-	HP	LN	MN	LN	-	MN	HN	HP	-	LN	HP	LP	MP	LN	HP	HN	LP	1																
32	-	LP	LN	-	LN	MP	LP	LP	LN	LN	-	HP	HP	LP	LP	-	LN	LP	-	LP	LP	HP	HP	MP	LP	MP	LP	LP	LP	MN	-	1															
33	MP	HP	LN	MP	-	HP	MP	LN	LN	LP	MP	LP	MP	HP	LN	LN	LN	-	LN	MN	HP	MP	-	MP	LN	MP	LP	MP	LN	LP	HP	LP	1														
34	LN	LN	LN	LN	LP	-	LP	-	LN	LN	LN	LP	LP	LN	-	LP	HP	-	LP	HP	LN	-	LP	LN	LP	LN	LN	LN	HP	LN	MN	-	MN	1													
35	LP	MP	-	LP	LP	HP	LP	-	MN	LN	LP	MP	LP	HP	LP	-	LN	LP	LN	-	MP	LN	LP	MP	LN	LP	LN	MP	LN	LN	MP	-	LP	-	1												
36	LN	MN	LP	HN	LP	LN	LN	MP	LP	MN	LP	-	LP	MN	LP	MP	LP	LN	LP	HP	MN	LP	LP	MN	LP	MN	-	MN	HP	MN	HN	LP	MN	HP	-	1											
37	HN	LN	-	-	-	LN	LN	-	LP	-	LN	-	LN	LN	LP	LN	-	LP	MP	-	-	-	-	-	LN	-	LP	LN	-	LN	LN	LP	LN	-	LN	LP	1										
38	HN	MN	LP	LN	LP	MN	LN	LP	LP	LN	-	LN	LN	MN	LP	LN	-	LP	MP	LN	LN	LN	LN	MN	LN	LN	LP	LN	LN	-	MN	LN	MN	LN	LN	LP	HP	1									
39	HN	LN	-	-	LP	LN	LP	LP	-	-	-	-	LN	LN	LP	-	LP	LP	LP	-	-	-	-	-	LN	LP	LP	LN	LP	-	LN	-	LN	LP	LN	LP	HP	HP	1								
40	MN	MN	LP	LN	LP	LN	LP	LP	LP	LN	LP	LN	-	LN	LP	-	LP	LP	LP	LP	-	LP	-	LN	-	-	MP	MN	LP	-	MN	-	LN	-	LN	LP	HP	HP	HP	1							
41	MN	LN	LN	LN	LN	LN	-	-	LP	LN	LN	LP	-	LN	LP	-	-	MP	LP	LP	-	LP	LP	-	LN	-	-	-	-	LN	LN	LP	LN	-	LN	LP	HP	HP	HP	MP	1						
42	MN	LN	LN	-	LP	LN	LP	-	LP	-	-	LN	-	LN	LP	-	LP	-	LP	-	-	LN	LN	LN	LN	LN	-	LN	-	-	LN	-	LN	-	LN	-	HP	HP	HP	MP	HP	1					
43	HP	MP	-	MP	LN	-	LN	LN	LN	MP	-	-	LN	LP	LP	MN	LN	-	LN	MN	LP	LN	LP	LP	LN	LP	-	LP	MN	MP	MP	LN	MP	LN	LP	MN	MN	MN	MN	MN	MN	MN	1				
44	-	LN	LP	MN	-	LN	LN	LN	LP	LP	-	-	LN	LN	LP	LP	LP	-	MP	LP	LN	LN	LP	LN	LN	LN	-	MN	LP	LP	LN	LN	LN	LP	LN	LP	-	LP	-	LP	-	-	LP	1			
45	MP	MP	LP	MP	LN	LP	LN	LN	MN	MP	-	-	LN	LP	-	-	LN	LN	MN	LN	-	LN	-	LP	-	LP	LN	LP	LN	MP	MP	LN	LP	LN	LP	LN	MN	MN	LN	LN	MN	MN	MP	-	1		
46	MN	LN	LP	LN	LP	LN	LN	LP	LN	LP	-	LN	LN	MN	LP	-	LP	LN	LP	LP	MN	LN	-	LN	LN	LN	-	LN	LP	LP	LN	-	MN	LP	-	LP	LP	MP	MP	LP	LP	LP	MN	LP	-	1	
47	HP	MP	LN	LP	LN	LP	-	LN	-	LP	LP	LP	-	LP	LN	-	LN	-	MN	LN	LP	LP	LP	MP	-	MP	-	LP	LN	LP	MP	-	MP	LN	LP	LN	MN	HN	MN	LN	MN	MN	HP	-	HP	HN	1
48	HP	MP	LN	LP	LN	LP	-	LN	-	LP	LP	LP	LP	LP	LN	-	LN	-	MN	LN	LP	LP	-	LP	LP	LP	-	LP	LN	LP	MP	-	MP	LN	LP	LN	MN	HN	MN	LN	MN	HN	HP	-	HP	HN	HP

Table A10 Correlation Matrix for Urban Area with 0.5 miles Buffer Width

0.5 miles_Urban	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	LP	1																																													
3	LN	LP	1																																												
4	LP	LP	LN	1																																											
5	LP	-	MP	LP	1																																										
6	-	MP	LN	LP	LN	1																																									
7	LP	LN	-	LP	HP	LN	1																																								
8	LP	LN	LN	LP	LP	LN	-	1																																							
9	-	LP	LN	MP	LP	LN	LP	LP	1																																						
10	LP	LP	-	LP	LP	LN	LN	LP	LP	1																																					
11	LP	-	-	MP	LP	LN	LP	HP	LP	LP	1																																				
12	LP	LP	MP	LN	LP	LN	-	LP	LP	LN	LN	1																																			
13	LP	LN	LN	LP	MP	LN	HP	-	-	LN	LP	LN	1																																		
14	-	LN	LN	LN	-	-	-	LN	-	LN	LN	-	-	1																																	
15	LN	LN	LN	LP	LN	LN	LP	LN	-	LN	LP	LN	LP	LP	1																																
16	LN	LN	LN	LN	-	LN	-	LN	LN	LP	LN	LN	LP	-	LP	1																															
17	LN	LN	LN	LP	LP	LN	MP	LN	LN	LN	LN	LN	MP	LP	LP	-	1																														
18	LN	LN	LN	-	LN	-	-	-	LN	LN	LN	-	LP	LP	-	LP	LP	1																													
19	LN	-	LN	LP	LP	LP	LP	LP	LP	LP	LP	-	-	-	-	LN	-	LN	1																												
20	-	LN	LN	LP	LN	LN	LP	LP	LP	LN	LP	LN	LP	-	LP	LP	LP	LN	LN	1																											
21	LP	LP	LN	MP	-	LP	LN	-	LP	LP	LP	LP	LN	-	LN	LN	LN	LN	-	-	1																										
22	LP	MP	MP	LP	LP	LP	LN	-	MP	LP	LP	LP	LN	-	LN	LN	LN	LN	-	-	LP	1																									
23	-	LP	LP	LP	-	LP	-	LN	MP	LN	LN	LP	-	MP	MP	LP	LP	-	LN	LP	LP	MP	1																								
24	LP	MP	LN	LP	LP	LP	LP	LN	MP	LN	LN	LN	LP	LP	LP	-	LP	-	LN	LP	LP	LP	HP	1																							
25	LP	LP	LN	LP	LP	LN	LP	LN	MP	LP	LP	LN	LP	-	-	LP	-	LN	-	LP	-	MP	LP	LP	1																						
26	LP	LP	LP	LP	LP	LN	LN	MP	LP	LP	MP	LP	LN	LN	LP	LN	LN	LN	-	LP	LP	MP	LP	LN	LP	1																					
27	LP	LP	MP	LP	MP	LN	LP	LP	LP	LP	MP	LP	LN	LN	LN	-	LN	LN	LP	-	-	MP	LP	LN	LP	HP	1																				
28	LP	LP	LP	LP	LP	LP	LN	-	LP	LP	LP	-	LN	LN	LN	LN	LN	-	LP	LN	LP	LP	LN	LN	-	LP	LP	1																			
29	LN	LN	LP	LN	LP	MN	LP	LP	LN	-	LP	LP	LP	LN	MP	LP	LP	LN	-	LP	LN	LN	LN	LN	LN	LP	-	LN	1																		
30	LP	LP	MP	MP	LP	LN	LN	LP	LP	MP	HP	LP	LN	LN	LN	LN	LN	LN	-	LP	LP	MP	LP	LN	LP	HP	HP	HP	LN	1																	
31	LP	HP	-	LP	LN	HP	LN	MN	-	LP	LN	-	LN	LN	MN	LN	LN	LN	LP	LN	LP	LP	-	LP	LP	LN	-	MP	MN	LP	1																
32	LP	LP	-	LP	-	-	-	LP	LP	LP	LP	LP	-	-	-	LN	-	LP	-	LP	LP	-	LP	-	LP	LP	LP	LP	-	MP	-	1															
33	LP	MP	LP	MP	-	LP	LN	LN	LP	LP	MP	LN	LN	LN	LN	LN	LN	LN	LP	LN	MP	MP	LP	LP	LP	LP	LP	LP	LN	LP	MP	LP	1														
34	-	LN	-	LN	LN	LN	LP	LP	LN	LN	-	LN	LP	-	LP	LP	LP	LN	LN	LP	LN	LN	-	-	LN	LP	LN	LN	HP	LN	LN	-	LN	1													
35	-	-	-	LN	LN	LP	LN	LN	LN	LN	LN	LN	-	LP	LP	LP	LN	LP	-	LN	LP	-	MP	LP	LP	LN	LN	LN	LN	LN	-	-	LP	LN	1												
36	LN	MN	LN	-	LP	LN	LP	MP	LN	-	LP	LN	MP	LN	MP	LP	LP	LP	-	MP	LN	MN	LN	LN	LN	LP	LN	LN	HP	LN	MN	LP	LN	HP	LN	1											
37	HN	LN	LP	LN	-	LN	LN	LP	LN	LN	-	LP	LN	-	LP	LP	-	-	LN	LN	LN	LN	LN	LN	LN	LP	-	LN	LP	LN	MN	-	LN	LP	LN	LP	1										
38	HN	LN	LP	LN	-	LN	-	LP	LN	LN	-	LP	LN	-	LP	-	LP	LN	LP	LN	-	LN	-	LN	LN	-	LN	LN	LP	LN	LN	LN	-	-	LN	LP	HP	1									
39	MN	LN	LP	LN	LN	-	LN	LP	-	LN	LN	LP	LN	LP	LP	LP	-	-	LN	LN	-	LP	LP	-	LN	LP	LN	LN	LP	LN	LN	LN	LN	LP	-	LP	HP	HP	1								
40	MN	LN	LP	LN	LN	LP	LN	LP	LN	LN	LN	LP	LN	LP	LP	LP	LP	-	LN	LN	-	LP	LP	-	LN	-	LN	LN	LP	LN	LN	-	-	LP	LN	LP	HP	MP	HP	1							
41	MN	LN	LP	LN	LN	-	LN	LP	LN	LN	-	LP	LN	-	LP	-	-	LP	-	LN	LN	LN	LN	LN	LN	-	-	-	LP	LN	LN	LP	LN	LP	LN	LP	HP	HP	HP	MP	1						
42	MN	LN	-	LN	LN	-	LN	LP	LN	LN	LP	LP	LN	-	-	LN	LP	-	-	LN	-	LN	LN	LN	LN	LN	LN	-	LP	-	LN	LP	LP	-	LN	LP	HP	HP	MP	MP	HP	1					
43	MP	MP	LP	LP	LP	LP	LP	LN	LP	LP	-	LP	LN	LN	LN	LN	LN	LN	LN	LN	LP	LP	LN	LP	LP	LP	LP	LP	LN	LP	LP	LN	LP	LN	-	LN	MN	MN	MN	MN	LN	LN	1				
44	-	LP	LP	-	LP	LP	LP	LP	-	LP	LP	LP	LP	-	LN	-	LP	LN	LP	LN	LP	LP	LP	LP	-	LP	LP	LP	LN	LP	LP	LP	LP	-	-	-	LP	LP	LP	LP	-	LN	LP	1			
45	MP	MP	LP	LP	LP	LP	LN	LN	LP	LP	LN	LP	LN	-	LN	LN	LN	LN	LN	LN	LP	MP	LP	LP	LP	LP	LP	LP	MN	LP	MP	LN	LP	LN	LP	HN	MN	MN	LN	LN	MN	MN	MP	LP	1		
46	LN	-	LP	LN	LN	LP	LN	LP	LN	-	-	LP	LN	-	-	-	LN	-	LP	LN	LN	-	-	-	LN	LP	LN	LN	-	-	LN	-	LP	LP	-	-	MP	MP	LP	LP	LP	LP	LN	LP	-	1	
47	MP	LP	LP	LP	-	LP	LN	LN	LP	LP	-	LN	LN	LP	LN	LN	LP	-	-	LN	LP	LP	LP	LP	LP	-	LP	LP	LN	LP	MP	-	LP	-	LP	LN	HN	HN	MN	LN	MN	MN	MP	LP	LP	LN	1
48	MP	LP	LP	LP	-	LP	-	LN	LP	LP	LP	LN	-	LP	LN	-	-	-	-	-	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	LP	MP	-	LP	LN	HN	HN	MN	LN	MN	MN	MP	LP	LP	LN	HP

Table A11 Correlation Matrix for Urban Area with 1-mile Buffer Width

Urban_1mile	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	LP	1																																													
3	-	LP	1																																												
4	LP	MP	LN	1																																											
5	LP	LN	MP	LN	1																																										
6	-	MP	LN	LP	LN	1																																									
7	-	LN	-	-	HP	LN	1																																								
8	-	MN	LP	LN	MP	LN	-	1																																							
9	-	-	LP	LN	MP	LN	LP	LP	1																																						
10	LP	MP	LN	HP	LN	LP	LN	LN	LN	1																																					
11	LP	LN	LP	LP	LP	LN	LP	HP	MP	LN	1																																				
12	-	-	HP	LN	LP	LN	LN	LP	LP	LN	-	1																																			
13	-	LN	LN	LP	MP	LN	HP	LP	LP	LN	LP	LN	1																																		
14	LP	MP	LN	MP	LN	MP	-	LN	LN	LP	LN	LN	LN	1																																	
15	LN	LN	LN	LP	LP	LN	HP	-	LP	LP	LP	LN	HP	-	1																																
16	LN	MN	LN	LN	LP	LN	MP	-	LP	LN	-	LN	MP	LN	HP	1																															
17	-	MN	LN	-	MP	LN	HP	LN	LP	LN	LN	LN	HP	-	MP	HP	1																														
18	-	LP	LN	LP	LN	LP	LP	LP	LP	LN	LP	-	LP	LP	LP	LP	LP	1																													
19	-	-	LN	LN	-	LN	-	LP	-	LN	LP	LN	-	LN	LN	LN	LN	LN	1																												
20	-	MN	LN	LN	-	LN	LP	LP	LP	LN	LP	LN	MP	LN	LP	MP	LP	LP	LN	1																											
21	LP	MP	-	MP	LN	MP	LN	LN	-	-	-	-	LN	HP	LN	LN	LN	LP	LN	LN	1																										
22	LP	MP	MP	LP	LP	LP	LN	LP	MP	LP	LP	MP	LN	LP	LN	LN	LN	MP	LN	LN	LP	1																									
23	-	LP	-	MP	-	LP	LP	LP	LP	LP	LP	LP	LP	LP	HP	LP	LP	HP	LN	LP	LP	MP	1																								
24	LP	MP	LN	HP	LN	MP	LP	LN	-	HP	-	LN	LP	HP	MP	-	LP	MP	LN	LP	MP	LP	HP	1																							
25	LP	LP	LN	LP	LP	LP	-	LN	MP	LP	LP	LN	-	LP	-	LP	LP	LP	LN	LN	LP	MP	LP	LP	1																						
26	LP	LP	LP	MP	MP	-	LP	MP	LP	LP	MP	-	LP	LP	MP	LP	LP	LP	LN	LP	LP	MP	MP	MP	LP	1																					
27	LP	LP	HP	LP	MP	LN	-	LP	LP	LP	MP	LP	LN	-	-	LN	LN	LP	LP	LN	-	MP	LP	LP	LP	HP	1																				
28	-	LP	LN	LP	-	MP	LN	LP	LP	LP	LP	-	LN	MP	LN	-	LN	MP	LP	LN	MP	LP	LP	LP	MP	LP	LP	1																			
29	LN	MN	LP	LN	LP	LN	LP	MP	LP	LN	LP	LP	LP	LN	MP	LP	LP	-	-	MP	LN	LN	-	LN	LN	LP	-	LN	1																		
30	LP	MP	LP	HP	LP	LP	LN	LP	LP	HP	MP	LP	LN	LP	-	LN	LN	LP	LN	LN	LP	MP	LP	MP	MP	HP	HP	MP	LN	1																	
31	LP	HP	LP	MP	MN	HP	MN	MN	LN	LP	LN	-	MN	MP	MN	MN	MN	LN	-	MN	MP	MP	-	LP	LP	LN	LP	LP	MN	LP	1																
32	LP	LP	LN	LP	LN	LP	-	LP	LP	-	LP	-	LP	-	LP	LP	LN	HP	LN	LP	-	MP	HP	MP	LP	LP	LP	LP	LP	LP	-	1															
33	LP	MP	LP	MP	LN	LP	LN	LN	LP	LP	MP	-	LN	LP	LN	MN	LN	LN	LP	MN	MP	MP	LP	LP	LP	LP	LP	LP	LN	MP	HP	LN	1														
34	LN	MN	LN	LN	LP	LN	MP	LP	-	LN	LP	LN	MP	LN	HP	MP	LP	LN	-	HP	LN	MN	LN	LN	LN	LP	LN	MN	HP	LN	MN	LN	LN	1													
35	-	LP	-	LP	LN	MP	LP	LN	LN	-	LN	LP	LP	HP	LP	LP	LP	LP	LN	-	HP	-	LP	MP	LP	-	-	LP	LN	-	LP	LN	LP	LN	1												
36	LN	HN	LN	LN	LP	LN	MP	HP	LP	LN	LP	LN	MP	LN	MP	MP	LP	LP	-	HP	LN	MN	LP	-	LN	LP	LN	LN	HP	LN	HN	LP	MN	HP	LN	1											
37	HN	LN	LP	LN	LP	-	LN	LP	-	LN	LP	LP	-	LN	LP	-	LN	LN	LN	LN	-	LN	LN	LN	LN	LP	LN	LP	LP	-	LN	LN	LN	LP	LN	LP	1										
38	HN	LN	LP	LN	-	-	-	LP	LN	LN	LP	LP	-	LN	LP	LN	LN	LN	-	LN	LN	LN	LN	LN	LN	-	LN	LN	LP	LN	LN	LN	-	LP	LN	LP	HP	1									
39	MN	LN	LP	-	LN	-	LN	LP	LP	-	LP	LP	LN	-	LP	LN	LN	-	LN	LN	-	-	LP	-	LN	LP	LN	-	LP	-	LN	LN	LN	LP	-	LP	HP	HP	1								
40	MN	LN	LP	-	LN	-	LN	LP	-	-	-	LP	LN	-	-	LN	LN	-	LN	-	LP	-	LP	-	LN	LP	LN	LN	LP	LN	LN	-	LN	LP	-	LP	HP	MP	HP	1							
41	MN	LN	LP	-	LN	LP	LN	LP	LN	-	LP	LP	LN	-	LP	LN	LN	-	-	-	-	LN	-	-	LN	LP	LN	LP	LP	LP	LN	LP	LN	LP	LN	LP	HP	HP	HP	MP	1						
42	MN	LN	LP	LN	LN	LP	LN	LP	LN	-	LP	LP	LN	LN	-	LN	LN	LN	LP	-	-	LN	LN	LN	LN	-	LN	LP	LP	-	-	-	LN	LP	LN	-	HP	HP	MP	MP	HP	1					
43	MP	MP	LP	LP	LP	LP	LN	LN	LP	LP	-	LP	LN	LP	LN	LN	LN	LN	LN	LN	LP	MP	LN	-	LP	LP	LP	LP	LN	LP	MP	LN	LP	MN	LP	MN	MN	MN	MN	MN	LN	LN	1				
44	-	LP	LP	-	LN	LP	LN	LP	LP	-	LP	LP	LN	-	LN	LN	LN	-	LP	LN	-	LP	LP	-	-	LP	LP	LP	LN	LP	LP	LP	LP	LN	-	LN	LP	LP	LP	LP	-	LN	LP	1			
45	MP	MP	MP	LP	LP	LP	LN	LN	LP	LP	LN	LP	MN	LP	LN	LN	LN	LN	LN	MN	LP	MP	-	-	MP	LP	LP	LP	MN	MP	MP	LN	LP	MN	LP	HN	MN	MN	LN	LN	MN	MN	MP	LP	1		
46	LN	-	LP	LN	LN	-	LN	LP	-	LN	LP	LP	LN	LN	LN	LN	LN	LN	LP	LN	LN	-	-	LN	LN	LN	-	LN	-	LN	LN	LN	LP	-	LN	LN	MP	MP	LP	LP	LP	LP	LN	LP	-	1	
47	MP	MP	LP	LP	LP	LP	-	LN	LP	LP	LN	LN	LN	LP	LN	-	-	LP	LP	LN	LP	LP	LP	LP	LP	LP	LP	-	LN	LP	MP	-	LP	LN	LP	LN	HN	HN	MN	LN	MN	MN	MP	LP	LP	LN	1
48	MP	MP	LP	LP	LP	LP	-	LN	LP	LP	-	LN	LN	LP	-	-	-	LP	LP	LN	LP	LP	LP	LP	LP	LP	LP	-	LN	LP	LP	LP	LP	LN	LP	LN	HN	HN	MN	LN	MN	MN	MP	LP	LP	LN	HP

Table A12 Correlation Matrix for Speed Limit < 45 mph with 0.5 miles Buffer Width

0.5miles_ <45 mph	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																													
3	LN	LN	1																																												
4	HP	MP	LN	1																																											
5	-	LN	LP	LN	1																																										
6	MP	HP	LN	HP	LN	1																																									
7	LP	LP	LN	LP	MP	LP	1																																								
8	LN	MN	LP	MN	LP	MN	LN	1																																							
9	-	LN	-	LP	LP	LN	-	LP	1																																						
10	LN	-	-	LP	LN	LN	LN	LN	LN	1																																					
11	LN	LN	-	LN	LP	LN	MP	HP	LP	LN	1																																				
12	LN	LN	LN	LN	-	-	-	LP	LN	LN	-	1																																			
13	HP	HP	LN	HP	-	HP	MP	MN	LP	LN	LN	LN	1																																		
14	LP	LP	LN	-	LP	LP	HP	LN	LN	LN	LP	MP	-	1																																	
15	HP	HP	-	HP	LN	HP	LP	MN	LP	-	LN	LN	HP	LN	1																																
16	LN	MN	LP	LN	LP	LN	LN	LP	LP	LN	-	-	LN	LN	LN	1																															
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1																														
18	MP	MP	LN	MP	LP	MP	MP	LN	LN	LN	LN	LN	HP	LP	MP	LN	-	1																													
19	LN	LN	-	LN	LP	LN	LN	LP	-	LN	LP	LP	LN	LN	LN	LP	-	LN	1																												
20	-	LN	LP	LN	LP	LN	LN	LP	LP	LN	LN	LP	-	LN	LN	LP	-	LN	LN	1																											
21	-	LP	LN	-	LP	LP	MP	-	LN	-	LP	LP	LN	HP	LN	LN	-	MP	LP	LN	1																										
22	HP	HP	LN	MP	LN	MP	LP	LN	LP	-	LN	LN	HP	LN	HP	LN	-	MP	LN	LP	LN	1																									
23	HP	HP	LN	HP	LN	HP	LP	MN	-	-	MN	LN	HP	LN	HP	LN	-	HP	LN	-	LN	HP	1																								
24	HP	HP	LN	HP	LN	HP	MP	MN	LN	-	LN	LN	HP	LP	HP	LN	-	HP	LN	LN	LP	HP	HP	1																							
25	MP	HP	LN	HP	LN	MP	-	LN	LP	-	LN	LN	HP	LN	HP	LP	-	MP	LN	LP	LN	HP	HP	HP	1																						
26	HP	HP	LN	HP	LN	HP	LP	LN	-	LP	-	LN	HP	LP	HP	LN	-	MP	LN	-	LP	HP	HP	HP	HP	1																					
27	MP	MP	-	MP	LP	LP	LP	LP	LP	LP	LP	LN	MP	-	MP	LN	-	MP	LN	LP	-	HP	HP	HP	MP	HP	1																				
28	LP	LP	LN	MP	LN	MP	LN	LN	-	LN	-	LN	LP	LP	LP	LN	-	LP	LN	LN	LP	-	LP	LP	LP	LP	-	1																			
29	LN	LN	HP	LN	LP	LN	-	LP	-	LN	-	LP	LN	LN	LN	LP	-	LN	LP	HP	LN	LN	LN	LN	LN	LN	LN	LN	1																		
30	LN	LN	-	-	-	MN	LN	LP	-	HP	MP	LN	MN	-	LN	-	-	MN	LN	LN	-	LN	LN	LN	LN	-	LP	LP	LN	1																	
31	MN	LP	-	LN	LN	LP	LN	-	LN	LP	-	LP	MN	LP	MN	LN	-	MN	LP	LN	LP	MN	MN	MN	MN	LN	LN	LP	LN	LP	1																
32	HP	HP	LN	HP	LN	MP	LP	LN	-	LN	LN	LN	HP	LN	HP	LN	-	MP	LN	LP	LN	HP	HP	HP	HP	HP	MP	LP	LN	LN	MN	1															
33	LN	LP	LN	LN	LN	-	LP	LN	-	MP	LP	LP	MN	MP	LN	LN	-	LN	LN	LN	LP	LN	LN	LN	LN	LP	LP	-	LN	HP	MP	LN	1														
34	LN	LN	HP	LN	-	LN	-	LP	-	LN	LN	-	LN	LN	LN	LP	-	LN	-	MP	LN	LN	LN	LN	LN	LN	LN	LN	HP	-	LN	LN	LN	1													
35	LP	LP	LN	-	-	LP	MP	LN	LN	LN	LP	MP	LP	HP	-	LN	-	LP	LN	LN	MP	LP	LP	MP	LN	LP	LP	LP	LN	LN	LP	-	MP	LN	1												
36	LN	MN	MP	LN	LP	MN	LN	MP	LP	LN	LP	LP	LN	LN	LN	MP	-	MN	-	HP	LN	LN	LN	MN	LN	LN	-	LN	HP	-	MN	LN	LN	HP	LN	1											
37	LP	MP	-	MP	LN	MP	LP	LN	LN	LP	LN	LP	MP	LP	MP	LN	-	LP	LN	LP	LP	MP	MP	MP	LP	MP	MP	LP	-	-	LN	MP	-	LP	LP	-	1										
38	LN	LP	LP	LN	-	LN	LN	LP	LP	LP	LP	-	LN	LN	LN	LN	-	LN	LP	-	LP	-	LN	LN	-	-	-	-	LN	LP	MP	-	LP	LN	LN	-	LN	1									
39	LP	LP	LP	LP	LN	LP	-	LN	-	LP	LN	LP	LP	LP	LP	LN	-	LP	LN	LP	LP	LP	LP	MP	LP	MP	LP	LP	-	-	LN	LP	LP	LP	LP	-	HP	-	1								
40	LN	LP	LP	-	LN	LP	LN	-	LP	LP	-	LP	-	LP	LP	LN	-	LP	-	LP	LP	LP	LP	LP	LN	LP	LP	-	-	-	-	-	LP	-	LP	-	MP	LP	HP	1							
41	LP	MP	-	LP	LN	MP	LP	LN	LN	LN	LP	-	MP	LP	LP	LN	-	MP	MN	-	LP	LP	MP	MP	LP	MP	LP	LP	LN	-	-	LP	-	-	LP	LN	HP	-	LP	LP	1						
42	LP	MP	-	LP	LN	LP	LP	LN	LN	LN	LP	LN	LP	LP	LP	LN	-	LP	MN	LN	LP	LP	LP	LP	-	LP	LP	LP	LN	LP	LP	LP	LP	-	LP	LN	MP	LP	LP	LP	HP	1					
43	-	-	-	LP	MP	LN	LP	-	LP	LP	LP	LN	-	LP	-	LP	-	LN	LP	LN	LP	LN	LN	-	LN	-	LN	-	LN	LP	LP	LN	LP	LN	LP	LN	LN	LP	LN	LN	LN	LN	1				
44	LN	LN	LP	LN	LP	LN	LN	LP	LP	-	LP	LN	LN	LN	LN	LP	-	MN	MP	-	-	LN	LN	LN	-	LN	LN	-	LP	LP	LP	LN	LP	LP	LN	LP	LN	LP	LN	-	LN	LN	LP	1			
45	-	-	-	LP	-	-	LN	LN	-	MP	LN	LN	LP	-	LP	LP	-	LN	LN	LN	LN	-	LP	LP	LP	LP	-	-	LN	LP	LP	-	LP	LN	-	LN	-	-	-	-	-	LN	LP	LP	1		
46	LN	LN	LP	LN	LP	LN	LN	-	LP	LP	LN	LN	LN	LN	LN	LP	-	MN	LP	LP	LN	LN	LN	MN	-	LN	LN	-	LP	LP	LP	LN	-	-	LN	LP	LN	LP	LN	LN	LN	LN	LP	LP	MP	1	
47	LP	LP	-	LP	LP	LP	LP	-	LP	LP	LP	-	LP	LP	LP	-	-	LP	LN	LN	LP	LP	LP	LP	LP	LP	LP	LP	LN	LP	LN	LP	LP	-	LP	LN	LP	-	LP	LP	LP	-	LP	LP	-	LN	1
48	LP	LP	-	LP	-	-	-	-	LP	LP	LP	-	LP	LN	LP	-	-	LP	LP	LN	LP	LP	LP	LP	LP	LP	LP	-	-	LP	LN	LP	-	LP	-	LP	LP	-	LP	LP	-	-	-	LP	-	LN	HP

Table A13 Correlation Matrix for Speed Limit < 45 mph with 1-mile Buffer Width

1-mile_<45mph	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	MP	1																																													
3	LN	LN	1																																												
4	HP	HP	LN	1																																											
5	LP	LN	LP	LP	1																																										
6	MP	HP	LN	HP	LP	1																																									
7	MP	MP	LN	HP	HP	HP	1																																								
8	LN	MN	MP	LN	MP	LN	LN	1																																							
9	LN	LN	LP	LN	MP	LN	LN	MP	1																																						
10	LN	-	LP	LP	LN	MN	LN	LN	LN	1																																					
11	LP	-	LP	LP	MP	LP	MP	MP	LP	LN	1																																				
12	-	LP	LN	LP	LN	MP	LP	LN	MN	LN	LN	1																																			
13	HP	HP	LN	HP	LP	HP	HP	LN	-	LN	LP	LP	1																																		
14	-	MP	LN	HP	LP	HP	MP	LN	LN	LN	MP	MP	LP	1																																	
15	HP	HP	LN	HP	LP	HP	HP	LN	LN	LN	-	LP	HP	LP	1																																
16	LN	HN	LP	MN	LP	MN	LN	LP	LP	LN	-	LN	MN	LN	MN	1																															
17	LN	MN	LN	LN	LP	LN	LP	-	LP	LN	LN	LN	LN	LN	LN	HP	1																														
18	HP	HP	LN	HP	LP	HP	HP	LN	LN	LN	-	MP	HP	LP	HP	LN	LN	1																													
19	MN	MN	LP	MN	-	MN	MN	LP	LP	LN	-	LN	MN	LN	MN	MP	LP	MN	1																												
20	LP	-	LP	-	LP	LP	-	MP	LP	LN	LN	LP	LP	MN	MP	LP	LN	MP	-	1																											
21	-	MP	LN	HP	LP	HP	MP	LN	LN	LN	MP	MP	LP	HP	LP	LN	LN	LP	LN	MN	1																										
22	HP	HP	LN	HP	-	HP	MP	LN	-	LN	LP	LP	HP	-	HP	MN	LN	HP	MN	MP	-	1																									
23	HP	HP	LN	HP	LP	HP	MP	LN	LN	LN	LN	LP	HP	-	HP	MN	LN	HP	MN	MP	LP	HP	1																								
24	HP	HP	LN	HP	LP	HP	HP	LN	LN	LN	-	MP	HP	MP	HP	MN	LN	HP	MN	LP	MP	HP	HP	1																							
25	MP	HP	LN	MP	LP	MP	LP	LN	LP	LN	LN	-	HP	LN	HP	LN	LN	HP	MN	MP	LN	HP	HP	HP	1																						
26	HP	HP	LN	HP	LP	HP	HP	LN	LN	-	LP	LP	HP	MP	HP	MN	LN	HP	MN	LP	MP	HP	HP	HP	HP	1																					
27	MP	HP	-	HP	LP	HP	MP	LP	LP	-	MP	-	HP	LP	HP	LN	LN	HP	MN	MP	LP	HP	HP	HP	HP	HP	1																				
28	LP	MP	LN	MP	LP	HP	LP	-	-	LN	LP	LP	MP	MP	LP	LN	LN	MP	MN	-	MP	LP	LP	MP	LP	MP	LP	1																			
29	-	LN	MP	LN	LP	LN	-	MP	LP	LN	-	LP	-	MN	-	LP	LP	LN	MP	HP	MN	LP	-	LN	LP	LN	-	LN	1																		
30	LN	LN	MP	LN	LP	MN	LN	LP	LP	HP	MP	MN	MN	-	LN	-	LN	MN	-	MN	-	MN	MN	LN	MN	LN	-	LN	LN	1																	
31	MN	LP	-	LN	LN	LP	LN	LN	LN	MP	LP	LN	MN	MP	MN	LN	LN	MN	LP	HN	MP	MN	MN	LN	MN	LN	MN	LP	MN	MP	1																
32	HP	HP	LN	HP	-	HP	MP	LN	LN	LN	LN	LP	HP	-	HP	MN	LN	HP	MN	MP	-	HP	HP	HP	HP	HP	HP	LP	-	MN	MN	1															
33	LN	LP	LN	LP	-	LP	LP	LN	-	LP	MP	-	LN	HP	LN	LN	LN	LN	-	MN	HP	LN	MN	LN	MN	-	-	LP	MN	MP	HP	LN	1														
34	LN	MN	MP	LN	LP	LN	-	LP	-	LN	LN	LP	LN	LN	LN	MP	LP	LN	MP	MP	LN	LN	LN	LN	LN	LN	LN	LN	HP	LN	LN	LN	LN	1													
35	LP	MP	-	MP	LP	HP	MP	LN	LN	LN	LP	MP	LP	HP	LP	LN	LN	MP	LN	LN	HP	LP	LP	MP	LP	MP	LP	MP	LN	LN	LP	LP	LP	LN	1												
36	LN	MN	LP	MN	LP	MN	LN	HP	LP	LN	LP	LP	LN	HN	LN	MP	LP	LN	MP	HP	HN	-	LN	MN	-	LN	LN	LN	HP	LN	HN	-	MN	HP	MN	1											
37	LP	MP	-	MP	LP	MP	LP	LN	LN	LP	LN	LP	MP	LP	MP	LN	LN	MP	LN	LP	LP	MP	MP	MP	MP	HP	MP	LP	LP	LN	LN	MP	-	-	LP	-	1										
38	LN	LP	LP	LN	LN	-	LN	LP	LP	-	LP	LN	LN	-	LN	LN	LN	LN	LP	LN	LP	LN	LN	LN	LN	LN	-	-	LN	LP	MP	LN	MP	LN	LN	LN	LN	1									
39	LP	LP	LP	LP	-	LP	LP	LP	LP	LP	LP	LP	LP	LP	LP	MN	LN	LP	LN	LP	LP	MP	LP	LP	LP	MP	MP	LP	LP	-	LN	LP	LP	LP	LP	LP	HP	-	1								
40	LN	LP	LP	LP	LN	LP	LN	LP	LP	LP	LP	LP	LP	LP	LP	MN	MN	LP	LP	LP	LP	LP	LP	LP	LN	LP	LP	-	-	-	-	LP	LP	-	LP	-	MP	LP	HP	1							
41	LP	MP	-	MP	-	MP	LP	-	LN	LN	LP	LP	MP	LP	MP	MN	MN	MP	LN	LP	LP	MP	MP	MP	LP	MP	MP	MP	-	LN	-	MP	-	LN	LP	LN	HP	-	LP	LP	1						
42	LP	MP	-	MP	LN	LP	LP	-	LN	-	LP	LP	LP	LP	LP	MN	HN	LP	LN	-	LP	LP	LP	LP	LP	MP	MP	LP	-	LP	LP	LP	LP	LN	LP	LN	MP	LP	LP	LP	HP	1					
43	-	-	LP	LP	MP	LN	LP	LN	LP	LP	LP	LN	LN	LP	LN	LP	LP	LN	LP	MN	LP	LN	LN	LN	LN	LN	LN	-	LN	LP	LP	LN	LP	-	LP	LN	LN	LP	LN	LN	LN	LN	1				
44	LN	MN	LP	LN	LP	MN	LN	LP	MP	LP	LP	LN	MN	LN	MN	MP	LP	MN	MP	LN	LN	MN	MN	MN	LN	MN	LN	LN	LP	MP	LP	MN	LP	LP	LN	LP	LN	LP	LN	-	LN	LN	LP	1			
45	-	-	LP	LP	LP	-	LN	LN	LN	MP	LN	LN	LN	-	LN	-	-	LN	LN	LN	-	LN	LN	LN	LN	LN	LN	LP	LN	LP	LP	LN	LP	LN	-	LN	-	-	-	-	-	LN	LP	LP	1		
46	LN	LN	LP	MN	LP	MN	LN	LP	LP	LP	LP	MN	MN	LN	MN	LP	LP	MN	LP	LN	LN	LN	MN	MN	LN	MN	LN	LN	-	LP	LP	MN	-	LP	MN	LP	LN	LP	LN	LN	LN	LN	LP	LP	MP	1	
47	LP	LP	-	LP	LP	LP	LP	LN	-	LP	LN	LP	LP	LP	LP	LN	-	LP	LN	-	LP	LP	LP	LP	-	LP	-	LP	LN	-	-	-	LP	-	LP	LN	LP	-	LP	LP	LP	-	LP	LP	-	LN	1
48	LP	LP	-	LP	LP	-	LP	LN	-	LP	LN	LP	LP	LN	LP	-	LP	LP	LP	LP	LN	LP	LP	LP	LN	-	LN	-	LP	-	LN	-	-	LP	LN	LP	LP	-	LP	LP	-	-	-	LP	-	LN	HP

Table A14 Correlation Matrix for Speed Limit between 45 - 50 mph with 0.5 miles Buffer Width

0.5 miles_ 45 to 50 mph	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	-	1																																													
3	LN	LP	1																																												
4	LP	LP	LN	1																																											
5	-	-	MP	LN	1																																										
6	LN	MP	LN	-	LN	1																																									
7	LN	LN	-	-	MP	LN	1																																								
8	LP	LN	LN	-	LP	LN	-	1																																							
9	-	-	LN	-	LP	LN	-	LP	1																																						
10	LP	-	LN	HP	LN	LN	-	LN	LN	1																																					
11	LP	LN	-	LP	LP	LN	LP	HP	LP	-	1																																				
12	LP	LP	MP	LN	LP	-	-	LP	LP	LN	LN	1																																			
13	LN	-	LN	LN	LP	LN	HP	-	LN	LN	LP	LN	1																																		
14	LN	-	LN	LP	LP	LP	-	-	-	LP	-	-	-	1																																	
15	LP	LN	LN	MP	LN	LN	LP	LN	LP	MP	LP	LN	LN	-	1																																
16	LN	LN	LN	LN	-	LN	-	LN	LN	-	LN	LN	-	-	LP	1																															
17	LN	LN	LN	-	MP	LN	HP	LN	-	-	-	-	HP	-	LN	-	1																														
18	LN	LN	LN	LP	-	LN	LP	LN	-	-	LP	LN	LP	HP	MP	-	-	1																													
19	LN	-	LN	-	LP	LP	LP	LP	LP	-	LP	-	-	LN	-	-	-	LN	1																												
20	LN	LN	LN	-	LN	LN	-	LP	LP	LN	-	LN	LP	LP	LP	LP	-	LP	LN	1																											
21	LP	LP	LN	LP	-	LP	LP	-	-	LP	LP	-	LN	LP	LP	LN	LN	MP	-	LN	1																										
22	-	HP	MP	LP	LP	LP	LN	-	MP	-	LP	LP	LN	LP	LN	LN	LN	LP	LN	LP	LP	1																									
23	-	MP	-	MP	-	-	-	LN	LP	MP	LN	-	LP	LP	MP	LP	-	LP	LN	MP	LP	MP	1																								
24	-	MP	LN	HP	LN	LP	-	LN	-	HP	LN	LN	LP	MP	MP	LN	-	LP	LN	LP	LP	MP	HP	1																							
25	LN	LP	LN	LP	LP	LN	-	-	HP	LN	LP	LN	LN	LP	-	-	-	LP	-	LP	LP	MP	LP	LP	1																						
26	LP	LP	-	HP	LP	LN	LP	LP	LP	MP	MP	-	-	MP	HP	LN	LN	HP	LN	LP	MP	MP	HP	MP	LP	1																					
27	LP	-	LP	LP	MP	LN	LP	LP	LP	LP	MP	LP	LN	LP	MP	LN	LN	MP	LP	LP	LP	LP	LP	LP	LP	HP	1																				
28	LN	LP	LP	LN	LP	LP	LN	-	LP	LN	LP	-	LN	LP	MN	LN	LN	-	LP	LN	-	LP	LN	LN	LP	LN	LN	1																			
29	LN	LN	LP	LN	LP	LN	LP	MP	-	LN	MP	LP	LP	-	LP	LP	-	-	-	LP	LN	LN	LN	LN	LN	-	LP	LN	1																		
30	LP	LP	LP	HP	LP	LN	-	LP	LP	HP	MP	LP	LN	-	MP	LN	LN	LP	-	LN	LP	MP	LP	MP	LP	HP	HP	LP	LN	1																	
31	LN	MP	-	LP	LN	MP	LN	LN	-	-	-	-	LN	LP	MN	LN	LN	LN	LP	LN	LP	LP	LN	-	LP	LN	LN	MP	MN	LP	1																
32	LN	LP	LN	LN	LP	LP	LP	LN	LN	LN	LN	-	LP	LP	LN	LN	-	LP	LN	LP	LP	LP	MP	MP	LP	LP	LP	LP	-	LN	LN	1															
33	LP	MP	LP	MP	LN	LP	LN	LN	-	LP	LP	LN	LN	LP	-	LN	LN	LN	-	LN	MP	LP	LP	LP	LP	-	LN	LP	LN	LP	MP	LN	1														
34	-	LN	LN	LN	LN	LN	-	LP	LN	LN	LP	LN	LP	-	LP	LP	LP	LN	-	-	LN	LN	LN	LN	LN	LN	LN	LN	HP	LN	LN	-	-	1													
35	LN	LP	LN	-	-	LP	-	-	LN	LN	LN	LN	LP	-	-	LP	LN	-	LN	LP	-	LP	MP	LP	LP	LP	-	LN	LN	-	-	LP	-	-	1												
36	LN	MN	LN	LN	LP	LN	LP	MP	-	LN	MP	LN	MP	-	LP	LP	LP	-	-	HP	LN	LN	-	LN	-	-	LP	LN	HP	LN	MN	LP	LN	MP	LP	1											
37	LN	LN	LP	LP	LP	LN	-	-	-	LP	-	LP	LP	LP	LP	-	-	LP	LN	LP	-	LP	LP	LP	-	LP	LP	-	LP	LP	MN	LP	-	LN	LP	LP	1										
38	MN	LP	LP	LN	LP	LP	-	LN	LN	LN	LN	LP	LP	MP	LN	LN	-	LP	LN	LP	LN	LP	LP	LP	-	LP	LP	LP	-	LN	LN	MP	LN	LN	LP	-	MP	1									
39	LN	LP	LP	LP	LP	-	LP	-	LP	LP	LN	LP	LP	LP	LP	LP	LP	LP	MN	-	LP	LP	MP	MP	LP	LP	LP	LN	LN	LP	LN	MP	-	LN	LP	LN	HP	MP	1								
40	-	LP	-	-	LP	-	LP	LP	-	LN	LN	LP	LP	LP	-	LP	LP	LP	MN	LN	LP	LP	LP	LP	LP	LP	-	LN	-	-	LN	LP	-	-	LP	-	LP	LP	HP	1							
41	LN	LN	-	-	LN	-	-	-	LP	-	LN	LP	LP	LP	LP	-	-	LP	LN	LP	LN	LP	LP	LP	-	-	-	LP	LP	LN	LN	LP	LN	-	LP	LP	HP	MP	MP	LP	1						
42	LN	LN	LN	LP	LN	LP	LP	LP	-	-	LN	LP	LP	LP	-	LN	LP	LP	-	LP	-	-	LP	LP	LN	LN	LN	LP	-	LN	-	LP	-	LN	LP	-	MP	LP	MP	LP	HP	1					
43	MP	LP	LP	LP	LP	LP	-	-	-	LP	-	LP	LN	LN	LP	LN	LN	-	LN	LN	MP	LP	-	-	-	LP	LP	LP	LN	MP	LP	LN	LP	LN	LN	LN	LN	MN	-	-	LN	-	1				
44	MP	-	LP	LP	LP	-	LP	LP	LP	LP	LP	LP	-	MN	LN	-	LP	LN	LP	LN	LP	-	LN	LN	LN	LN	LP	LP	LN	LP	LP	MN	LP	-	LN	LN	MN	HN	LN	LN	LN	LN	HP	1			
45	LP	LP	MP	LP	LP	LP	LN	-	-	-	-	LP	MN	LN	LN	LN	LN	LN	-	LN	-	LP	LN	LN	LN	LN	LP	LP	LN	MP	MP	LN	LP	LN	-	MN	LN	LN	LN	-	MN	LN	LP	MP	1		
46	LN	LP	LP	LN	LP	LP	-	LP	LN	LN	-	LP	LP	-	LN	LN	LP	LN	LP	LN	MN	-	LN	LN	MN	LN	LN	-	LP	-	-	LN	-	LP	-	-	LN	LP	-	-	LN	LN	LN	LP	LP	1	
47	MP	LP	LP	LP	-	LP	LN	LN	LP	-	LP	LN	MN	LN	LP	LP	LN	LN	LP	LN	LP	LP	LN	LN	LP	-	LP	LP	-	LP	MP	LN	MP	LP	LN	LN	LN	MN	LN	-	LN	LN	MP	MP	LP	LN	1
48	LP	LP	LP	-	-	-	LN	-	LP	LN	LP	-	LN	LN	-	LP	LN	LN	LP	LN	LP	LP	LN	LN	LP	-	LP	-	-	LP	LP	LN	MP	LP	LN	LN	LN	MN	LN	LP	LN	LN	MP	MP	LP	LN	HP

Table A15 Correlation Matrix for Speed Limit between 45 - 50 mph with 1-mile Buffer Width

1-mile_45to50mph	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	-	1																																													
3	-	LP	1																																												
4	LN	MP	LN	1																																											
5	-	LN	MP	-	1																																										
6	LN	MP	LN	LP	LN	1																																									
7	LN	LN	LN	LP	HP	LN	1																																								
8	LP	LN	LP	LN	HP	LN	LP	1																																							
9	-	-	LP	LN	LP	MN	LP	LP	1																																						
10	LP	MP	LN	HP	LN	-	LN	LN	LN	1																																					
11	LP	LN	LP	LN	MP	LN	LP	MP	MP	LN	1																																				
12	-	LP	HP	LN	LP	-	LN	LP	LP	LN	-	1																																			
13	MN	LP	LN	HP	LP	LP	HP	-	-	LN	LN	-	1																																		
14	-	MP	LN	MP	-	LP	LP	LP	-	LP	LP	-	LP	1																																	
15	LN	LP	LN	HP	LP	LP	MP	-	LP	LP	-	LN	HP	-	1																																
16	LN	MN	LN	LN	LP	LN	MP	-	-	LN	LN	LN	LP	LN	LP	1																															
17	LN	MN	LN	LN	MP	LN	HP	LN	-	LN	LN	LN	MP	-	LP	HP	1																														
18	LN	LP	LN	MP	LN	LP	LP	LN	MP	LN	LN	-	HP	LP	HP	LN	-	1																													
19	-	LN	LN	LN	-	LN	-	LP	-	LN	LP	LN	LN	LN	LN	LN	LN	LN	1																												
20	LN	LN	LN	LP	-	LN	LP	LP	LP	LN	LN	LN	MP	LN	LP	LP	LP	LP	-	1																											
21	-	LP	LN	MP	LP	LP	LP	LP	LP	-	LP	-	LP	HP	LP	LN	LN	MP	LN	LN	1																										
22	LN	HP	MP	MP	LP	LP	LN	LP	MP	-	LP	MP	LP	LP	LP	LN	LN	MP	LN	LN	LP	1																									
23	LN	MP	LN	HP	LN	LP	LP	LN	LP	LP	LN	LP	HP	LP	HP	LN	LN	HP	LN	LP	LP	HP	1																								
24	LN	HP	LN	HP	LN	LP	LP	LN	LN	MP	LN	-	HP	MP	HP	LN	LN	HP	LN	LP	LP	MP	HP	1																							
25	LN	MP	LN	MP	LP	MP	LP	LN	LP	LP	LP	LN	LP	MP	LP	LP	LP	MP	LN	-	LP	MP	MP	MP	1																						
26	LP	MP	-	HP	MP	-	MP	LP	MP	LP	LP	-	MP	LP	HP	LN	-	HP	LN	LP	MP	MP	HP	HP	MP	1																					
27	LP	LP	MP	LP	MP	LN	LP	LP	LP	-	MP	LP	-	LP	LP	LN	LN	LP	-	LN	LP	MP	LP	LP	LP	HP	1																				
28	LN	MP	LN	MP	LP	MP	LP	LP	LP	-	LP	-	LP	MP	LP	-	LN	LP	LP	LN	MP	MP	LP	MP	HP	MP	LP	1																			
29	LN	MN	LP	LN	MP	LN	MP	HP	LP	LN	LP	LP	LP	LN	LP	LP	LP	LN	-	MP	LN	LN	LN	LN	LN	LP	-	LN	1																		
30	LP	MP	LP	MP	LP	LN	LN	LP	LP	HP	LP	LP	LN	LP	LP	LN	LN	LN	LN	MN	LP	LP	LP	LP	LP	HP	HP	LP	LN	1																	
31	-	HP	LP	LP	LN	MP	MN	LN	LN	LP	-	LP	MN	LP	LN	MN	MN	LN	-	HN	LP	LP	LN	-	LP	LN	LN	MP	MN	LP	1																
32	LN	MP	LN	HP	-	MP	LP	-	LN	LN	LN	LP	HP	LP	HP	LN	LN	HP	LN	MP	LP	MP	HP	HP	MP	MP	LP	LP	-	LN	LN	1															
33	LP	LP	LP	LP	LN	LP	LN	-	LP	LP	MP	LP	LN	LP	LN	LN	LN	LN	LP	MN	LP	LP	LN	-	-	-	LP	LP	LN	LP	HP	LN	1														
34	LN	MN	LN	LN	LP	LN	LP	LP	LN	LN	LP	LN	LP	LN	LP	LP	MP	LN	LP	MP	LN	MN	LN	LN	LN	-	LN	LN	HP	LN	MN	LN	LN	1													
35	-	MP	-	LP	-	MP	-	LP	LN	-	-	LP	LP	MP	MP	LP	LP	LP	LN	LP	LP	LP	MP	MP	MP	MP	LP	MP	LN	LP	LP	MP	LP	LN	1												
36	LN	MN	LN	LN	LP	LN	MP	MP	LP	LN	LP	LN	MP	LN	LP	MP	MP	LP	LP	HP	LN	MN	LP	-	LN	LP	-	LN	HP	LN	HN	LP	MN	HP	-	1											
37	LN	-	LP	MP	LP	LP	LP	LP	LP	-	-	LP	MP	-	LP	LP	LP	LP	LN	LP	LP	MP	MP	MP	LP	LP	LP	LP	LP	LP	LN	MP	LN	-	LP	LP	1										
38	MN	LP	LP	MP	LP	LP	LP	LP	LN	LN	LN	LP	HP	LP	MP	LN	LN	MP	LN	LP	LP	MP	HP	MP	LP	LP	LP	LP	-	LN	LN	HP	LN	LN	LP	LP	MP	1									
39	LN	LP	LP	MP	LP	-	LP	LP	LP	LP	-	LP	LP	LP	LP	LP	LP	LP	LN	-	LP	MP	MP	MP	MP	LP	LP	LP	-	LP	LN	LP	LN	LN	LP	LN	HP	MP	1								
40	-	LP	LP	LP	LP	-	-	LP	-	LP	-	LP	LP	LP	LP	-	-	LP	LN	-	LP	LP	LP	LP	LP	LP	-	-	-	LP	LN	LP	LN	LP	LP	-	LP	LP	HP	1							
41	LN	-	-	LP	-	LP	LP	LP	LP	-	LN	LP	MP	-	LP	LP	LP	MP	-	LP	LP	LP	MP	MP	LP	LP	-	LP	LP	-	LN	MP	LN	-	LP	LP	HP	MP	MP	LP	1						
42	LN	LN	LN	LP	LN	LP	LP	LN	-	LP	LN	LP	LP	-	LP	-	LP	LP	-	LP	-	-	LP	LP	LP	-	LN	LP	-	LN	-	LP	LN	LP	LP	-	MP	LP	MP	LP	HP	1					
43	MP	LP	LP	LN	-	LP	LN	-	LP	LP	LP	LP	MN	-	LN	MN	LN	LN	LN	MN	LP	LP	LN	LN	-	LP	LP	-	LN	MP	MP	MN	MP	MN	-	MN	LN	MN	-	-	LN	-	1				
44	MP	-	LP	MN	LN	LN	MN	LN	LP	LP	LP	LP	HN	LN	MN	LN	LN	LN	LP	LN	LN	LN	MN	MN	LN	LN	LP	LN	LN	LP	LP	MN	MP	LN	LN	LN	MN	HN	LN	LN	LN	LN	HP	1			
45	LP	LP	MP	LN	LP	LP	LN	LN	-	-	-	LP	MN	LN	MN	LN	LN	MN	-	MN	LN	LP	LN	MN	-	LN	LP	-	LN	LP	MP	MN	LP	LN	LN	MN	LN	LN	LN	-	MN	LN	LP	MP	1		
46	LN	LP	LP	LN	LP	LP	LN	LP	LN	LN	-	LP	LP	LN	LN	LN	LN	LN	LP	-	MN	-	-	LN	LN	LN	LN	LN	LP	LN	-	LP	-	LP	-	-	LN	LP	-	-	LN	LN	LN	LP	LP	1	
47	MP	LP	LP	LN	LN	-	LN	LN	LP	LP	LP	LN	MN	-	LN	-	LN	LN	LP	MN	-	-	LN	LN	-	LN	-	LN	LN	LP	MP	MN	MP	LN	-	LN	LN	MN	LN	-	LN	LN	MP	MP	LP	LN	1
48	LP	LP	LP	LN	LN	LN	LN	-	LP	LP	LP	-	MN	-	LN	LP	LN	LN	LP	MN	-	-	LN	LN	-	LN	-	LN	LN	LP	LP	MN	LP	LN	-	LN	LN	MN	LN	LP	LN	LN	MP	MP	LP	LN	HP

Table A16 Correlation Matrix for Speed Limit > 50 mph with 0.5 miles Buffer Width

0.5 miles_ >50mph	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	LP	1																																													
3	LN	-	1																																												
4	LP	HP	LN	1																																											
5	MP	LP	-	MP	1																																										
6	-	HP	LN	HP	LP	1																																									
7	MP	MP	LN	MP	HP	LP	1																																								
8	LN	LN	MP	LN	-	LP	LN	1																																							
9	LN	LP	LN	MP	LP	-	MP	LN	1																																						
10	LN	LN	-	LN	LN	LN	LP	LN	HP	1																																					
11	-	LP	-	MP	MP	MP	MP	MP	MP	LP	1																																				
12	LN	LN	-	LN	LN	LP	MN	LP	LN	LN	LN	1																																			
13	LP	HP	LN	HP	HP	MP	HP	LN	LP	LN	LP	LN	1																																		
14	MP	LN	-	-	-	-	-	-	LN	-	-	LN	-	1																																	
15	LP	HP	LP	HP	LP	MP	MP	-	LP	LP	HP	MN	HP	LP	1																																
16	LN	LN	-	LN	-	LN	LN	-	LN	LN	LN	LN	LN	-	-	1																															
17	HP	LN	LN	-	HP	LN	MP	LN	-	LN	-	LN	LP	LP	-	-	1																														
18	LP	HP	LN	HP	MP	HP	MP	MN	LP	LN	LP	-	HP	-	MP	LN	LN	1																													
19	LN	LN	-	LN	LP	-	-	MP	LN	-	MP	LP	LN	LN	LN	LP	-	LN	1																												
20	MP	-	-	LN	-	LN	LN	-	MN	LN	LN	LN	LN	LP	-	-	LP	LN	LN	1																											
21	LP	MP	LN	HP	LP	HP	LP	LN	LP	LN	MP	LN	MP	-	LP	-	LN	MP	LN	LN	1																										
22	LP	HP	LN	HP	LP	MP	MP	LN	LP	-	LP	LN	HP	-	HP	-	LN	HP	MN	LN	LP	1																									
23	LP	HP	-	HP	LP	HP	MP	LN	MP	-	MP	LN	HP	-	HP	LN	-	HP	LN	LN	LP	HP	1																								
24	LP	HP	LN	HP	LP	HP	HP	LN	MP	-	MP	LN	HP	-	HP	LN	LN	HP	LN	LN	MP	HP	HP	1																							
25	LP	LP	LP	LP	HP	LN	MP	-	LP	-	LP	MN	HP	-	MP	-	LP	-	LN	LP	LN	LP	LP	LP	1																						
26	LN	HP	-	HP	-	MP	MP	-	HP	MP	HP	MN	MP	-	HP	-	LN	MP	LN	LN	MP	HP	HP	HP	LP	1																					
27	-	HP	LP	MP	-	-	MP	LN	HP	HP	MP	MN	LP	LN	HP	LN	LN	MP	LN	-	LP	MP	HP	HP	LP	HP	1																				
28	LN	MP	LN	MP	-	LP	LP	MN	HP	MP	-	-	LP	LN	-	-	MN	HP	LN	MN	MP	MP	LP	MP	LN	MP	MP	1																			
29	-	LN	MP	LN	LP	MN	-	MP	LN	LN	-	-	-	-	LN	MP	LP	LN	-	LP	LN	LN	LN	LN	LP	LN	LN	LN	1																		
30	LN	LN	LN	LN	LN	-	-	-	MP	MP	LP	LN	-	-	MP	LP	LN	LN	LN	-	LP	-	LP	-	LP	MP	LP	MP	LN	1																	
31	LN	-	LN	LN	MN	LP	MN	LP	MN	LN	LN	HP	LN	LN	MN	LN	MN	-	MP	LN	LN	-	LN	LN	LN	MN	MN	-	LN	-	1																
32	LP	HP	LN	HP	LP	LP	LP	MN	LP	LN	LP	LN	HP	-	LP	LN	LN	HP	LN	MP	MP	HP	MP	HP	-	MP	MP	MP	-	LN	LN	1															
33	LN	LN	LN	LN	-	LP	LN	MP	-	-	MP	-	LN	-	-	LP	LN	LN	HP	LN	-	LN	LN	LN	-	-	LN	-	-	LP	MP	LN	1														
34	-	LN	HP	LN	-	LN	LN	MP	LN	LN	-	-	LN	LP	LN	LP	LP	LN	LN	-	LN	LN	LN	LN	-	-	LN	LN	HP	LN	LN	LN	LN	1													
35	MP	-	-	-	-	MP	-	LP	LN	LN	LP	LN	-	MP	HP	LN	LN	-	LN	LP	-	LP	LP	LP	-	LP	-	LN	LN	LP	LN	-	-	-	1												
36	-	MN	MP	MN	LP	LN	-	HP	LN	LN	LP	-	LN	-	LN	MP	LP	MN	LP	LP	LN	MN	MN	MN	LP	LN	MN	MN	HP	-	LN	LN	MP	MP	LP	1											
37	HN	MN	-	MN	MN	LN	MN	LP	-	LP	LN	MP	MN	LN	MN	LP	MN	LN	LP	HN	-	LN	LN	LN	MN	-	LN	LP	-	LP	MP	MN	LP	LP	MN	-	1										
38	MN	MN	-	LN	LN	MN	-	LN	MP	HP	LN	LN	MN	LN	LN	LP	LN	MN	-	LN	LN	LN	LN	LN	MN	LP	LP	LP	LP	LP	LN	LN	-	LP	MN	-	HP	1									
39	HN	MN	-	LN	HN	LN	MN	LP	LP	LP	LN	MP	MN	LN	MN	LP	HN	LN	-	MN	LN	LN	LN	LN	HN	-	LN	LP	LP	LP	LP	LN	-	LP	LN	LN	HP	HP	1								
40	HN	MN	LP	LN	MN	LN	LN	-	LP	MP	LN	-	LN	LN	LN	LP	MN	LN	-	HN	-	LN	LN	LN	MN	LP	LP	LP	-	LP	-	MN	-	LP	MN	LN	HP	HP	HP	1							
41	HN	LN	-	LN	MN	-	LN	LP	LP	LP	-	MP	LN	LN	LN	LP	HN	-	LP	HN	-	-	-	-	MN	LP	-	LP	-	LP	MP	MN	LP	-	MN	LN	HP	HP	HP	HP	1						
42	HN	LN	-	LN	HN	LN	MN	-	LP	HP	LN	-	MN	LN	LN	LP	MN	LN	LN	LN	LN	LN	LN	LN	MN	LP	LP	MP	-	MP	LN	LN	-	LP	LN	LN	HP	HP	HP	HP	HP	1					
43	-	-	LP	LN	-	LN	LN	-	LN	-	LN	-	LN	LP	LN	LN	LP	LN	LN	LP	MN	-	LN	LN	-	LN	LN	LN	LN	LN	-	LN	LN	-	LN	-	LN	LN	LN	-	LN	-	1				
44	LN	MN	-	HN	-	MN	LN	LP	LN	-	MN	LP	MN	-	LN	LP	LP	MN	LP	-	HN	LN	LN	MN	-	MN	LN	MN	LP	LN	LP	MN	-	-	LN	LP	LP	-	LP	-	LP	-	MP	1			
45	LN	MP	MP	LP	LN	LP	MN	LP	-	LP	-	LN	-	-	LP	LN	MN	LP	LN	-	LN	LP	-	-	LN	LP	MP	LP	LN	-	LP	LP	-	LN	-	MN	-	-	-	LP	-	LP	HP	-	1		
46	MN	LN	-	LN	HN	LP	HN	LP	LN	LP	LN	LP	MN	-	LN	-	HN	LN	LN	LN	-	-	LN	LN	MN	-	-	LP	LN	LP	MP	LN	LP	-	-	LN	MP	LP	MP	HP	MP	HP	LP	LN	MP	1	
47	MP	LN	LN	-	LN	LN	LN	LN	LN	LN	LN	LN	LN	MP	-	-	HP	-	LN	LP	LN	-	-	-	-	LN	LN	LN	LN	LN	LN	LN	-	LP	-	-	MN	LN	MN	-	MN	LN	MP	-	-	LP	1
48	MP	LN	LN	-	LN	LN	LN	LN	LN	LN	LN	LN	LN	MP	-	-	HP	-	LN	LP	LN	-	-	-	-	LN	LN	LN	LN	LN	LN	LN	-	LP	-	-	MN	LN	MN	-	MN	LN	MP	-	-	LP	HP

Table A17 Correlation Matrix for Speed Limit > 50 mph with 1-mile Buffer Width

1-mile _ >50mph	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
2	LP	1																																													
3	LN	LN	1																																												
4	LP	HP	LN	1																																											
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37	HN	MN	-	MN	HN	LN	HN	LP	LP	LP	LN	MP	HN	LN	HN	LN	MN	LN	MP	HN	LN	MN	MN	MN	HN	MN	LN	LP	LP	LP	MP	MN	LP	-	HN	LN	1										
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ABBREVIATIONS AND ACRONYMS

BT	Buffer Time
BTI	Buffer Time Index
CBD	Central Business District
DOW	Day-of-the-Week
ITE	Institute of Transportation Engineers
GEE	Generalized Estimating Equation
OBD	Other Business District
PT	Planning Time
PTI	Planning Time Index
RITIS	Regional Integrated Transportation Information System
RTDM	Regional Travel Demand Model
TAZ	Traffic Analysis Zones
TDMs	Travel Demand Models
TIS	Traffic Impact Studies
TOD	Time-of-the-Day
TTV	Travel Time Variability
VMT	Vehicle Miles Traveled

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