AADT Estimation Models and Analytical Comparison of Pedestrian Safety Risk Evaluation Methods for Signalized Intersections

by

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Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

Chapter 5 of this thesis includes several components of analysis contributed by my supervisor, Dr. Bruce Hellinga, and my colleague, PhD candidate Mohammad Zarei. The calibration of the safety performance function and calculation of potential for safety improvement values were performed by Mohammad, with discussion contributed by Dr. Hellinga. The rank error methodology was developed by Mohammad and Dr. Hellinga, and the discussion of the rank error is attributable to them.

Abstract

Pedestrian road safety is a priority for Canadian municipalities due to the particularly large social and economic impact that pedestrian-vehicle collisions can have on society. There is a constant need to improve roads to make them safer for all users, but especially for vulnerable road users such as pedestrians. Despite the existence of several methods to prioritize locations for improvements in pedestrian safety, there is no consensus on which method should be used.

In this thesis, several methods were identified which could be used to prioritize sites for pedestrian safety improvement (i.e., network screening), specifically signalized intersections, using their geometric, operational, and land-use characteristics. Three methods were selected for further investigation, including the NCHRP ActiveTrans Priority Tool (APT), the FHWA Pedestrian Intersection Safety Index (Ped ISI), and the ODOT Pedestrian Intersection Risk Score. Traffic volume data in the form of annual average daily traffic (AADT) are required as input for these methods. Given that AADT are frequently not available for all intersections, another objective of this thesis was to develop a set of multiple linear regression models for the AADT of signalized intersection legs. Site data for both safety method application and AADT estimation modelling were collected for 438 Niagara Region signalized intersections from site imagery, GIS, and other online sources.

Using existing AADT data as the dependent variable, six multiple linear regression models were developed. Each model is structured to be applied when different geometric, operational, and land-use characteristics are available as inputs. As one might expect, the models with the highest predictive power were those that also required the greatest amount of knowledge about existing conditions. Nevertheless, all models were shown to be statistically significant and provided reasonably strong to very strong predictive power.

The AADT estimation models were used to estimate AADT for intersections for which observed AADT was not available. The pedestrian safety risk evaluation methods were then each applied to rank the 438 signalized intersections in Niagara Region. The potential for safety improvement (PSI) method was also applied to obtain a ranking based on collision frequency.

Overall, the rankings were found to be very different between methods, as demonstrated by high measures of rank error (relative rank error weighted averages ranged from a low of 34% to more than 80%). This revealed a substantial challenge for practitioners as they would be faced with substantially different and inconsistent site prioritization results depending on which ranking method was chosen, despite all methods aiming to provide measures of pedestrian risk.

To explain the differences in ranking between methods, the contribution of each method's input variables and their correlations were examined. A combination of differences in the inclusion of input variables, their influence on the levels of risk for sites within a given method, and poor correlation among surrogate variables were suggested for the lack of similarity between rankings of different methods. The question of which method should be applied could not be answered. Several considerations for choosing a method were discussed. Further research into development of a robust pedestrian safety evaluation method was recommended.

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1. Introduction

1.1 Motivation and Context

The pedestrian mode is the basis for all human transportation. With cities and towns literally built at the intersection of different modes, the integrated movement of pedestrians, cyclists, motor vehicles, and other network users results in a complex system influenced by physical and social factors. Collisions between different users result in a significant number of personal injuries and fatalities, and substantial costs associated with health and property damage. Therefore, it is in society's best interests to commit to continually improving the safety of transportation infrastructure. While the priority of transportation engineers is the safety of all network users, pedestrians are among the most exposed and vulnerable road users, and being more susceptible to injury, they deserve particular consideration in the design of our transportation networks.

In the growing field of highway safety engineering, the severity of motor vehicle collisions is defined by the level of damage to human health; fatal collisions are the most severe, followed by injury collisions, and property damage only (PDO) collisions. According to the Canadian National Collision Database, more than three million people were involved in a motor vehicle collision over a ten-year period between 2008 and 2017 (Government of Canada, Transport Canada, 2019). Of these, 87.0% were occupants of the involved vehicles and 50.5% were injured or killed. In contrast, pedestrians accounted for only 4.2% of those involved in collisions, yet 89.1% of those pedestrians were killed or injured. Evidently, pedestrians are more likely than automobile occupants to suffer injury or loss of life in a vehicle collision, though this is not the only loss encountered. The United States Federal Highway Administration (FHWA) estimates the societal cost for fatal collisions as approximately $11.2 million USD per collision, while the average societal cost per injury collision is approximately $325,000 USD (Harmon et al., 2018). These societal costs reflect tangible and intangible consequences including lost quality-of-life, medical expenses, legal and insurance costs, lost market and workplace productivity, traffic congestion, and property damage. More pedestrian-vehicle collisions tend to occur at intersections than midblock locations, a trend commonly seen in North American cities. For instance, the city of Toronto, Ontario found 69% of pedestrians and cyclists were involved in collisions at intersections compared to 22% for midblock locations in 2015 (Bassil et al., 2015); in the Region of Waterloo, 67.9% of pedestrian collisions occurred at intersections, compared to 22.7% at midblock locations (Regional Municipality of Waterloo, 2018); and in Seattle, Washington, from 2007 to 2013, 65% of pedestrian collisions occurred at intersections, compared to 35% at midblock segments (Quistberg et al., 2015).

In recent decades, there has been an increasing global effort to improve pedestrian road safety and reduce collisions with non-vehicular modes; most notable is the Vision Zero initiative implemented in Sweden in 1997, which has since spawned similar legislation and movements to reduce severe traffic collisions across the world (Vision Zero Canada, 2020). In Canada, the Canadian Council of Motor Transport Administrators (CCMTA) has published the *Road Safety Strategy (RSS) 2025* with the aim of "Towards Zero [collisions]" across the country (Canadian Council of Motor Transport Administrators, 2016). Meanwhile, municipalities in Canada and the United States have adopted policies similar to Vision Zero with the aim of improving safety for all users, including Toronto (City of Toronto, 2017), Edmonton (City of Edmonton, 2020), New York City (City of New York, 2019), and Boston (City of Boston, 2018) among many others. A general objective of these road safety policies is the improvement of road infrastructure to reduce safety risks, which inherently necessitates locating where infrastructure safety improvements should be made. Though the safety of an entire network is a priority, it is not possible nor effective for municipalities to allocate resources to improve all locations at once. For the purposes of achieving the largest reduction in risk and being fiscally responsible, the locations requiring improvements must be prioritized.

Network screening is the process whereby locations (intersections or midblock segments) in a road system are evaluated and ranked according to a measure of predicted safety risk (Carter et al., 2017). Generally, the higher the predicted risk, the greater priority a location has for safety improvements. While site evaluation scores can be based on collision counts or collision rates, a more statistically rigorous score can be generated using safety performance functions (SPF): these regression models use the physical characteristics, collision histories, and motor vehicle traffic volumes of locations to generate expected numbers of crashes via empirical Bayes inference methods (American Association of State Highway and Transportation Officials, 2010). SPFs can be used to determine the potential for safety improvement (PSI) of locations (also known as "excess predicted average frequency"), which is a scoring metric used for network screening. The use of SPFs in network screening is a common practice today in road safety engineering but this method typically uses all vehicular collisions (not just those involving pedestrians), and because pedestrians are involved in only a small fraction of all collisions, the resulting site rankings are primarily determined by the frequency of vehicle collisions rather than other factors influencing pedestrian risk. The low numbers of collisions involving pedestrians (relative to all vehicular collisions) and the lack of exposure data (i.e., pedestrian volumes) in most municipalities limits the use and development of SPFs for pedestrian safety improvements since the calibration of these models is imprecise without sufficient data. For example, vehicular traffic volumes in the form of Annual Average

Daily Traffic (AADT) are an important input to most SPFs involving motor vehicle collisions. Although one can expect a municipality to have AADT counts for most major roads in the network, it is rare that a municipality has AADT values for every major road segment due to the economic and time cost of collecting and assembling estimates. It is even rarer that a municipality will have pedestrian daily traffic volumes available for most locations, due to the difficulty of collecting such data, thus making the development and application of safety performance functions for collisions involving pedestrians impractical for most jurisdictions.

In order to perform network screening specifically for pedestrian safety risk, other methods have been developed which rely on the geometric, operational, and land-use characteristics of intersections to calculate a risk score. Road traffic volumes are often a key input characteristic to these methods. While several methods have been created, a problem lies in the lack of consensus or standard for the choice of pedestrian safety risk evaluation methods, particularly across Canada. Without a specific guideline or standardized process, municipalities are left uncertain as to how they should evaluate pedestrian safety risks across locations in their road networks.

1.2 Problem Statement

The safety and integrity of all transportation network users is a priority for municipal engineers and practitioners, and continuous efforts must be undertaken to improve the safety of road networks to reduce loss of life and costs to society. Pedestrians, in particular, are a vulnerable group of network users, and their safety on roads is a concern of focus for municipalities, especially at signalized intersections where pedestrian collisions are more frequent. Given that municipalities have limited resources to spend and the assumption that certain network locations have higher risks than other locations, it is unreasonable to expect municipalities to allocate resources to improve all locations at once. A number of methods have been developed to prioritize locations for pedestrian safety improvements in a road network, but in order to act in the best interests of network users, society, and taxpayers, municipalities need to know which evaluation methods are most applicable. However, there has not yet been a comparative assessment of the available evaluation methods which identifies their applicability to Canadian municipalities (as most have been developed in the United States); therefore, municipalities remain uncertain which methods should be used to prioritize locations for pedestrian safety improvements. Moreover, traffic volume is a key input to most existing pedestrian risk evaluation methods, but these data are not readily available for all sites.

1.3 Research Goals and Objectives

The goal of this research is to identify which pedestrian safety risk evaluation methods are most applicable to signalized intersections in Canadian municipalities. This thesis has the following specific objectives:

1. Review and assess the literature to identify a set of best-practice methods for evaluating pedestrian risk at signalized intersections.
2. Apply the selected methods to a chosen Canadian municipality. This requires the identification of the input data requirements for the selected methods and assembling these data for the selected municipality.
3. Develop and evaluate models for estimating AADT for the legs of signalized intersections using the available geometric, operational, and land-use data.
4. Apply the AADT estimation models from Objective 3 to estimate traffic volumes for locations at which AADT is not available, as AADT is a required input for Objective 5.
5. Compare and contrast the different pedestrian risk estimation methods in terms of the results of their application to the chosen municipality.

The remainder of this thesis is structured into five additional chapters. Chapter 2 provides a review of the relevant literature pertaining to pedestrian safety risk evaluation methods and recommends three methods which are then applied and evaluated as part of this thesis. Chapter 2 also describes the relevant literature related to traffic volume (AADT) estimation models. Chapter 3 describes the municipality chosen as the study site for this thesis and the associated empirical data set. Chapter 4 presents the development and validation of the proposed AADT estimation models. Chapter 5 describes the pedestrian risk evaluation methods selected as part of the literature review in Chapter 2. These models are then applied to the signalized intersections within the study site. A description is provided for the application of all three methods to a single sample intersection. Then the results of the application of the methods to all intersections are presented, compared, and discussed. Finally, Chapter 6 provides conclusions and recommendations.

2. Literature Review

2.1 Methods for Pedestrian Safety Risk Evaluation at Intersections

2.1.1 Methods

In recent decades, greater attention has been given to quantifying and improving pedestrian safety on North American roads, particularly as transportation planning and engineering paradigms have shifted away from automobile-centric policies to a more inclusive “complete streets” direction which considers all modes, including walking and cycling. While the body of literature surrounding specific factors affecting pedestrian safety is vast, there has been less work devoted to the development of methods that quantify pedestrian safety based on the characteristics of pedestrian environments, possibly due to the infrequent nature of pedestrian collisions and their data.

In general, the development of pedestrian safety prioritization methods follows a common process. First, a review of factors influencing pedestrian safety on roads is conducted. Then, data for selected factors are collected for a series of locations, along with some measure of pedestrian safety for each location (usually the number of pedestrian collisions). Finally, through statistical analysis, the relationship between the significant factors and the measure of safety is identified and presented in some form that allows the calculation of a safety parameter for each location.

The Systemic Pedestrian Safety Analysis Process (Thomas et al., 2018) is a generalized seven-step process published by the National Cooperative Highway Research Program (NCHRP) which guides agencies through the prioritization (i.e., ranking) of sites and the subsequent selection, implementation, and evaluation of countermeasures. The prioritization process is conducted in the first four steps, which include definition of the study scope, compilation of site data, determination of risk factors, and finally the identification of potential treatment sites. The determination of risk factors is where the method and criteria (variables) for ranking sites is selected. The development of safety performance functions for pedestrians is suggested for this step, with the use of collision frequency or local judgment as alternatives. While the process provides a useful framework for prioritizing improvement locations and countermeasures, as well as suggestions for potential risk factor variables, it does not specifically calculate a quantifiable measure of pedestrian safety. This systemic analysis process was applied to a prioritization of midblock pedestrian crash predictions in Seattle (Kumfer et al., 2019), who developed and applied SPFs to rank road segments. At the time of publishing, the city was still in the process of applying the prioritization and comparing the ranking results with the costs of the various projects as a validation of the procedure. It is noted that the city to which the process was applied had detailed pedestrian and cyclist traffic data for the site (i.e., road segments), which is an uncommon data resource for many jurisdictions.

A more specific and statistically rigorous crash prediction index was developed by Al-Mahameed et al. (2019) by using a structural equation modelling (SEM) approach. Data for 60 potential explanatory variables was collected for 200 highway corridors in Wisconsin, and SEM was used to quantify the safety of locations by analyzing the relationship between the location variables and collisions. The study found that variables related to pedestrian/cyclist-oriented road design, exposure (i.e., levels of pedestrian/cyclist activity and density of employment), and social status (i.e., education levels, income) all contributed to crash frequency. The authors state that the SEM method was selected because it can explain complex relationships between variables better than regression models, which may help practitioners understand the interrelationships of factors relating to pedestrian and cyclist collisions. Although this study examined road segments, the approach to modelling could be applied to intersections.

Stipancic et al. (2020) developed a regression model for the number of pedestrian injuries using collision, exposure, geometry, and signalization data from 1,864 signalized intersections in the city of Montreal. The model was then used to identify hotspot locations with an increased pedestrian safety risk using two measures: the expected number of pedestrian injuries, and the expected pedestrian crash rate. The study identified several significant correlations with the number of pedestrian collisions at intersections, including positive correlations with total numbers of lanes, presence of commercial entrances, and presence of a straight green arrow signal, and negative correlations with the presence of curb extensions, raised medians, all-red and half-red signal phases, and the number of exclusive turn lanes. The study presented a complex method of prioritizing signalized intersections for pedestrian improvements in Montreal, but also indicated which geometric and operational countermeasures were significant in reducing collision risk.

Three additional pedestrian safety evaluation methods were examined for further consideration in this thesis, given their reasonable data demands, ease-of-use, and relatively tangible output values compared to methods previously discussed. These methods include the NCHRP ActiveTrans Priority Tool, the ODOT Pedestrian Intersection Risk Score, and the FHWA Pedestrian Intersection Safety Index.

2.1.2 NCHRP ActiveTrans Priority Tool (APT)

The ActiveTrans Priority Tool (APT) is a method developed by the NCHRP that guides the prioritization of improvements to pedestrian and bicycle facilities (Lagerwey et al., 2015). Through a 10-step process, the APT outputs a prioritization score based on selected factors for a set of locations. The score is a positive numeric value where a higher value indicates a higher priority for improvement of the facility.

The process can be grouped into two phases; Phase 1 involves scoping of the project and Phase 2 is the prioritization of the locations. In the first phase, the purpose of the prioritization project is identified, and the weights of the factors and variables used for generating the prioritization score are selected. The users assess the availability of data and technical resources before moving on to Phase 2, where the required data for each location is input to the tool (a spreadsheet), the variables scaled, and the scores generated for prioritization. The factors provided by the APT include the following:

- stakeholder input
- constraints
- opportunities
- safety
- existing conditions
- demand
- connectivity
- equity
- compliance (Lagerwey et al., 2015)

Within each factor, the APT suggests a number of variables that have been identified in the literature as being a measure of that factor; for example, for the factor called "Safety", the number of pedestrian collisions for each location is suggested as a variable. Of the provided factors, "Safety", "Existing Conditions," and "Demand" are the factors that correspond to geometric, operational, and land-use characteristics.

The weights and scaling of each of the chosen factors is intentionally left to the user to select, which provides flexibility in the way the prioritization scores are calculated to meet agency and community values. However, the APT does not specify any particular factors, variables, weightings, or scaling methods to use, instead relying on the judgement of practitioners to select reasonable items and values for their specific needs. Apart from the suggestion of several variables in each factor (based on literature review and expert input), there is no statistical analysis in the score development process. Despite the lack of statistical rigour, the APT has been used by numerous agencies since its creation for the purposes of improving pedestrian safety; selected municipalities include York Region, Ontario (Piovesana, 2019) Washington, DC (National Capital Region Transportation Planning Board, 2019), Harrisonburg, VA (Barrella, 2019), and the Arizona Department of Transportation (Zegeer, 2017). The flexibility of the APT in terms of scope applicability and data requirement as well as its ability to generate a prioritization score make it a popular method for municipalities, and a method worth considering in more detail.

2.1.3 ODOT Pedestrian Intersection Risk Score

In 2017, the Oregon Department of Transportation (ODOT) published a set of crash occurrence risk scoring tools to aid in the prioritization of pedestrian and cycling facility improvement projects. Scores were produced for intersections and midblocks for pedestrian and cyclist modes, leading to four total risk scoring tools. Binomial logistic regression models for the number of pedestrian or cyclist collisions were calibrated using data from 184 intersections and 188 segments randomly selected across the state; geometric, land-use, and volume data were used for the independent variables (Monsere et al., 2017). The binomial distribution was applicable for modelling since the models represented the probability of two complementary outcomes at a given location (i.e., a crash either occurs or does not occur). The following variables were found significant for the application of the intersection risk scores:

- total population density per square mile
- number of transit lines with routes through the intersection
- major AADT
- presence of a median on the major road
- presence of right-turn lanes on the minor road
- presence of right-turn lanes on the major road (Monsere et al., 2017)

After generating regression models, the odds ratios and percentiles of the gathered dependent variables were used to develop a points-based scoring tool where the characteristic values at each location contributed points to a risk score out of 100 points. The input variables are binned, and each bin has a point value that contributes towards a total risk score. A higher score relative to other scores indicates a higher risk of collision and, by implication, higher priority for a pedestrian or cyclist project. To demonstrate the applicability of the risk scores, several sets of in-progress pedestrian and cyclist project locations were scored using the risk scoring tool and compared with the benefit-cost ratios for each project. A reasonably strong correlation between the scores and the benefit-cost ratios indicated that the proposed risk scores were reasonably aligned with the importance of pedestrian/cyclist projects, thus demonstrating the applicability of the proposed risk scores to the prioritization of projects.

Though these risk scores were developed for a particular state, it would be reasonable to assume the scoring tool could be applied to another locality in the United States or Canada to provide relatively analogous results. The methodology for creating the risk scoring tool is also accessible to municipalities, allowing for creation of similar risk scoring tools for another locality if desired. The straightforward development of the method as well as the simple data requirements and efficient points-based scoring method would make this an attractive process for municipalities, and warranted further examination in this thesis.

2.1.4 FHWA Pedestrian Intersection Safety Index (Ped ISI)

The FHWA has developed pedestrian and bicyclist intersection safety indices (ISI) to provide a quantifiable measure of safety of individual intersection legs, with the goal of prioritizing sites for improvement based on safety (Carter et al., 2006). The pedestrian intersection safety index (Ped ISI) is a numerical risk score that acts as a measure of safety for the crossing of a single intersection leg. The bicyclist intersection safety index (Bike ISI) is a set of three measures that individually calculate the safety of left-turn, right-turn, and through movements for a bicyclist approaching an intersection for a given leg. Both the Ped ISI and Bike ISI provide measures for single legs, as opposed to a measure for the intersection as a whole.

The indices were developed using data from three major cities across the United States and included a mixture of conflict and avoidance behaviour data from intersection video recordings and safety ratings of intersections by experts. Crash data was limited because of the small number of pedestrian and cyclist crashes, so it was not included in the modelling process. Multi-variable linear regression models were computed for both the ratings and behavioral results of a given location. The models were then combined to generate a single safety index calculation based on the geometric, operational, and land-use characteristics of each intersection, in the form of multiple linear equations. The resulting Ped ISI has an R-squared value of 0.83 (where the dependent variable is the average numerical safety rating for a given site), indicating a strong fit.

To rank the safety of a set of locations, data for the variables of the ISI equations are collected for each intersection crossing, then input to the equation for the desired mode to generate the ISI. Higher index values relative to other values indicate higher priority for improvement. The final Ped ISI calculation involves the following significant variables:

- presence of traffic signal control
- presence of stop sign control
- total number of through lanes across the street being crossed (inbound and outbound)
- 85th percentile speed of traffic on street being crossed, in miles per hour
- location in a predominantly commercial land-use area (Carter et al., 2006)

The developers of the Ped ISI suggest that the index is used most appropriately for intersections that meet the following characteristics, as index values for intersections with characteristics beyond the following ranges should be used "with the understanding that the models were not developed using intersections of that type" (Carter et al., 2007):

- Three-leg and four-leg intersections
- Signalized, two-way stop, and four-way stop
- Traffic volumes from 600 to 50,000 vehicles per day
- One-way and two-way roads
- One to four through lanes (total of inbound and outbound)
- Speed limits of 24.1 to 72.4 kilometres per hour, or 15 to 45 miles per hour (Carter et al., 2007)

Since the ISI calculations focus on individual legs, additional processing must be done to prioritize intersections for improvements. The developers of the index suggest taking an average of scores at a given intersection if the entire intersection is to be examined. This suggestion appears to have been adopted by practitioners as demonstrated in a 2010 report in which the City of Ottawa presented their Pedestrian Safety Evaluation program by computing the FHWA intersection safety index as the average of the individual leg indices (City of Ottawa, 2010).

The main advantages of the Ped ISI are that it is straightforward to apply as it is a single equation, and the output is an easily comparable value. While the data requirements for the Ped ISI are relatively few for each leg, the need to collect data for all legs in order to evaluate an intersection means there is still a relatively large data requirement to evaluate the pedestrian safety for a large set of intersections. The suggested ranges of characteristics may also cast some uncertainty on index values for intersections not meeting all of the given criteria. Nonetheless, the Ped ISI was considered a method worth examining further given that it had been used by a Canadian jurisdiction, it had reasonable data requirements, and provided an easily comparable output.

2.2 Traffic Volume Estimation Models

Vehicular traffic volume is an important measurement in road transportation engineering and is a key input to the three pedestrian risk assessment methods outlined in the previous section. The most common measure of motor vehicle traffic volume on roadways is the annual average daily traffic (AADT), which is the estimated average number of vehicles per day on a segment of roadway (bi-directional) over a one-year period (Federal Highway Administration, 2018). The average daily traffic (ADT) is similar but represents the estimated average traffic volumes over an arbitrary number of days. In this thesis, we treat AADT and ADT as equivalent measures. Vehicle counts are taken on roads in a number of ways including manual, loop detector, Bluetooth detector, and camera counts. These counts are usually taken for a specific period of time on specific days, then mathematically manipulated and expanded to estimate the average daily traffic volumes. This expansion process is necessary because jurisdictions usually have only a few (if any) permanent count stations within their network and typically only perform temporary counts for a subset of network locations in a given year.

In order to estimate traffic volumes for locations where counts have not been measured, predictive models are often used. The most well-known predictive model is the four-step model, which forecasts the demand (traffic) on a given transportation network based on surrounding land-use and sociodemographic factors and mode choice. The four-step model, which is used for long range transportation planning purposes, requires significant effort in data collection and calibration and therefore is updated infrequently. Furthermore, though the four-step model can provide estimates of traffic volumes for each link in the network, these volumes are typically for a peak period, not AADT, and typically do not provide an appropriate level of accuracy of link traffic volumes for operational analyses.

Another approach is to use regression models to directly estimate AADT. Mohamad et al. (1998) developed multiple linear regression models for the AADT of county roads using sociodemographic characteristics of roadway locations. A final model for the base-10 logarithm of AADT was developed using backwards stepwise regression and identified the following significant independent variables: urban versus rural locale, ease of access to state highways, county population, and the $\log_{10}$ of the total arterial mileage of the county. The final model had an adjusted R-squared value of 0.77, indicating a high goodness of fit.

Xie et al. (2011) required estimates of minor road volumes at rural locations in order to calibrate Highway Safety Manual (HSM) SPFs for Oregon state highways, as rural AADT data was not readily available. Two stepwise multi-variable linear regression models were developed for the base-10 logarithm of the minor leg AADT, one model for rural multilane signalized intersections, and one model for all two-lane intersections or multilane unsignalized intersections. The same geometric, operational, and sociodemographic independent variables were used across the two models: county population, nearest city population, income, distance to freeways, cross street functional road class, location in a city limit, minor right-turn lane presence, developed land, centreline presence, and striped edgeline presence. Continuous independent variables were log-transformed to be consistent with the dependent variable and minimize unbalanced variance between variables. The variance inflation factors (VIF) were also calculated to examine potential multicollinearity between the variables. Data was collected using remote online maps and video observations. Adjusted R-squared values of 0.62 and 0.64, respectively, resulted from the regression. The same models were designated for use with urban streets in Dixon et al. (2012).

In a similar vein, Dixon et al. (2015) required minor road volume estimates in order to develop improved SPFs for signalized intersections in the state of Oregon. Two multi-variable linear regression models for the base-10 logarithm AADT of minor road legs were calibrated using data from 66 intersections with known minor and major AADT values, as well as geometric and operational data already collected for SPF development. Significant variables included major road AADT, number of minor approach through lanes, road functional class (arterial or collector), presence of a major two-way left-turn lane, and the AADT of parallel roads. One model included the parallel road AADT, while a second model was calibrated without parallel road AADT for instances when the variable was not available. A $\log_{10}$ transformation was performed on the major and parallel AADT independent variables prior to regression. Adjusted R-squared values of 0.71 and 0.67, respectively, resulted from the regression, indicating reasonably good fits. The models were validated using data from 25 other intersections in the state.

Not all multi-variable regression relationships between AADT and location characteristics are strong. Barnett (2015) attempted to predict the AADT of stop-controlled minor legs with nearby geometric and operational characteristics, but was unable to find a strong relationship, attributing a myriad of factors that could contribute to volume and a large amount of variability in the collected variables.

In all of the aforementioned models, logarithmic transformations of the dependent variable (AADT) were performed, using either a natural or base-10 logarithm. The purpose of log transformation is to account for high variability in the data, but also to reduce skewness of collected data. Doustmohammadi et al. (2017) examined which combination of log transformations on dependent and independent variables resulted in the greatest improvement of estimation accuracy, and suggested that linear-log structures resulted in the best improvement (i.e., where the dependent variable of AADT is untransformed, but continuous (non-discrete) independent variables are log-transformed), though log-log structures (i.e., where the dependent and independent variables were both log-transformed) were also found to improve model accuracy. Given that multiple models for AADT estimation have used log transformations, it seemed reasonable to adopt a similar transformation for the required model development in this thesis.

Overall, the review of literature for the estimation of pedestrian safety risk on roads identified several methods that could prioritize different locations and relied on the characteristics of roadways, including AADT, geometry, operational characteristics, and land-use traits. The NCHRP ActiveTrans Priority Tool, FHWA Pedestrian Intersection Safety Index, and the ODOT Pedestrian Intersection Risk Score were chosen for further examination given their applicability to a wide range of locations, reasonable data input requirements, and ability to quantitatively evaluate locations. The literature review also demonstrated that AADT could be estimated by developing regression models that include roadway geometry, other AADT values, and land-use characteristics as independent variables. Finally, in most AADT estimation models, it appears appropriate to log transform AADT values in regression given the skewness of AADT data.

3. Empirical Data Set

3.1 Description of Niagara Region

To investigate the pedestrian safety risk evaluation measures, data was obtained from the Regional Municipality of Niagara (Niagara Region) in Ontario, Canada. Niagara Region spans an area of 1,852 square kilometres and has a population of 447,888 as of 2016 (Niagara Region, 2020). The regional municipality is located east of Hamilton, Ontario, west of New York state, USA, and borders Lake Ontario to the North and Lake Erie to the south (Figure 3.1). The region has a humid continental climate (Climate-Data.org, 2020). The population is divided between the 12 smaller municipalities comprising Niagara Region (Figure 3.2 and Table 3.1)

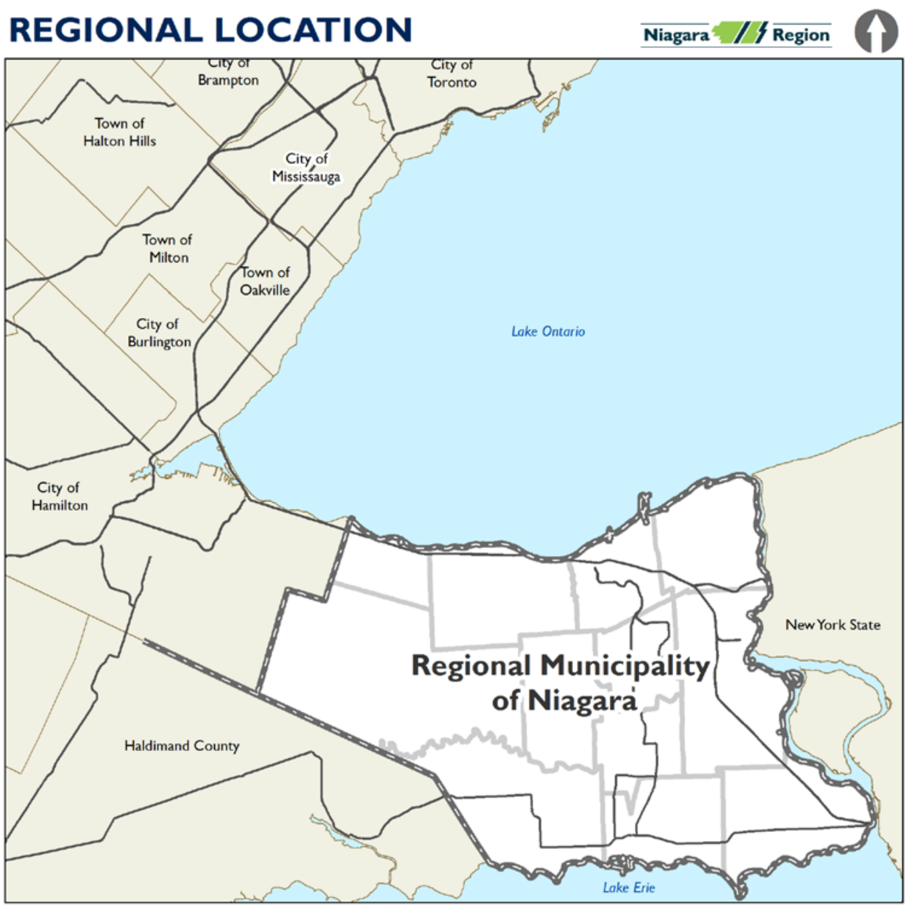


Figure 3.1: Map of Niagara Region in Ontario, Canada (modified from Niagara Region, 2014)

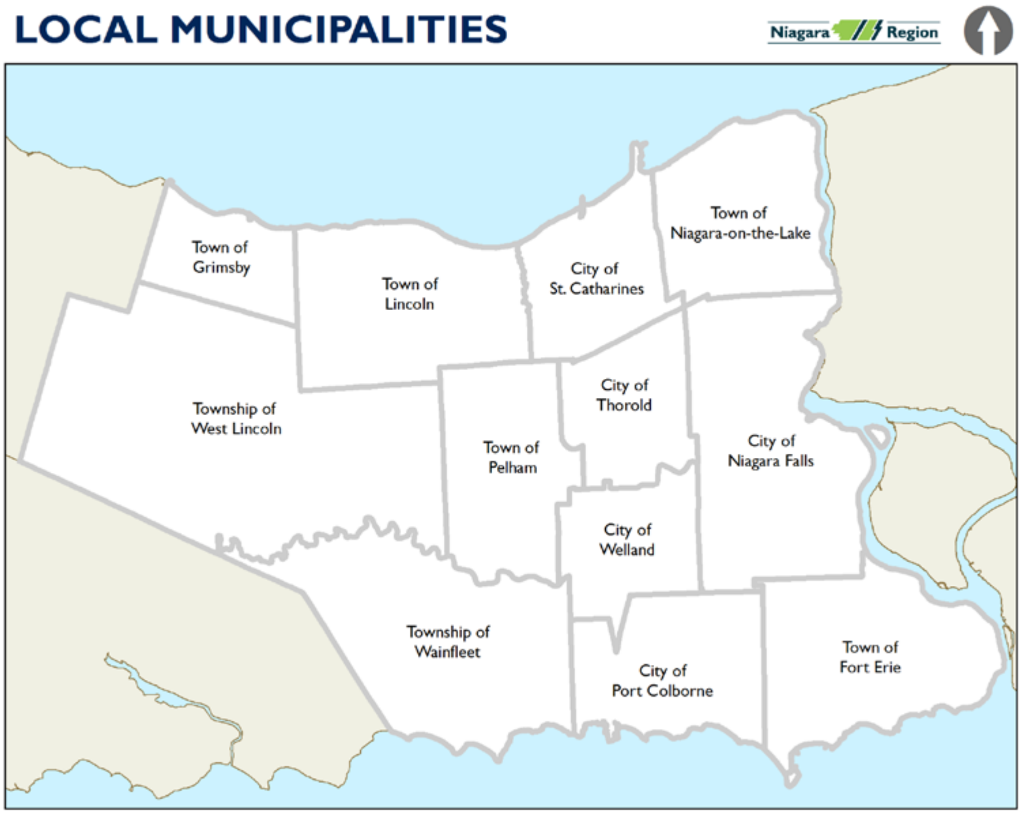


Figure 3.2: Local municipalities of Niagara Region (modified from Niagara Region, 2014)

Table 3.1: Municipalities and Population (2016) of Niagara Region (modified from Niagara Region, 2020)

Municipality	Population (2016)
Fort Erie	30,710
Grimsby	27,314
Lincoln	23,787
Niagara Falls	88,071
Niagara-on-the-Lake	17,511
Pelham	17,110
Port Colborne	18,306
St. Catharines	133,113
Thorold	18,801
Wainfleet	6,372
Welland	52,293
West Lincoln	14,500
Total	**447,888**

The city centres of the individual municipalities are dispersed throughout the region and fairly separated from one another. Agriculture and tourism are a large part of the Region's economy, as well as manufacturing with the presence of the Welland Canal through the region as a major shipping route (Niagara Region, 2014). The road network in Niagara Region includes municipal roads (local, collector, arterial), and rural and urban highways. Niagara Region was considered an appropriate municipality in which to apply the pedestrian safety evaluation methods because it could be considered representative of a large number of municipalities in Canada, those that contain a large amount of rural land use with pockets of urban development.

3.2 Pedestrian Safety Evaluation Variables

In order to compare the evaluation methods and their applicability to municipalities, this thesis aimed to apply the selected pedestrian safety evaluation methods to 438 intersections in Niagara Region and compare the results of the prioritization. Each of the methods selected considered a series of input characteristics of locations in order to output an evaluation result. The necessary inputs for application of the FHWA Ped ISI and ODOT Pedestrian Risk Score are predetermined and fixed. In the ActiveTrans Priority Tool (APT) however, the user must choose which variables to include in the prioritization score, which may include those suggested by the APT, or other variables as the user sees fit. To select from the suggested APT variables, potential independent variables were gathered from the sources in the literature review and compared to those suggested in the APT. The variables that the literature review and the APT shared in common were chosen as inputs for the APT prioritization. The variables used to apply the three methods are listed below in Table 3.2, Table 3.3, and Table 3.4.

Table 3.2: Required Data for NCHRP ActiveTrans Priority Tool (modified from Lagerwey et al., 2015)

Variable	Definition	Data type	Units
Total pedestrian crashes	The total number of collisions involving pedestrians at an intersection over a selected period of time.	Numeric	Crashes
ADT	The average daily traffic (ADT) of a road being crossed.	Numeric	Vehicles per day
Traffic speed	A measure of traffic speed for the given road, commonly the 85^{th} percentile speed, or speed limit.	Numeric	Kilometres per hour
Total Crossing Distance	The pedestrian crossing distance across a given intersection leg.	Numeric	Metres
Number of right-turn lanes	The number of exclusive right-turn lanes at a given intersection leg (approaching the intersection).	Numeric	Lanes
Number of general-purpose travel lanes	The number of through lanes at a given intersection or intersection leg (approaching and leaving the intersection).	Numeric	Lanes
Presence of raised median	A binary variable indicating if a raised median exists for the intersection or intersection leg.	Binary	If no, 0. If yes, 1.
Population density	A measure of population density for a given intersection.	Numeric	Population per square kilometre
Number of bus stops	The number of bus stops located at an intersection.	Numeric	Number of bus stops

Table 3.3: Required Data for FHWA Ped ISI (modified from Carter et al., 2006)

Variable name	Definition	Data type	Units
SIGNAL	A binary variable indicating if an intersection crossing is signal-controlled.	Binary	If no, 0. If yes, 1.
STOP	A binary variable indicating if an intersection crossing is stop-controlled.	Binary	If no, 0. If yes, 1.
THRULNS	The number of through lanes on the street being crossed (both directions i.e., approaching and leaving)	Numeric	Number of lanes
SPEED	85^{th} percentile speed of the street being crossed	Numeric	Miles per hour
MAINADT	Average daily traffic of the street being crossed	Numeric	Vehicles per day
COMM	A binary variable indicating if the predominant land use of the surrounding area is commercial development, including retail and restaurants.	Binary	If no, 0. If yes, 1.

Table 3.4: Required Data for ODOT Pedestrian Intersection Risk Score (modified from Monsere et al., 2017)

Variable	Definition	Data type	Units
Total population density (per square mile)	The total population density of the area surrounding the intersection.	Numeric	Population per square mile
Number of transit lines with routes through intersection	The total number of transit lines with routes through the intersection.	Numeric	Number of transit lines
Major AADT (2014)	The annual average daily traffic of the major road (given that a major and minor direction are identified at the intersection).	Numeric	Vehicles per day
Presence of median on major road	A binary variable indicating if a raised median exists for the major road (given that a major and minor direction are identified at the intersection).	Binary	If no, 0. If yes, 1.
Minor road, presence of right turn lanes	A binary variable indicating if exclusive right-turn lanes exist on the minor road (given that a major and minor direction are identified at the intersection).	Binary	If no, 0. If yes, 1.
Major road, presence of right-turn lanes	A binary variable indicating if exclusive right-turn lanes exist on the major road (given that a major and minor direction are identified at the intersection).	Binary	If no, 0. If yes, 1.

The required variables from the three methods were condensed into a single list of variables for data collection. Certain variables were modified and additional variables were added so that data processing could be performed for each method and secondary variables could be calculated. For example, an indicator of major and minor road direction was necessary for calculating the ODOT intersection score. Certain variables were collected for the entire intersection, while others were collected for the individual legs of the intersection. Intersection legs were denoted by their closest cardinal orientation of the leg with respect to the intersection (i.e., the north leg of an intersection radiates north from the intersection node), thus up to four values were collected for leg-related variables (i.e., for the north, south, west, and east directions). A four-leg intersection would have four AADT values collected, one for each leg. Additional variables beyond those found in the pedestrian risk evaluation methods were also gathered for each intersection, as these additional variables were seen as potentially valuable for future analyses and some were used in the AADT estimation modelling process, as discussed in Section 3.3. Data was gathered from several sources for 438 signalized intersections in Niagara Region, including Niagara Region, Google Maps, Google Earth, and other online sources such as Niagara Open Data, the Ontario Ministry of Transportation, and Statistics Canada. Table 3.5 lists the sources and collection methods for each of the input variables, where an "X" indicates that variable is applicable to a method.

Table 3.5: Data Sources for Pedestrian Safety Risk Evaluation Methods

Input	Intersection or leg	Method applicable			Source
		APT	Ped ISI	ODOT RS	
Number of pedestrian collisions	Intersection	X			Niagara Region
Traffic volume (AADT)	Leg	X	X	X	Niagara Open Data (GIS) (Niagara Open Data, 2018), Ontario Ministry of Transportation (Ministry of Transportation of Ontario, 2016)
Speed limit	Leg	X	X		Google Maps (Google, 2020), Google Earth (Google, 2020)
Total crossing distance	Leg	X			Google Maps, Google Earth
Number of right-turn lanes	Leg	X	X	X	Google Maps, Google Earth
Number of through lanes, approaching	Leg	X	X		Google Maps, Google Earth
Presence of raised median	Leg	X		X	Google Maps, Google Earth
Population density	Intersection	X		X	Statistics Canada (GIS) (Government of Canada, Statistics Canada, 2017a)
Number of bus stops	Leg	X			Google Maps, Google Earth
Signal control	Leg		X		Google Maps, Google Earth
Stop control	Leg		X		Google Maps, Google Earth
Commercial area	Intersection		X		Google Maps, Google Earth
Number of through lanes, leaving	Leg	X	X		Google Maps, Google Earth
Number of transit lines	Intersection			X	Niagara Open Data (GIS) (Niagara Open Data, 2020)
Major road leg	Leg			X	Google Maps, Google Earth, Niagara Open Data (GIS)
Minor road leg	Leg			X	Google Maps, Google Earth, Niagara Open Data (GIS)
Number of legs	Intersection	X	X		Google Maps, Google Earth

NB: “X” indicates inclusion of a variable for a method

The data collection procedures for specific sources are outlined in Section 3.4.

3.3 AADT Estimation Modelling Variables

Traffic volume data (AADT) was a required input to all three pedestrian risk models. Available AADT data was assembled but AADT data was not available for all legs of all signalized intersections in Niagara Region. Consequently, it was necessary to develop a model to estimate AADT for those intersection legs for which data were not available. A list of potential explanatory variables for an AADT estimation model was developed on the basis of the literature review and engineering judgment. Variables included the characteristics of the intersections and leg of interest, as well as characteristics from locations upstream of a given intersection leg. The list of variables collected for the AADT modelling of intersection legs and their sources is provided in Table 3.6.

Table 3.6: Collected Potential Variables for AADT Estimation Modelling

Variable Name	Intersection or leg	Definition	Data type	Units or values	Source
Traffic volume (AADT)	Leg	Annual average daily traffic of a leg.	Numeric	Vehicles per day	Niagara Open Data (GIS), Ontario Ministry of Transportation
Number of left-turn lanes	Leg	Number of exclusive left-turn lanes at a given intersection leg (approaching the intersection).	Numeric	Number of lanes	Google Maps, Google Earth
Number of right-turn lanes	Leg	Number of exclusive right-turn lanes at a given intersection leg (approaching the intersection).	Numeric	Number of lanes	Google Maps, Google Earth
Number of through lanes, approaching	Leg	Number of through lanes at a given intersection or intersection leg (approaching the intersection).	Numeric	Number of lanes	Google Maps, Google Earth
Number of through lanes, outbound	Leg	Number of through lanes at a given intersection or intersection leg leaving the intersection.	Numeric	Number of lanes	Google Maps, Google Earth
Distance to upstream intersection or location	Leg	Distance from intersection of interest to a nearby intersection or upstream location on the leg of interest, as determined in Section 3.4.	Numeric	Metres	Niagara Open Data (GIS)
Number of lanes at selected upstream location	Leg	Number of lanes at upstream location, as determined in Section 3.4.	Numeric	Number of lanes	Google Maps, Google Earth
AADT of legs of upstream intersection or location	Leg	AADT of the legs of an upstream intersection or location as determined in Section 3.4, where available.	Numeric	Metres	Niagara Open Data (GIS)

Table 3.6: Collected Potential Variables for AADT Estimation Modelling, continued

Variable Name	Intersection or leg	Definition	Data type	Units or values	Source
Major road Leg	Leg	Binary variable indicating if a leg forms the major or minor direction.	Binary	If no, 0. If yes, 1.	Google Maps, Google Earth
Presence of raised median	Leg	Binary variable indicating if a raised median exists for the leg.	Binary	If no, 0. If yes, 1.	Google Maps, Google Earth
Presence of slip lane	Leg (corner)	Binary variable indicating if a raised median exists for the corner between two legs.	Binary	If no, 0. If yes, 1.	Google Maps, Google Earth
Number of transit stops	Leg	Number of transit stops on the leg, near the intersection.	Numeric	Number of transit stops	Google Maps, Google Earth
Number of transit lines	Intersection	Total number of transit lines with routes through the intersection.	Numeric	Number of transit lines	Niagara Open Data (GIS)
Commercial area	Intersection	Binary variable indicating if the predominant land use of the surrounding area is commercial development, including retail and restaurants.	Binary	If no, 0. If yes, 1.	Google Maps, Google Earth
Arterial road	Leg	Binary variable indicating if the leg is an arterial/regional road.	Binary	If no, 0. If yes, 1.	Google Maps, Google Earth
Local road	Leg	Binary variable indicating if a leg is a local road.	Binary	If no, 1. If yes, 0.	Google Maps, Google Earth
Speed limit	Leg	Speed limit on a leg.	Numeric	Kilometres per hour	Google Maps, Google Earth
One-way traffic	Leg	Binary variable indicating is a leg has one-way or two-way traffic.	Binary	If no, 0. If yes, 1.	Google Maps, Google Earth

Table 3.6: Collected Potential Variables for AADT Estimation Modelling, continued

Variable Name	Intersection or leg	Definition	Data type	Units or values	Source
Population density	Intersection	Population density of the area surrounding the intersection.	Numeric	Population per square kilometre	Statistics Canada (GIS)
Municipality population	Intersection	Population of the local municipality in which the intersection is located	Numeric	Population	Niagara Region
Number of Legs	Intersection	Binary variable indicating if an intersection has 3 or 4 legs.	Binary	If 0, 3 legs. If 1, 4 legs.	Google Maps, Google Earth

The data collection procedures for specific sources are outlined in Section 3.4.

3.4 Data Collection Procedures

Data was obtained from a variety of sources including the Regional Municipality of Niagara, Google Maps, Google Earth, Niagara Region Open Data, Ministry of Transportation of Ontario, and Statistics Canada.

The collision database for Niagara Region consisted of collision records (from 2011 to 2018) and primary road characteristic data for intersections and midblocks. Data were extracted for only signalized intersections resulting in a total of 438 intersections.

A number of variables identified from the literature were not present in the collision database leading to the need to obtain these data from other sources for each intersection. The data collection process for each intersection involved locating the intersection in a given source and recording the required data fields. Some fields were applicable to the entire intersection, while others specific to a directional leg of an intersection; these directional legs were denoted as North, South, West, and East legs, referring to their approximate compass orientation from the intersection. Geometric information was obtained through visual inspection of aerial and location photography in Google Earth and Google Maps. Operational data were collected using Niagara Region Open Data using GIS. The majority of variables were collected from Google Maps and Google Earth. Table 3.7 lists the data collection procedures for each of the variables from the imagery. Figure 3.3 illustrates how geometric properties of an intersection were measured from aerial/satellite images.

Table 3.7: Data Collection Procedures from Google Maps

Characteristic	Intersection or leg	Data collection procedure
Speed limit	Leg	• Locate and record values from speed limit signs for each leg in the immersive "Street View" function. • For urban or "built-up" areas, if no speed limit signs are seen, assume a speed limit of 50 kilometres per hour, as outlined in the Highway Traffic Act (Highway Traffic Act, R.S.O. 1990, c. H.8, s 128). • For rural areas "not within a built-up area" assume a speed limit of 80 kilometres per hour.
Intersection leg width (total crossing distance)	Leg	• Measure and record the width of each leg using the ruler tool in Google Maps. • When there is a pedestrian crossing, measure within the crossing to emulate the width a pedestrian would typically cross. • When there is no pedestrian crossing, measure between the apexes of the two curb radii forming the leg. • When there are slip lanes/right-turn channels, measure the distance across the roadways of the slip lane, and the width of the two main legs joined by the slip lane. For each leg joined by the slip lane, record the width as the sum of the main legs width plus the slip lane width(s). • When there is a roadway median on the leg, include the width of the median in the measurement.
Number of lanes	Leg	• Count the total number of lanes across the leg. • Count slip lanes as a lane on the leg they start from, and not on the leg they terminate on. Only count slip lanes on the terminating leg if there is a merging lane on the terminating leg.

Table 3.7: Data Collection Procedures from Google Maps, continued

Characteristic	Intersection or leg	Data collection procedure
Leg lane configuration (number of left-turn, right-turn, through, and leaving through lanes)	Leg	• Count the number of lanes across the leg that fall into the following classifications: o **Left-turn lane:** Lanes approaching the intersection that are exclusive left-turn lanes. o **Through lane:** Lanes approaching the intersection that are through lanes, including shared through-left and through-right lanes. o **Right-turn lane:** Lanes approaching the intersection that exclusive right-turn lanes. o **Outbound lanes:** Lanes travelling away from the intersection on the given leg. • In the case of a shared left and right turn lane, include the lane as a right-turn lane and do not count the lane for both categories.
Presence of slip lanes	Leg (corner)	• Record if there is a slip lane in either the northwest, northeast, southwest, or southeast corners of the intersection.
Transit stops	Leg	• Record the number of transit stops for both directions of travel on each leg within 50 metres of the intersection.
Presence of concrete median	Leg	• Record if there is a concrete curb median for the leg.
One-way traffic	Leg	• Record if there is one-way or two-way traffic on the leg based on lane configuration or presence of one-way signs.
Commercial area	Intersection	• Record if the area at and surrounding the intersection includes commercial businesses, including retail and service businesses.

Table 3.7: Data Collection Procedures from Google Maps, continued

Characteristic	Intersection or leg	Data collection procedure
Road type	Leg	• Record what type of road each leg appears to be according to the following classification: ○ **Arterial** roads are identified as Regional Roads (with a Regional road number present). ○ **Collector** roads are non-regional roads that appeared to be a significant thoroughfare throughout an area. ○ **Local** roads are typically smaller streets that do not appear to be a main thoroughfare, and often part of residential areas; parking lot entryways ("**Entry**") and **Ramps** were grouped into the local category.
Traffic Control	Leg	• Record if a leg includes a stop control, as may be the case for intersection pedestrian signals (IPS).
Major Road Leg	Leg	• Record if a leg appears to be part of the major direction, based on the classification of the leg. • If the major direction is not obvious, locate the intersection using the GIS shapefile, and assign the major direction to the one with higher AADT. • For three-way intersections, the leg that terminates at the intersection is automatically designated as the minor leg.

Figure 3.3: Aerial view of Glenridge Avenue & Glendale Avenue, St. Catharines, GeoID 00747 (modified from Google, 2020)

For this four-leg signalized intersection (Glenridge Avenue & Glendale Avenue, St. Catharines, GeoID 00747), the north, south, west, and east legs were identified with labels “N”, “S”, “W”, and “E”, respectively. Referring to the south leg (marked “S”), a width of 28 metres was measured using the blue ruler tool in Google Maps. From visual inspection, it was seen that the south leg had four lanes total at the intersection (one through lane, one left-turn lane, one right-turn lane, and one outbound lane), zero slip lanes, two transit stops, a concrete median, two-way traffic, was in a commercial area, and was part of an arterial road. A speed limit sign on the south leg in the “Street View” function showed a 50 kilometre per hour limit.

This visual inspection procedure was repeated for all legs of all signalized intersections.

GIS shapefiles containing operational and land-use characteristics were used to collect additional data for each intersection. Table 3.8 lists the data collection procedures from GIS data, which is demonstrated in Figure 3.4.

Table 3.8: Data Collection Procedures for GIS Data

Characteristic	Intersection or leg	Data collection procedure
AADT (2017)	Leg	• Record the AADT at each leg according to the 2017 AADT shapefile provided by Niagara Open Data. • If no AADT is present in the shapefile, search for the road in the MTO report. • If no AADT value is present for the leg, record a value of 0 for the AADT.
Number of transit lines	Intersection	• Record the total number of transit lines (bus routes) that travel through the intersection according to the transit line shape file.
Major road leg	Leg	• Record if a leg appears to be part of the major direction, based on the apparent road type of the leg (arterial, collector, local). • If the major direction is not obvious, locate the intersection using the GIS shapefile, and assign the major direction to the one with higher AADT.
Population density	Intersection	• Select all 2016 Census dissemination areas within a 50-metre buffer radius of each intersection, and divide the total population of the selected areas by the total selected area to obtain the average population density for an intersection. Record the average population density for each location.

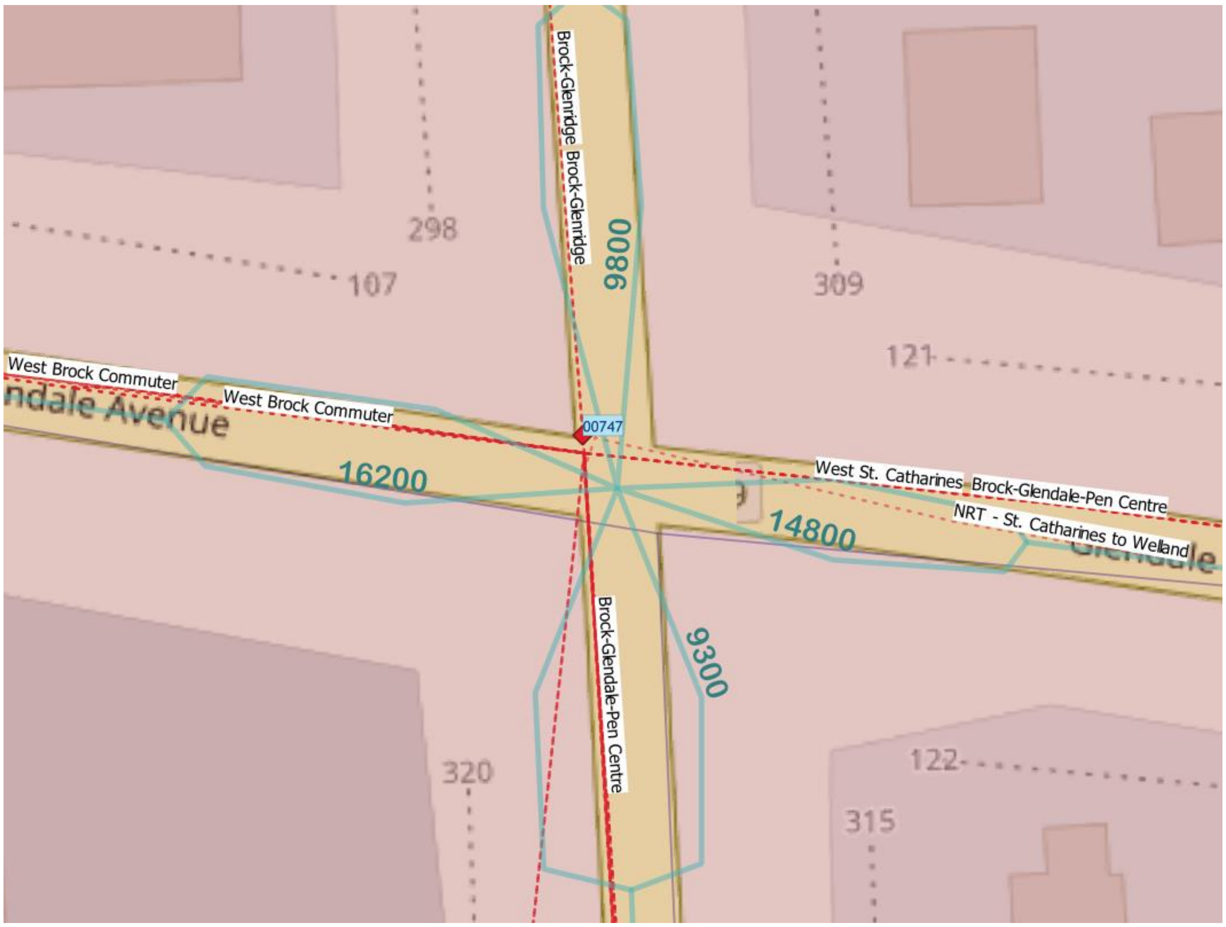


Figure 3.4: View of Glenridge Avenue & Glendale Avenue, St. Catharines, GeoID 00747 (Niagara Open Data, 2018, 2020, Map data © *OpenStreetMap*)

Figure 3.4 illustrates how AADT and public transit data were extracted from open-source GIS data. For the same intersection as shown in Figure 3.3, Figure 3.4 provides a screenshot of the GIS file indicating the 2017 AADT for each of the intersection legs, and the transit lines running through the intersection. From visual inspection, 5 transit lines were seen running through the intersection, and the south leg showed an AADT of 9,300. Based on their higher average AADT values, the east-west legs appeared to form the major direction, leaving the north-south legs classified as part of the minor direction. Note that the “loops” of the blue lines reflected the presence of a median, but the AADT value shown in blue was the total volume for the leg in both directions.

In addition to the characteristics of the intersection and leg of interest, characteristics from locations upstream of a given intersection leg were hypothesized to be related to the AADT of that leg, and thus could also be used as an input to AADT prediction model for the leg. The upstream location was chosen with the goal to obtain a value of AADT wherever possible, and to make use of existing signalized intersection data to make the process of data collection more efficient. For each leg of interest, three characteristics were collected in this procedure whenever possible:

1. The distance from the intersection of interest to the upstream location being recorded.
2. The number of lanes across each leg of the upstream location being recorded
3. The AADT of each leg of the upstream intersection location being recorded (or at a midblock location along the leg).

A value of 0 for any of these three fields indicated that either the item did not exist, or data was not recorded for that characteristic. The availability and location of data varied upstream of each leg, leading to 11 possible cases for data collection. The decision tree in Figure 3.5 defines these cases. Using the symbols shown in Figure 3.6, the 11 cases are illustrated in Table 3.9 where “Intersection A” is the intersection data is being collected for, and “Intersection B” or “Intersection C” are upstream intersections.

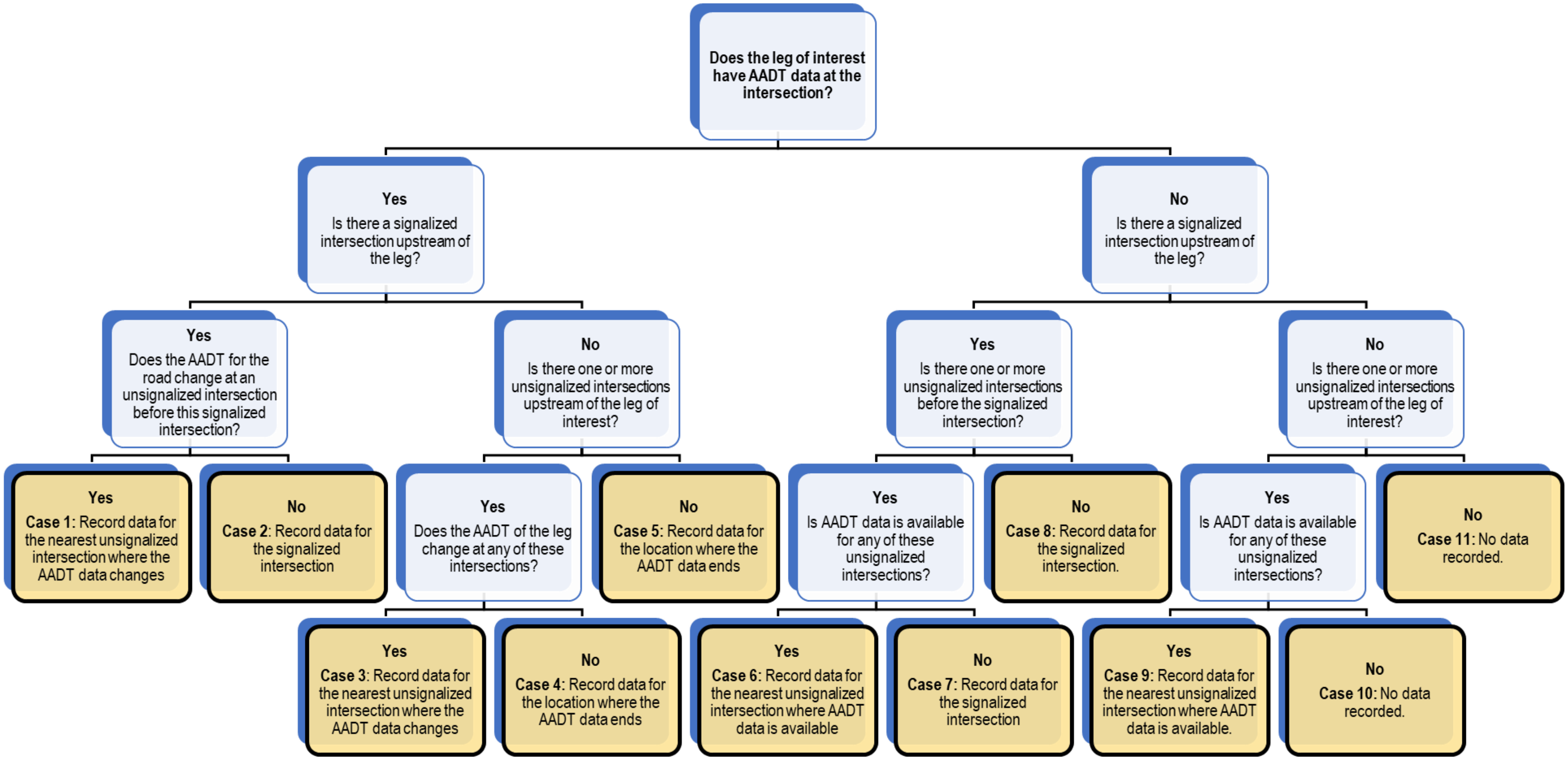


Figure 3.5: Decision tree for identifying upstream location for data collection

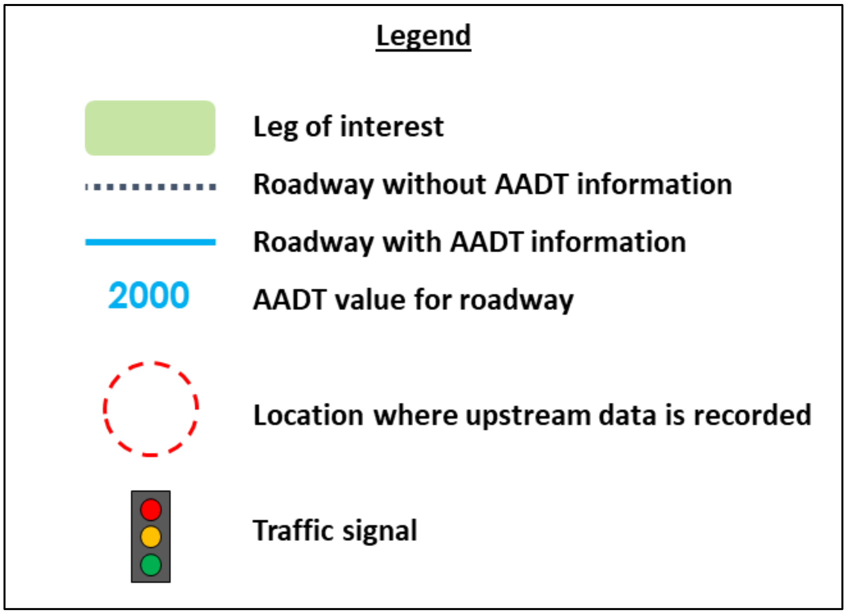


Figure 3.6: Legend for illustration of cases in Table 3.9

Table 3.9: Illustration of Cases for Selecting Upstream Locations to Record Nearby Data

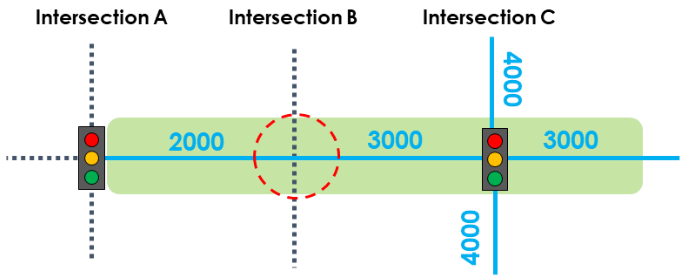
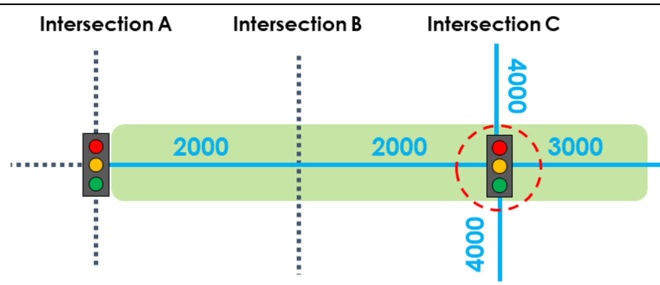
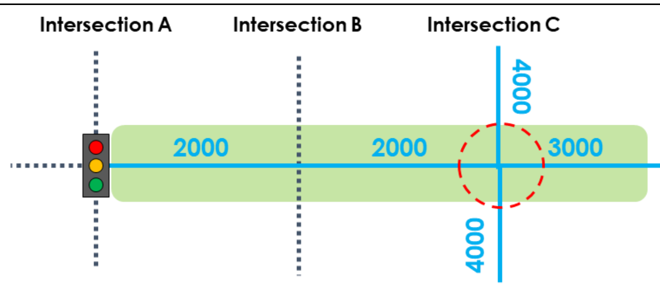
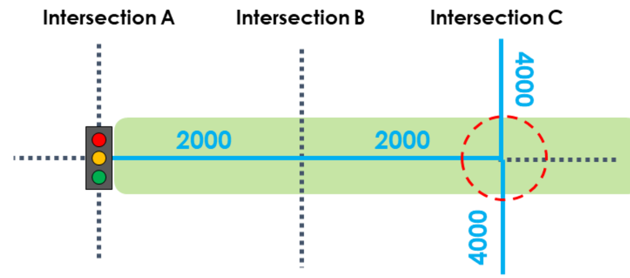
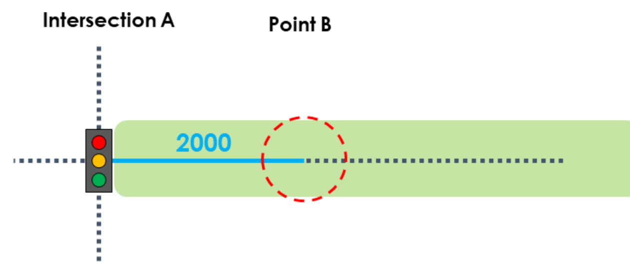
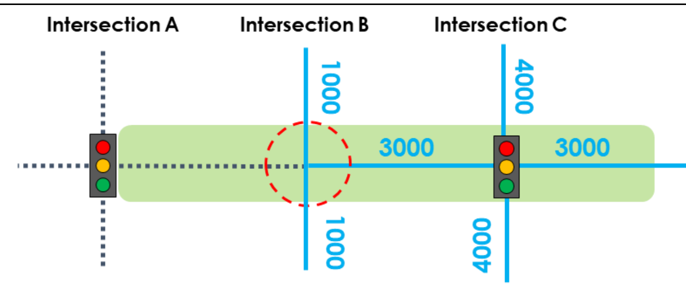
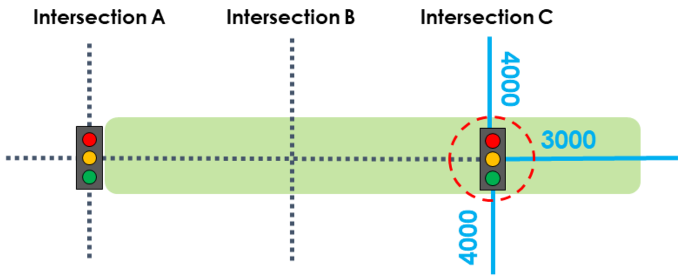
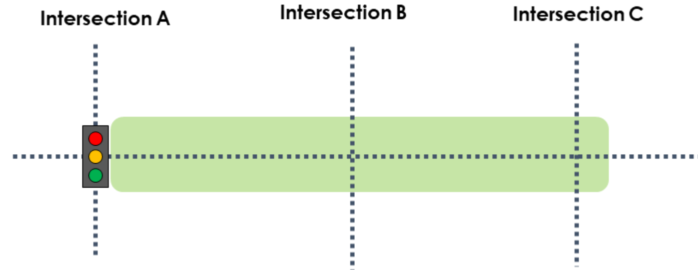
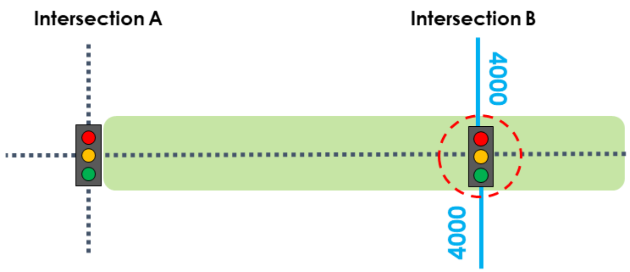
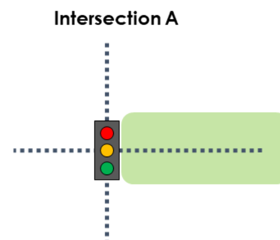
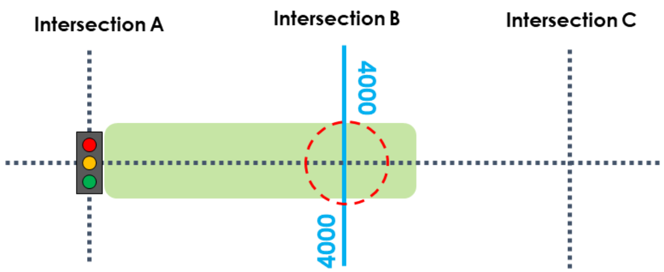
Case	Illustration
1	
2	
3	
4	
5	
6	

Table 3.9: Illustration of Cases for Selecting Upstream Locations to Record Nearby Data, continued

Case	Illustration	Case	Illustration
7		10	
8		11	
9			

3.5 Data Description

For the 438 signalized intersections considered in Niagara Region, 1,670 legs were identified in total.

3.5.1 Operational, Land-Use, and Transit-Related Variables

The majority of signalized intersections considered are found in the larger cities of St. Catharines and Niagara Falls, with the remainder among the ten smaller municipalities as shown in Table 3.10. The number of legs in each municipality is shown. The number of individual legs in each municipality tends to correlate with the number of intersections.

Table 3.10: Number of Signalized Intersections in Niagara Region Local Municipalities

Municipality	Population (2016)	Number of signalized intersections	Percentage of signalized intersections	Number of legs	Percentage of legs
St. Catharines	133,113	152	34.7%	575	34.4%
Niagara Falls	88,071	100	22.8%	383	22.9%
Welland	52,293	64	14.6%	246	14.7%
Fort Erie	30,710	27	6.2%	105	6.3%
Grimsby	27,314	19	4.3%	73	4.4%
Port Colborne	18,306	19	4.3%	73	4.4%
Niagara-on-the-Lake	17,511	14	3.2%	53	3.2%
Lincoln	23,787	13	3.0%	46	3.1%
Pelham	17,110	13	3.0%	51	3.1%
Thorold	18,801	13	3.0%	51	2.8%
West Lincoln	14,500	3	0.7%	10	0.6%
Wainfleet	6,372	1	0.2%	4	0.2%

Though the analysis focussed on signalized intersections, a small number (29) of these intersections consisted of a combination of signalized and stop-controlled legs (Table 3.11). These intersections were classified as intersection pedestrian signals (IPS) and were relatively uncommon in Niagara Region.

Table 3.11: Traffic Control of Signalized Intersection Legs in Niagara Region

Traffic control of leg	Number of intersections	Percentage
Stop-controlled	29	1.7%
Signal-controlled	1,641	98.3%

Although the majority of signalized intersections are located in the larger municipalities, the distribution of the average population density of the area immediately surrounding the intersection is skewed towards lower densities (Figure 3.7). For reference, the city of Toronto, Ontario has a population density of 4,334.4 people per square kilometre (Government of Canada, 2017), which shows that the Niagara Region densities are relatively low in comparison.

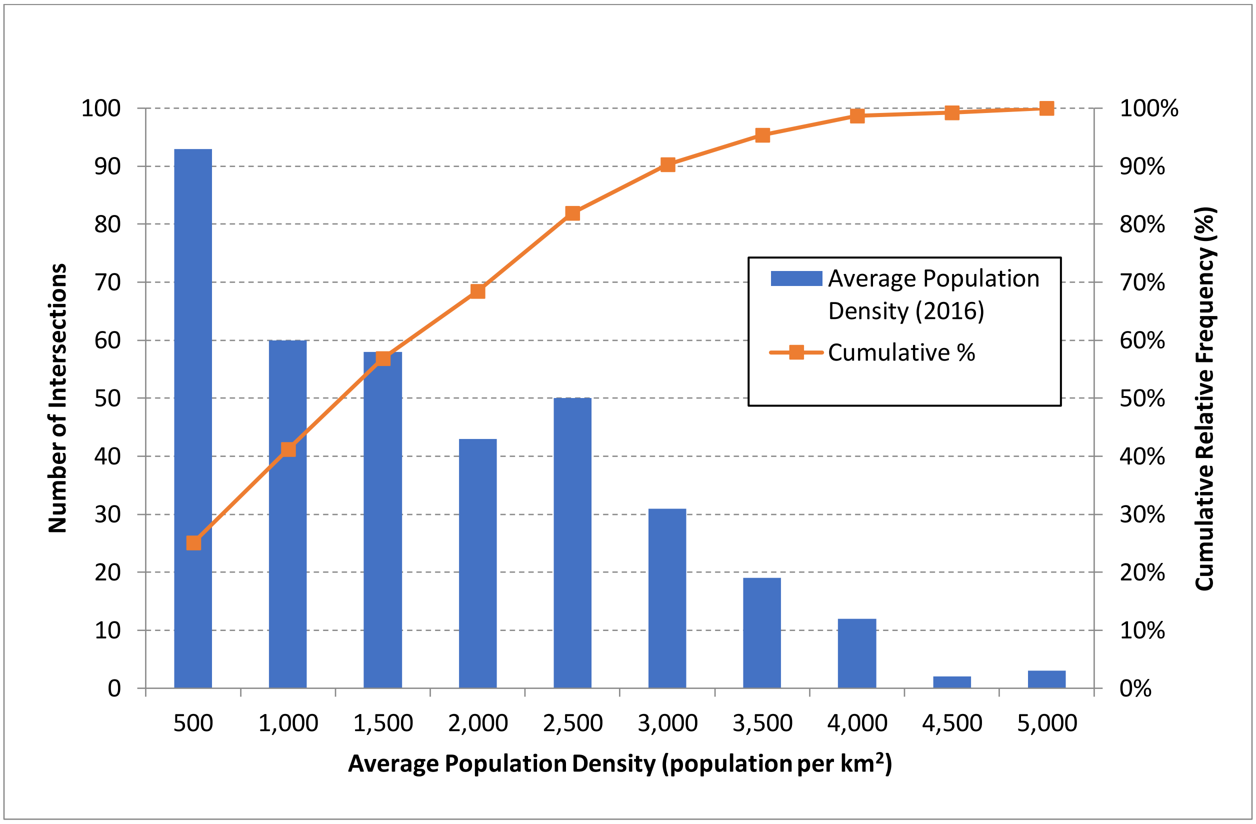


Figure 3.7: Average population density (2016) surrounding signalized intersections in Niagara Region

Commercial land use was identified for the majority of signalized intersections in Niagara Region, with residential land use the next most common, as seen in Table 3.12.

Table 3.12: Land Use Surrounding Signalized Intersections in Niagara Region

Land-use type	Number of intersections	Percentage
Commercial	253	57.8%
Residential	111	25.3%
Rural	54	12.3%
Industrial	8	1.8%
Natural	8	1.8%
Institutional	4	0.9%

In Niagara Region, 81.3% of signalized intersections had 4 legs, and the remainder (18.7%) had only 3 legs. Most signalized intersections were found to have 1 or 2 transit lines routed through the intersection, as seen in Figure 3.8.

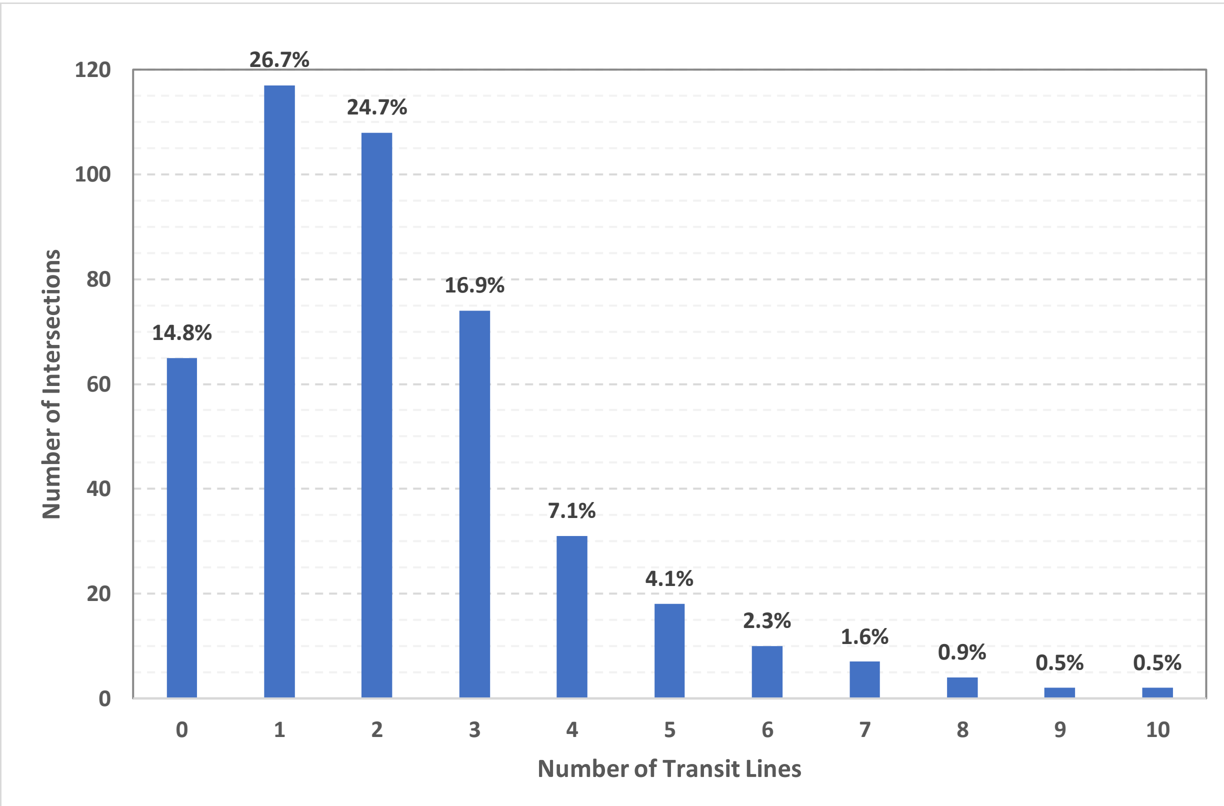


Figure 3.8: Number of transit lines passing through signalized intersections in Niagara Region

Most intersections and legs did not have transit stops surrounding the intersection (within 50 metres), as seen in Table 3.13.

Table 3.13: Number of Transit Stops at Signalized Intersections and Legs in Niagara Region

Number of transit stops	Number of legs	Percentage	Number of intersections	Percentage
0	790	47.3%	220	50.2%
1	314	18.8%	78	17.8%
2	387	23.2%	96	21.9%
3	103	6.2%	25	5.7%
4	64	3.8%	16	3.7%
5	4	0.2%	1	0.2%
6	8	0.5%	2	0.5%

3.5.2 Geometric Variables

Road types and major or minor roads were classified by leg. The majority of legs at signalized intersections were either Arterial or Collector roads, as seen in Table 3.14. The majority of legs (876, or 52.5%) were classified as major as well, with the remainder classified as minor (794, or 47.5%). The difference was due to assigning parallel legs at three-leg intersections as major legs.

Table 3.14: Road Classification of Signalized Intersection Legs in Niagara Region

Road type	Number of legs	Percentage
Arterial	773	46.3%
Collector	669	40.1%
Local	132	7.9%
Ramp	33	2.0%
Entrance	63	3.8%

The most common speed limit identified was the standard 50 kilometre per hour limit as seen in Table 3.15. The speed limit of 20 kilometres per hour was assumed for entrance roadways leading to parking lots of businesses and other facilities.

Table 3.15: Speed Limit of Signalized Intersection Legs in Niagara Region

Speed limit (km/h)	Number of legs	Percentage
15	1	0.1%
20	53	3.2%
30	1	0.1%
40	28	1.7%
50	1,405	84.1%
60	96	5.7%
70	29	1.7%
80	57	3.4%

The distributions of the leg width are provided in Figure 3.9, which shows most signalized intersection legs being between 15 and 20 metres in width.

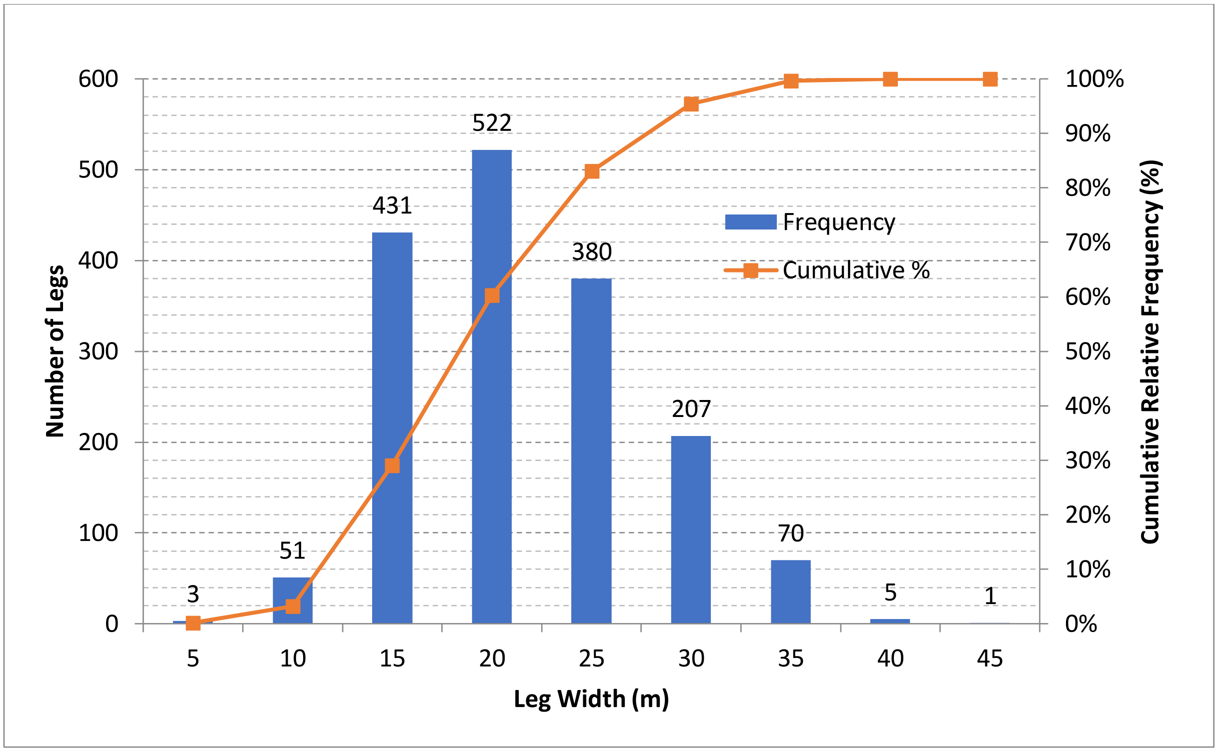


Figure 3.9: Distribution of width of signalized intersection legs in Niagara Region

Most of the intersection legs considered had three lanes, as seen in Table 3.16.

Table 3.16: Number of Lanes Across Signalized Intersection Legs in Niagara Region

Number of Lanes	Number of Legs	Percentage
1	21	1.3%
2	467	28.0%
3	652	39.0%
4	224	13.4%
5	256	15.3%
6	43	2.6%
7	6	0.4%
8	1	0.1%

When examining the lane configurations of signalized intersection legs (Table 3.17) , most legs have one exclusive left-turn lane, one through lane (including shared left-through or right-through lanes), and one outbound lane. There were more legs without exclusive right-turn lanes than legs with at least one exclusive right-turn lane.

Table 3.17: Number of Lanes of Different Types at Signalized Intersection Legs in Niagara Region

Number of type of lane on leg	Types of Lanes							
	Left-turn lanes (exclusive)		Through lanes (including shared left-through and shared right-through)		Right-turn lanes (exclusive)		Outbound lanes	
	Number of legs	%	Number of legs	%	Number of legs	%	Number of legs	%
0 lanes	611	36.6%	90	5.4%	1,278	76.5%	26	1.6%
1 lane	1,044	62.5%	1,208	72.3%	386	23.1%	1,180	70.7%
2 lanes	15	0.9%	362	21.7%	6	0.4%	436	26.1%
3 lanes	0	0.0%	9	0.5%	0	0.0%	27	1.6%
4 lanes	0	0.0%	1	0.1%	0	0.0%	1	0.1%

Most intersections in Niagara Region did not have any slip lanes, as shown in Table 3.18.

Table 3.18: Number of Slip Lanes at Signalized Intersections in Niagara Region

Number of slip lanes	Number of intersections	Percentage
0	339	77.4%
1	68	15.5%
2	28	6.4%
3	3	0.7%

Because slip lanes are associated with two legs, a binary variable indicating the presence or lack of presence of a slip lane at an intersection was defined instead and consequently 77.1% of legs did not have a slip lane present and 22.9% did have a slip lane present.

Only 21.4% of legs had a median on that leg and only 34.6% of legs were located at an intersection at which one or medians existed. Most (95.6%) of legs permitted two-way travel, with the remainder being one-way legs.

3.5.3 AADT-Related variables

Of the 1670 intersection legs, 707 had AADT values available for the leg, and 963 did not have AADT data.

The distribution of the available AADT values is shown in Figure 3.10. The distribution is positively skewed, indicating a higher number of lower AADT values. The AADT values ranged from 1,200 to 42,700 vehicles per day.

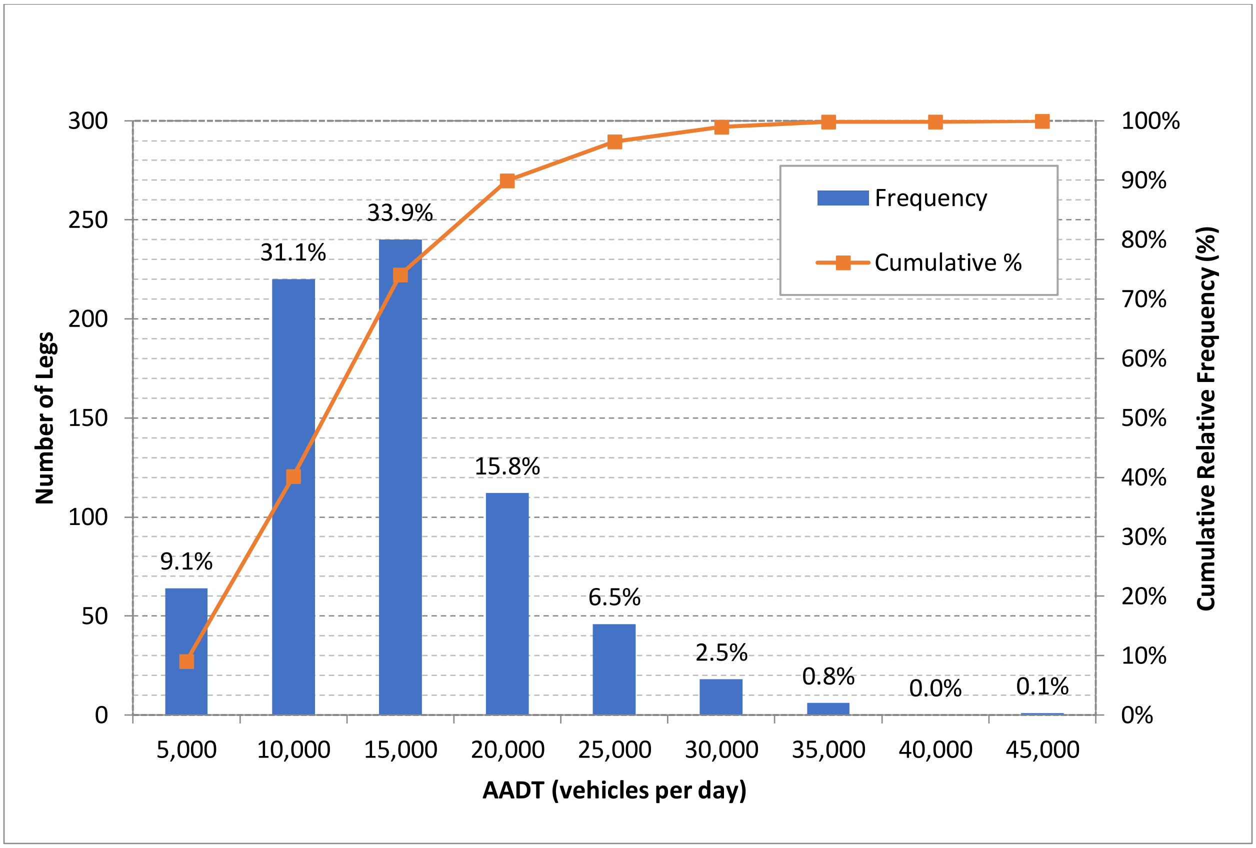


Figure 3.10: AADT distribution of signalized intersection legs in Niagara Region

When the availability of AADT values at intersections was considered, 702 of the 707 legs with AADT had AADT values available for at least one other leg at the intersection at which they were located, while 5 did not have any other AADT values available. For the 963 legs that did not have an AADT value, 445 of these legs had AADT available for at least one other leg at the intersection at which they were located, and 518 did not have any AADT values for other legs at the intersection, as shown in Table 3.19.

Table 3.19: Availability of AADT for Other Legs of the Same Intersection for Signalized Intersections in Niagara Region

	AADT available for leg of interest	AADT not available for leg of interest	Sum
AADT available for at least one other leg at the intersection	702	445	1,147
AADT not available for other legs at the intersection	5	518	523
Sum	707	963	1,670

As discussed in section 3.4.3, the AADT upstream of the leg at a specific location, the number of lanes at that specific location, and the distance to that location were collected where possible for the 1,670 legs in order to provide more data to calibrate AADT prediction models. Of the 707 legs for which AADT was available, 625 legs had AADT at an upstream location and the upstream number of lanes available. An additional 54 values for the upstream number of lanes were identified from the data for legs that did not have an upstream AADT value, leading to 679 observations for the upstream number of lanes. Of the legs for which AADT data was not available, 32 had AADT values upstream of the leg as well as the number of lanes upstream, with an additional 387 only having the upstream number of lanes available, leading to 419 legs total with the upstream number of lanes. The number of these additional variables is summarized in Table 3.20.

Table 3.20: Additional Variables for AADT Estimation Modelling

Variable	Number of legs for which AADT available	Number of legs for which AADT not available	Total
Upstream AADT (vehicles per day)	625	32	657
Upstream number of lanes	679	419	1,098
Upstream distance (m)	679	419	1,098

The distribution of the distance to the upstream location is shown in Figure 3.11. For 48.4% of cases, the distance measured was less than or equal to 0.5 kilometres. For 96.0% of cases, the distance was less than or equal to 3.0 kilometres.

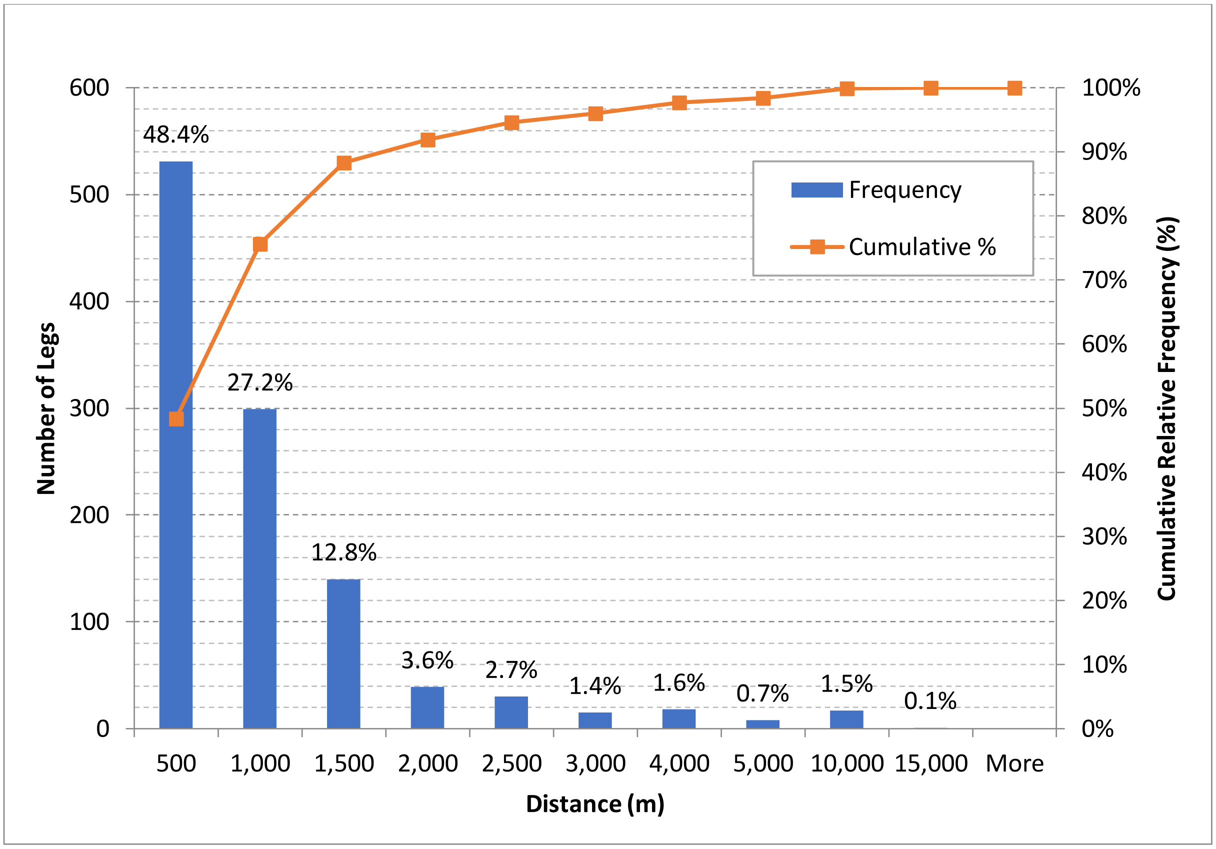


Figure 3.11: Distribution of distance to upstream location

This chapter provided a description of the Niagara Region data set, to which we applied the pedestrian safety evaluation methods. An examination of the data inputs to the safety evaluation methods identified overlapping inputs to the three selected methods. The data inputs for AADT estimation were also identified in this chapter, showing some overlap with the inputs for the safety methods. After determining the required data, the data collection processes from Google Maps, open-source GIS, and other sources were summarized, including a specific collection process for AADT estimation model variables. The summary of collected data provided a unique overview of the characteristics of signalized intersections of a municipality with both urban and rural land use. Moreover, the data allow for the development of AADT estimation models that consequently allow for the application of the pedestrian safety risk evaluation methods to Niagara region.

4. Proposed AADT Estimation models

For the 438 signalized intersections identified in Niagara Region, a total of 1,670 legs were identified, of which 707 had AADT values, and the remaining 963 had no AADT data. From the literature review, AADT estimation models using multiple linear regression with geometric, operational, and land-use characteristics were proposed as a way to impute missing values of AADT, which were a required input for all selected pedestrian evaluation methods.

4.1 Model Structure

To estimate AADT for legs without AADT values, prediction models in the form of multi-variable linear regression models were chosen. The dependent variable was the AADT, while the independent variables were a range of geometric, operational, and land-use variables identified from the literature.

From the 1,670 legs, a calibration data set and an application data set were defined. The calibration data set consisted of characteristics for the 707 observation points (legs) with AADT values. The application data set consisted of characteristics for the remaining 963 legs for which an AADT value would need to be estimated. The legs in both data sets were also classified initially by whether they had AADT values available for at least one other leg at the intersection, or if there were no other AADT values available for other legs at the intersection, as shown in the first column of Table 3.19.

Two further sub-conditions were defined for the data, leading to six proposed mutually exclusive model types based on the availability of collected data for 3 specific variables:

1. At least one other AADT value at the intersection available
2. An AADT value available at an upstream location for the leg
3. Lane number data available at an upstream location for the leg

In other words, six different models were proposed for six situations where the availability of certain independent variables varied. Table 4.1 shows the six mutually exclusive model categories and the number of calibration observations available for each category. An “X” indicates a characteristic is available for a leg. Although six categories were identified, only four of the six categories had calibration legs that fell exclusively into the categories.

Table 4.1: Classification of AADT Estimation Models for the Calibration Set

Model	AADT for at least one other leg at the intersection	Upstream location		Number of observations (legs) in calibration data set
		AADT	Number of Lanes	
1	X	X	X	620
2	X		X	54
3	X			28
4		X	X	5
5			X	0
6				0

NB: “X” indicates that a characteristic is available for a leg.

The inclusion of Models 2 and 5 are the result of the nearby intersection selection procedure (outlined in Figure 3.1) choosing the closest signalized intersection by default. Because a number of signalized intersections in the database were missing AADT values but had data for the number of lanes on each leg, the number of lanes for each leg of the nearby intersection was available but the AADT value remains empty. Hence, when the data was collected for the upstream location, only the upstream number of lanes was recorded for these legs.

While the observed legs were classified into mutually exclusive categories based on the availability of three characteristics outlined above, there remain other characteristics that are shared between different categories of legs. These shared characteristics between the different categories of legs allow for the aggregation of characteristics in one category with characteristics from another category to form a larger calibration observation set. This is because the available characteristic in one category is unneeded in the other. For example, observed data for Model 1 can be included with data for Model 2 because the characteristic of upstream AADT values is unneeded in the data for Model 2. However, data from Model 3 is missing data for the upstream number of lanes, which is a characteristic needed for modelling in Model 2. Thus, Model 3 data cannot be included in the Model 2 calibration set. The aggregation of observations based on shared availability of data is shown in the matrix in Table 4.2.

Table 4.2: Aggregation of Observations to Form Calibration Sets

Model	Model type from which data is aggregated				Number of observations
	1	2	3	4	
1	X				620
2	X	X			674
3	X	X	X		702
4	X			X	625
5	X	X		X	679
6	X	X	X	X	707
NB: "X" indicates that a characteristic is included in the aggregation of data					

If there is AADT for at least one other leg at the intersection, then secondary variables computed using AADT characteristics can be used in the calibration process; otherwise, AADT-related variables are excluded from the calibration process for a given model.

4.2 Final AADT Estimation Modelling Variables

The potential primary independent variables for AADT estimation modelling were identified in Table 3.6. This list of variables was condensed, and the modelling inputs generated as shown in Table 4.3. In addition to these primary variables, two secondary variables were computed using the AADT data for other legs at the same intersection if such AADT was available: the average AADT per leg (for which AADT data was available), and the average AADT per lane (from legs for which AADT data was available).

All variables involving AADT were log transformed, as suggested in the literature. Base-10 was chosen for ease of interpretation. Consequently, any secondary independent variables based on AADT values were also $\log_{10}$ transformed for consistency between the calculated values. No other variables were transformed.

All independent variables included in the regression modelling and their designated variable names are provided in Table 4.3. The variables included in the calibration for each of the six models is shown in Table 4.4, where an "X" indicates the exclusion of a variable (due to its unavailability).

Table 4.3: Final Variables for AADT Estimation Modelling

Variable name	Variable	Intersection or leg	Definition	Data type	Units or values
Log10_Leg_AADT	AADT of leg, $\log_{10}$ transformed	Leg	Log_{10} of the annual average daily traffic of a leg.	Numeric	Vehicles per day
Leg_NumberOfLanes	Number of lanes across leg	Leg	Number of lanes across a given intersection leg.	Numeric	Number of lanes
UpstreamIntDistance	Distance to upstream intersection or location	Leg	Distance from intersection of interest to a nearby intersection or upstream location on the leg of interest, as determined in Section 3.4.	Numeric	Metres
Log10_Upstream_AADT	AADT of legs of upstream intersection or location, $\log_{10}$ transformed	Leg	AADT of the legs of an upstream intersection or location as determined in Section 3.4, where available.	Numeric	Vehicles per day
Upstream_NumLanes	Number of lanes at selected upstream location	Leg	Number of lanes at upstream location, as determined in Section 3.4.	Numeric	Number of Lanes
MajorRd_Leg	Major road Leg	Leg	Binary variable indicating if a leg forms the major or minor direction at an intersection.	Binary	If 0, leg is on minor road, If 1, leg is on major road

Table 4.3: Final Variables for AADT Estimation Modelling, continued

Variable name	Variable	Intersection or leg	Definition	Data type	Units or values
Log10_AvgAADT_PerLeg	Average AADT per leg, $\log_{10}$ transformed	Leg	Average AADT of legs at the intersection (excluding leg of interest). Calculated by taking the sum of available AADT at other legs and dividing by the sum by the number of AADT values. Log_{10} transformed.	Numeric	Vehicles per day per leg
AvgNumLanes_PerLeg	Average number of lanes per leg	Intersection	Average number of lanes per leg at the intersection. Calculated by dividing the sum of the *Leg_NumberOfLanes* of an intersection by the number of legs.	Numeric	Number of lanes per leg
Log10_AvgAADT_PerLane	Average AADT per lane, $\log_{10}$ transformed	Leg	Average AADT per lane at the intersection (excluding leg of interest). Calculated by dividing the *AvgAADT_PerLeg* by the *AvgNumLanes_PerLeg*. Log_{10} transformed.	Numeric	Vehicles per day per lane
NumberOfMedians	Number of medians at the intersection	Intersection	Number of legs on which a concrete curb median exists.	Numeric	Number of medians
MedianAtIntersection	Presence of median at the intersection	Intersection	Binary variable indicating if a raised median exists for the intersection.	Binary	If 0, no medians. If 1, one or more medians.

Table 4.3: Final Variables for AADT Estimation Modelling, continued

Variable name	Variable	Intersection or leg	Definition	Data type	Units or values
MedianOnLeg	Presence of median on the leg	Leg	Binary variable indicating if a raised median exists for the leg.	Binary	If 0, no median. If 1, median present.
SlipLaneAtIntersection	Presence of slip lanes at the intersection	Intersection	Binary variable indicating if slip lane exists for the corner between two legs.	Binary	If 0, no slip lanes. If 1, one or more slip lanes present.
NumberOfSlipLanes	Number of slip lanes at the intersection	Intersection	Total number of slip lanes at an intersection.	Numeric	Number of slip lanes
TransitStopPresence	Presence of transit stops at an intersection	Intersection	Binary variable indicating if a transit stop exists at the intersection.	Binary	If 0, no transit stops. If 1, one or more transit stops present.
TransitStopOnApproach	Presence of transit stops on a leg	Leg	Binary variable indicating if a transit stop exists on the leg.	Binary	If 0, no transit stops. If 1, one or more transit stops present.
NumberOfTransitStops	Number of transit stops at the intersection	Intersection	Number of transit stops on the leg, near the intersection.	Numeric	Number of transit stops
NumberTransitLines	Number of transit routes passing through the intersection	Intersection	Total number of transit lines with routes through the intersection.	Numeric	Number of transit routes
UrbanLandType	Urban land type	Intersection	Indicator for location of intersection in an urban area or rural area.	Binary	If 0, non-urban area. If 1, urban area.

Table 4.3: Final Variables for AADT Estimation Modelling, continued

Variable name	Variable	Intersection or leg	Definition	Data type	Units or values
CommercialArea	Presence of commercial area	Intersection	Binary variable indicating if the predominant land use of the surrounding area is commercial development.	Binary	If 0, non-commercial area. If 1, commercial area.
Arterial	Arterial road type	Leg	Binary variable indicating if the leg is an arterial/regional road.	Binary	If 0, non-arterial road. If 1, arterial road.
RT2	Local or collector road type	Leg	Binary variable indicating if a leg is a local road or collector road (if not an arterial road). When “Arterial” = 1, *RT2* is not applicable.	Binary	When “Arterial” = 0: If 0, collector road. If 1, local road.
Leg_SpeedLimit	Speed limit of leg	Leg	Speed limit on a leg.	Numeric	Kilometres per hour
OneWayLeg	Presence of one-way leg	Leg	Binary variable indicating is a leg has one-way or two-way traffic.	Binary	If 0, two-way. If 1, one-way.
AvgPopDens16	Average population density (2016)	Intersection	Average population density of the area surrounding the intersection (2016).	Numeric	Population per square kilometre
MuniPopulation2016	Municipal population (2016)	Intersection	Population (2016) of the local municipality in which the intersection is located.	Numeric	Population

Table 4.3: Final Variables for AADT Estimation Modelling, continued

Variable name	Variable	Intersection or leg	Definition	Data type	Units or values
FourLeg	Number of legs	Intersection	Binary variable indicating if an intersection has 3 or 4 legs.	Binary	If 0, 3 legs. If 1, 4 legs.

Table 4.4: Variables Used in Calibration Data Sets for Proposed AADT Models

Variable	Model in which variable is excluded					
	1	2	3	4	5	6
Log10_Leg_AADT						
Log10_Upstream_AADT		X	X		X	X
Upstream_NumLanes			X			X
UpstreamIntDistance			X			X
Leg_NumberOfLanes						
Log10_AvgAADT_PerLeg				X	X	X
AvgNumLanes_PerLeg						
Log10_AvgAADT_PerLane				X	X	X
Leg_SpeedLimit						
AvgPopDens16						
MuniPopulation2016						
NumberOfTransitStops						
NumberTransitLines						
NumberOfMedians						
NumberOfSlipLanes						
MedianAtIntersection						
MedianOnLeg						
SlipLaneAtIntersection						
TransitStopPresence						
TransitStopOnApproach						
MajorRd_Leg						
Arterial						
RT2						
OneWayLeg						
UrbanLandType						
CommercialArea						
FourLeg						

NB: “X” indicates exclusion of a variable from a model

4.3 Model Development

To develop multiple regression models, a correlation analysis was first completed, followed by regression modelling in R.

4.3.1 Correlation Analysis

The goal of correlation analysis was to identify the strength of correlation between the different variables considered for each of the six AADT estimation models. A correlation matrix was developed for each of the six model calibration data sets. The correlation matrices are included in Appendix A: Correlation Matrices for Model Calibration Data Sets. The strength of correlation is helpful in selecting variables for stepwise regression, as one of the goals of regression modelling is to include independent variables that are not strongly correlated with each other to increase a model's explanatory potential.

4.3.2 Model Calibration

The six model calibration datasets were imported to R for multiple linear regression. The same procedure was undertaken with each calibration data set to develop six different regression models in R.

1. Generate a baseline model containing the dependent variable and all relevant independent variables.
2. Perform initial backwards stepwise regression.
3. Examine the p-values of the variables in the initial model and identify any variables that are insignificant at the 95% level. If there are any insignificant variables, remove the most insignificant variable (i.e., with the largest p-value) and calibrate a new model to the remaining variables. Continue removing insignificant variables and calibrating models until all variables in the model are found to be significant at least at the 95% level.
4. If any remaining significant variables have unreasonable coefficients based on their sign direction and/or magnitude, or are strongly correlated with another variable (based on its correlation matrix), remove these variables only if they do not result in a significant change in adjusted R-squared value and AIC.
5. Examine the Variance Inflation Factors (VIF) for the final model to ensure no issues with multicollinearity.

To perform a backwards stepwise regression, it was first necessary to generate a baseline model. To start, a multiple linear regression model was fit to all the variables in each data set, with the dependent variable being the *Log10_Leg_AADT* and the independent variables being the remaining variables; the "*lm*" function from the "*stats*" library in R was used for this initial model-fitting.

Next, an initial backwards-stepwise linear regression was performed by R on the baseline model using the "*step*" function in the "*stats*" library. The "*step*" function works iteratively, determining in each iteration which one of a given model's variables results in a model with the lowest Akaike Information Criterion (AIC) when removed, and removing the variable to create a new model with a lower AIC. The iterations continue until a significant drop in AIC is not observed by dropping any more variables, resulting in an initial backwards stepwise regression model generated by R. The AIC is a metric that evaluates a model based on the balance between its goodness-of-fit and the number of explanatory variables involved. A model with a lower AIC value relative to that of other models is desirable, as it indicates a better goodness-of-fit using fewer explanatory variables relative to other models calibrated to the same dependent variable (Gray-Steinhauer, 2018). The AIC can only be compared between models using the same initial calibration data and cannot be compared between models with different initial calibration data.

Following the initial backwards regression in R, the initial regression model was examined using the "*summary*" function, which provides the coefficients of each variable in a "model" object, the significance (expressed as a p-value), the adjusted R-squared value, and the standard error for each model. In addition to this summary, the "*AIC*" function was used to state the AIC of the model.

If the initial regression model contained coefficients that were not significant, the least significant variable was removed, and the model was recalibrated to the remaining variables. This process was repeated until all remaining variables were significant. Once all variables in the model were significant, the sign direction and magnitudes of the coefficients were considered; any variables with unreasonable coefficients were removed and the model recalibrated until all coefficients were significant and reasonable, though significant variables were only removed if they did not result in a major decrease in adjusted R-square. As well, if any variables were found to be strongly correlated, the less significant of the variables was removed from the model to reduce effects of collinearity. This manual regression process was repeated for each of the six data sets to generate six significant AADT estimation models for the dependent variable *Log10_Leg_AADT*.

The Variance Inflation Factor (VIF) is a measure of the strength of correlation between the independent variables in a regression model. For a given independent variable, the VIF is a numerical value greater than 0, where a higher value indicates stronger correlation with other variables in the model and greater potential for multicollinearity issues. Generally, a model does not have issues with multicollinearity if the VIF of its variables is less than 5 (Frost, 2017). When computed from the "*VIF*" function, the VIF values for each variable of the six final models were found to be less than 5, thus indicating little issue with collinearity among the independent variables within each model.

4.3.3 Proposed AADT Estimation Models

The coefficients of the final six models are shown below in Table 4.5 along with their adjusted R-squared values. A blank cell indicates the inclusion of a potential independent variable from the initial baseline model, while an "X" indicates exclusion of the variable from the starting baseline model. The AIC value is not shown for the models because it cannot be used for comparison between models with different calibration datasets.

Table 4.5: Proposed AADT Estimation Models

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	0.6381	1.4799	1.3666	1.5296	3.5168	3.3957
Log10_Upstream_AADT	0.4683	X	X	0.5758	X	X
Upstream_NumLanes		0.0310	X		0.0439	X
UpstreamIntDistance	-1.794E-05	-2.860E-05	X	-2.063E-05	-3.076E-05	X
Leg_NumberOfLanes	0.0299	0.0303	0.0424	0.0344	0.0493	0.0780
Log10_AvgAADT_PerLeg		0.5469	0.5875	X	X	X
AvgNumLanes_PerLeg	0.0287					
Log10_AvgAADT_PerLane	0.3505			X	X	X
Leg_SpeedLimit			-0.0019			
AvgPopDens16			2.024E-05	1.309E-05	3.094E-05	3.819E-05
MuniPopulation2016					4.700E-07	7.840E-07
MedianAtIntersection		-0.0390				
SlipLaneAtIntersection	0.0289					
MajorRd_Leg	0.0986	0.1523	0.1950	0.0718	0.1428	0.1894
Arterial		0.0447	0.0574			0.0623
OneWayLeg				-0.0656	-0.0952	
CommercialArea				0.0249	0.0461	0.0602
Adjusted R-squared	0.7939	0.6393	0.6059	0.7236	0.4753	0.4224

NB: “X” indicates exclusion of variable from initial baseline model. Blank cell indicates inclusion of variable from initial baseline model.

The observed and predicted log_{10} AADT values were transformed back to their original values for ease of comparison, then plotted against each other in order to observe the goodness-of-fit according to the line with slope equal to 1. The "*summary*", and "*VIF*" outputs from R are provided for each of the models, along with an examination of each of the models.

Model 1 as seen in Figure 4.1 and Table 4.6 applies to legs at intersections that have at least one other AADT value available for a leg, and have *Upstream_AADT* and *Upstream_NumLanes* available for the leg. Model 1 has the highest adjusted R-squared value (0.7940) among the six final models. The sign of the *UpstreamIntDistance* variable (indicating the distance upstream until the closer of either another traffic signal or a change in AADT value) is negative, which suggests a lower AADT between more closely spaced intersections.

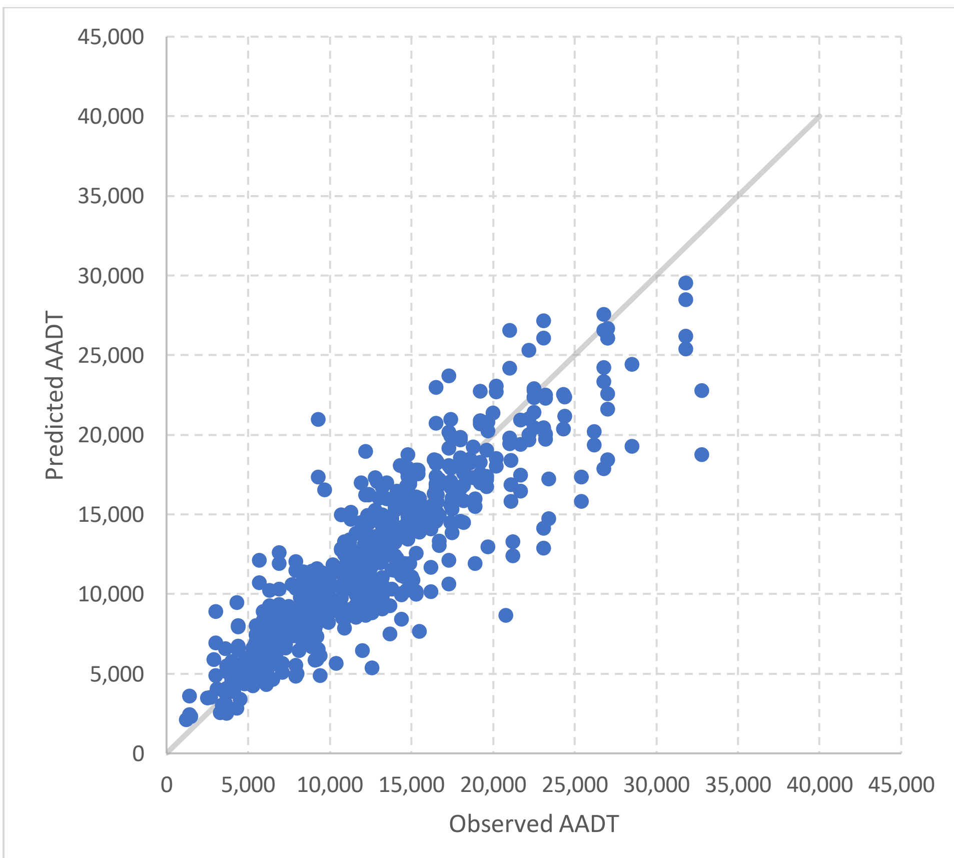


Figure 4.1: Observed versus predicted AADT values for Model 1

Table 4.6: Model 1 Regression Summary and VIF Values

Variable	Coefficients	Standard error	P-value	Significance	Variance inflation factor (VIF)
Intercept	0.63809	0.0946	0.000	***	
Log10_Upstream_AADT	0.46834	0.0213	0.000	***	1.703
UpstreamIntDistance	-0.00002	0.0000040	0.000	***	1.180
Leg_NumberOfLanes	0.02991	0.00714	0.000	***	4.322
AvgNumLanes_PerLeg	0.02872	0.00927	0.002	**	4.310
Log10_AvgAADT_PerLane	0.35055	0.0246	0.000	***	1.370
SlipLaneAtIntersection	0.02895	0.00959	0.002	**	1.074
MajorRd_Leg	0.09856	0.0127	0.000	***	1.470
Residual standard error: 0.010313 on 612 degrees of freedom					
Adjusted R-squared:0.79389					
Significance Codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1					

Model 2 as seen in Figure 4.2 and Table 4.7 applies to legs at intersections that have at least one other AADT value available for a leg, do not have *Upstream_AADT* available, but have *Upstream_NumLanes* available for the leg. Model 2 has a lower adjusted R-squared value compared to Model 1 (0.6393). The same negative sign for the *UpstreamIntDistance* coefficient is observed (as in Model 1), along with a negative sign for the *MedianAtIntersection* variable (which indicates if there is at least one concrete curb median at one of the legs at an intersection), suggesting the presence of medians at an intersection implies a lower AADT; this could be true of suburban intersections that may have less traffic.

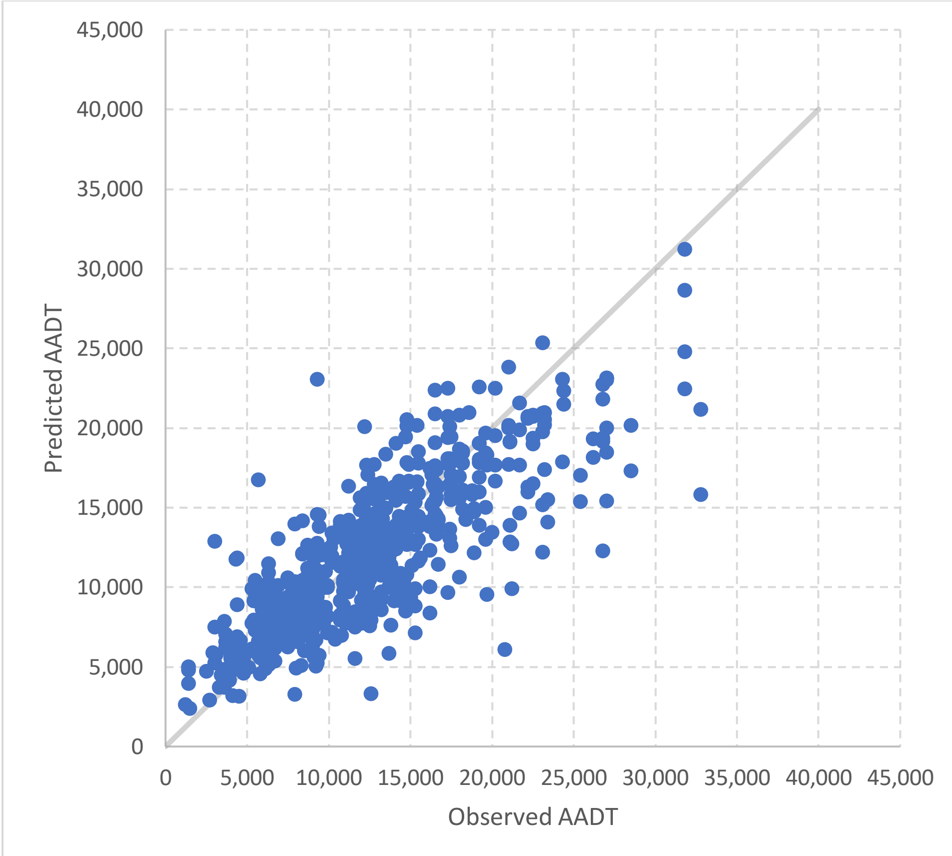


Figure 4.2: Observed versus predicted AADT values for Model 2

Table 4.7: Model 2 Regression Summary and VIF Values

Variable	Coefficients	Standard error	P-value	Significance	Variance inflation factor (VIF)
Intercept	1.47991	0.1128	0.000	***	-
Upstream_NumLanes	0.03102	0.0052	0.000	***	1.566
UpstreamIntDistance	-0.00003	0.000005	0.000	***	1.147
Leg_NumberOfLanes	0.03031	0.0066	0.000	***	2.257
Log10_AvgAADT_PerLeg	0.54688	0.0286	0.000	***	1.279
MedianAtIntersection	-0.03903	0.0140	0.006	**	1.697
MajorRd_Leg	0.15235	0.0143	0.000	***	1.145
Arterial	0.04468	0.0216	0.039	*	1.085
Residual standard error: 0.13828 on 666 degrees of freedom					
Adjusted R-squared: 0.63931					
Significance Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

Model 3 as seen in Figure 4.3 and Table 4.8 applies to legs at intersections that have at least one other AADT value available for a leg, and have neither *Upstream_AADT* or *Upstream_NumLanes* available for the leg. Of all three models for which AADT information was available for one other leg, Model 3 has the lowest adjusted R-squared value (0.6059). The *LegSpeedLimit* sign is negative, which may be the influence of urban roads carrying more traffic at lower speeds compared to rural roads carrying less traffic at higher speeds. This negative correlation was identified when the observed AADT values were plotted with the posted speed limits (Figure 4.4).

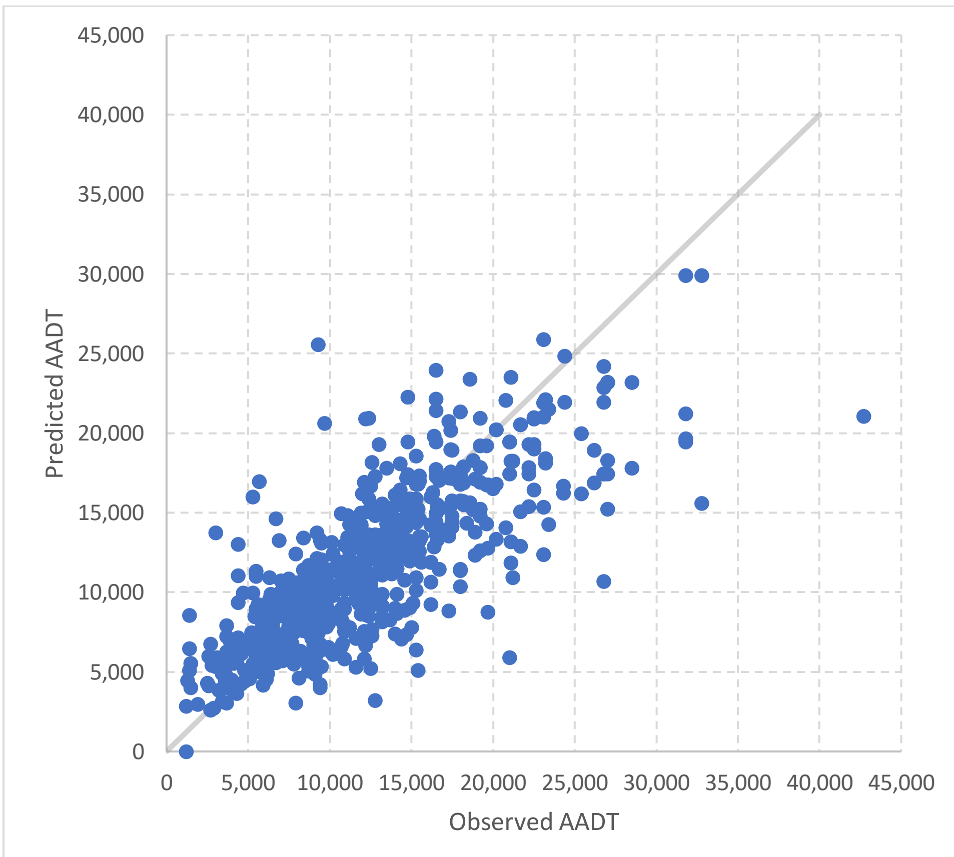


Figure 4.3: Observed versus predicted AADT values for Model 3

Table 4.8: Model 3 Regression Summary and VIF Values

Variable	Coefficients	Standard error	P-value	Significance	Variance inflation factor (VIF)
Intercept	1.36664	0.1318	0.000	***	-
Leg_NumberOfLanes	0.04244	0.0055	0.000	***	1.391
Log10_AvgAADT_PerLeg	0.58749	0.0312	0.000	***	1.302
Leg_SpeedLimit	-0.00187	0.0007	0.012	*	1.255
AvgPopDens16	0.00002	0.000007	0.000	**	1.343
MajorRd_Leg	0.19495	0.0148	0.003	***	1.101
Arterial	0.05742	0.0229	0.012	*	1.076
Residual standard error: 0.152 on 695 degrees of freedom					
Adjusted R-squared: 0.60923					
Significance Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

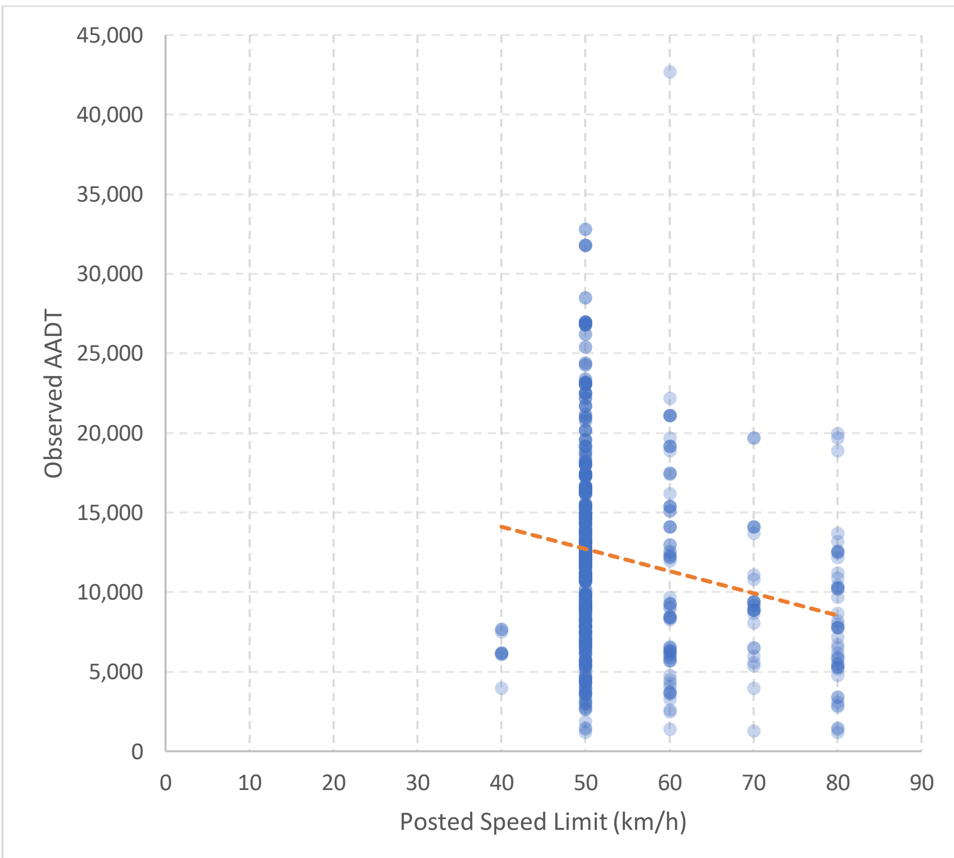


Figure 4.4 Observed AADT and posted speed limit

Model 4 as seen in Figure 4.5 and Table 4.9 applies to legs at intersections that do not any AADT values available for other legs, and that have both *Upstream_AADT* and *Upstream_NumLanes* available for the leg. Model 4 has the second-highest adjusted R-squared value of the six models (0.7236), and the highest value among models for intersections without AADT data at another intersection. The negative sign for *OneWayLeg* (which indicates if a leg has one direction of travel or not) is reasonable, given that one-way legs may be more common in areas with less traffic volume. This correlation is seen when the mean observed AADT for one-way legs and two-way legs is computed. One-way legs have an average observed AADT of 7944 vehicles per day, while two-way legs have a higher average observed AADT of 12360 vehicles per day.

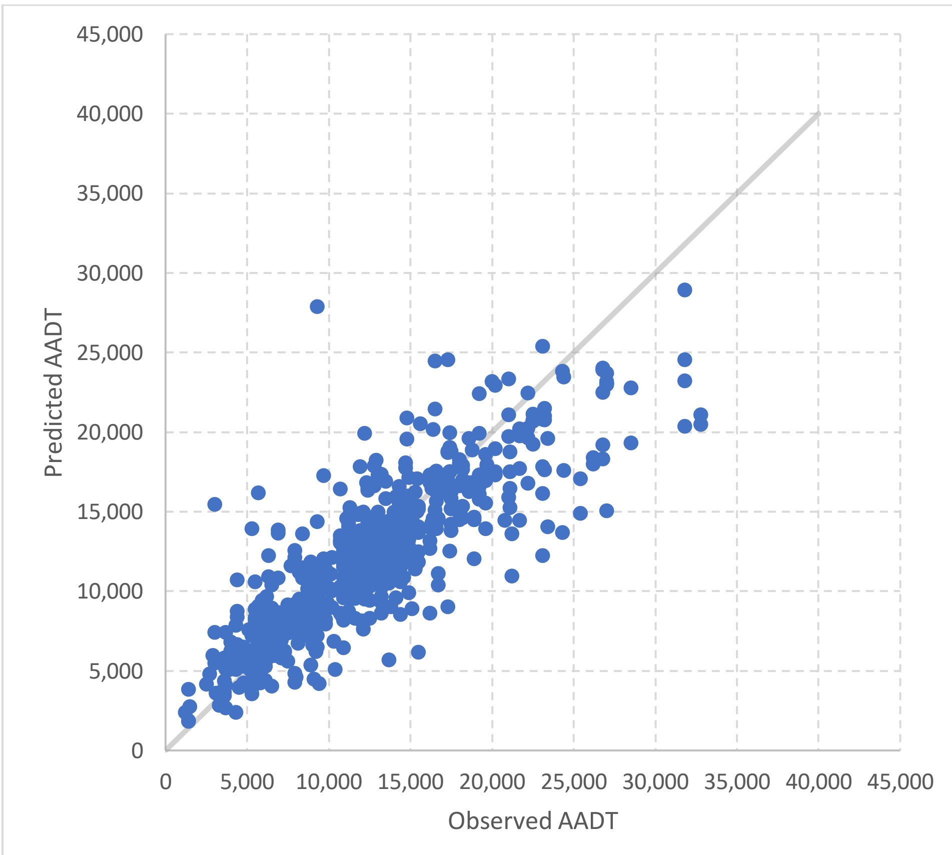


Figure 4.5: Observed versus predicted AADT values for Model 4

Table 4.9: Model 4 Regression Summary and VIF Values

Variable	Coefficients	Standard error	P-value	Significance	Variance inflation factor (VIF)
Intercept	1.52963	0.0859	0.000	***	-
Log10_Upstream_AADT	0.57579	0.0231	0.000	***	1.487
UpstreamIntDistance	-0.00002	0.000005	0.000	***	1.291
Leg_NumberOfLanes	0.03439	0.005	0.000	***	1.393
AvgPopDens16	0.00001	0.000006	0.018	*	1.270
MajorRd_Leg	0.07182	0.0129	0.006	***	1.151
OneWayLeg	-0.06557	0.0289	0.024	*	1.137
CommercialArea	0.02492	0.0104	0.017	*	1.156
Residual standard error: 0.11933 on 617 degrees of freedom					
Adjusted R-squared: 0.72357					
Significance Codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1					

Model 5 as seen in Figure 4.6 and Table 4.10 applies to legs at intersections that do not any AADT values available for other legs, and that do not have *Upstream_AADT* available but do have the *Upstream_NumLanes* available for the leg. Model 5 has a relatively low adjusted R-squared value (0.4753) compared to Models 1-4, which is seen in the scatterplot. All coefficient sign directions make sense and are consistent with previous models.

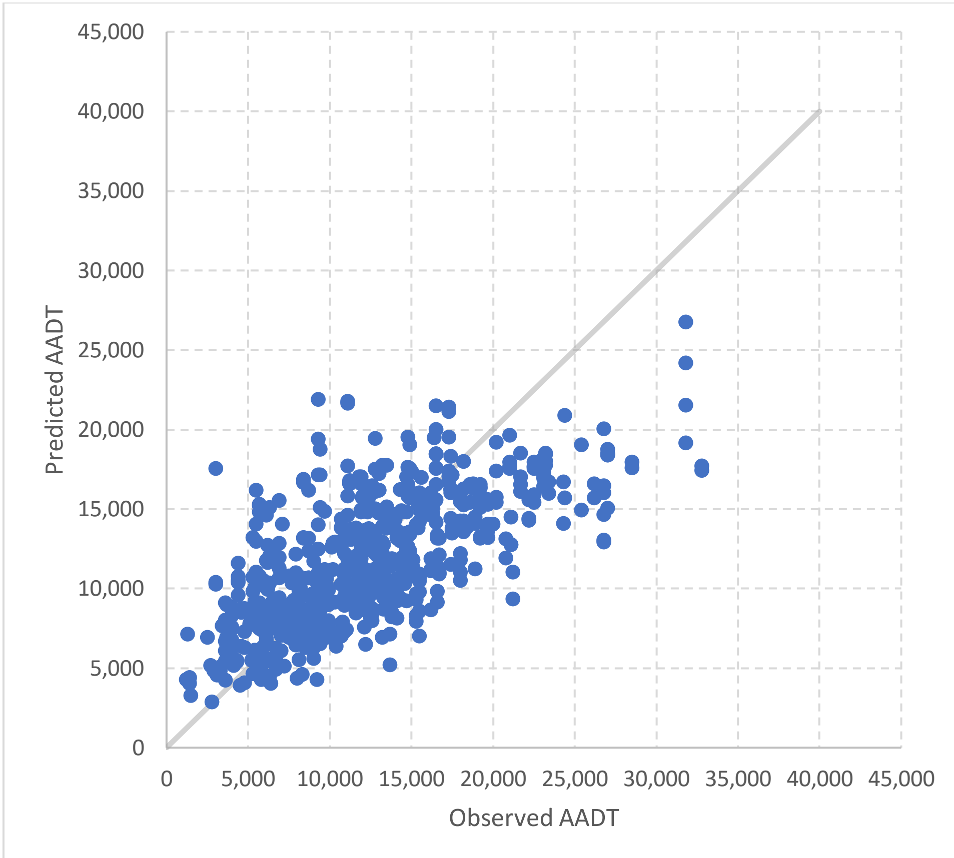


Figure 4.6: Observed versus predicted AADT values for Model 5

Table 4.10: Model 5 Regression Summary and VIF Values

Variable	Coefficients	Standard error	P-value	Significance	Variance inflation factor (VIF)
Intercept	3.51682	0.0321	0.000	***	-
Upstream_NumLanes	0.04385	0.0062	0.000	***	1.542
UpstreamIntDistance	-0.00003	0.000006	0.000	***	1.309
Leg_NumberOfLanes	0.04928	0.0066	0.000	***	1.637
AvgPopDens16	0.00003	0.000008	0.000	***	1.435
MuniPopulation2016	0.00000	0.0000002	0.002	**	1.272
MajorRd_Leg	0.14279	0.0168	0.000	***	1.101
OneWayLeg	-0.09525	0.0367	0.009	**	1.171
CommercialArea	0.04608	0.0139	0.000	***	1.149
Residual standard error: 0.16661 on 670 degrees of freedom					
Adjusted R-squared: 0.47528					
Significance Codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1					

Model 6 as seen in Figure 4.7 and Table 4.11 applies to legs at intersections that do not have any AADT values available for other legs, and that have neither *Upstream_AADT* and *Upstream_NumLanes* available for the leg. Model 6 has the lowest adjusted R-squared value (0.4224) among the six models, with both Models 5 and 6 having relatively lower fit compared to Models 1 to 4. All coefficient sign directions are reasonable.

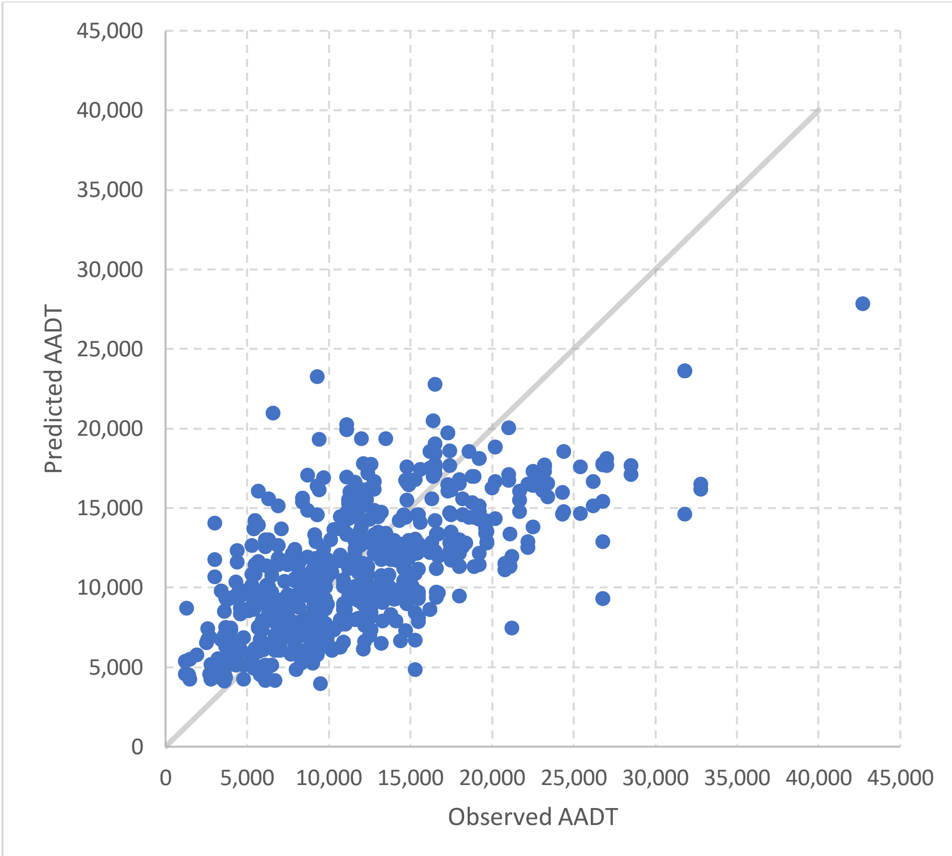


Figure 4.7: Observed versus predicted AADT values for Model 6

Table 4.11: Model 6 Regression Summary and VIF Values

Variable	Coefficients	Standard error	P-value	Significance	Variance inflation factor (VIF)
Intercept	3.39570	0.0338	0.000	***	-
Leg_NumberOfLanes	0.07803	0.0062	0.000	***	1.203
AvgPopDens16	0.00004	0.000008	0.000	***	1.336
MuniPopulation2016	0.00000	0.0000002	0.000	***	1.225
MajorRd_Leg	0.18937	0.0176	0.000	***	1.084
Arterial	0.06232	0.0275	0.02	*	1.077
CommercialArea	0.06023	0.0144	0.000	***	1.069
Residual standard error: 0.18376 on 700 degrees of freedom					
Adjusted R-squared: 0.42735					
Significance Codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1					

Overall, the fit between the observed and predicted values from the six models is acceptable, with Models 1 to 4 having reasonably good fit. Unsurprisingly, the models requiring the most knowledge of existing conditions were also the ones with the highest predictive power and adjusted R-squared values (such as Model 1 and 4).

4.4 Model Validation and Application

While all models were found to be reasonable based on the fit of their observed and predicted values, the models required validation to demonstrate their predictive ability. Validation with data from another municipality was not considered feasible given the required effort to collect a similar set of such detailed data for another region. Instead, k-fold cross validation was applied in R in order to validate the models' predictive abilities.

4.4.1 k-fold Cross-Validation

k-fold cross validation is a method used in machine learning to evaluate the performance of a predictive model on unseen data and is particularly applicable in instances where limited data is available. The method involves separating a given data set randomly into *k* groups (or "folds"), where each group is used once as a testing set and the remaining *k*-1 groups used as a training set for calibration of a model. A total of *k* models are calibrated, and the average error across the *k* models is computed, allowing for comparison of the average error from the cross validation to the error of the original regression model (Kassambara, 2018). If error measures from the cross-validation procedure are similar to those for a given regression model, the model may be considered robust and is not overfitting the data. This procedure allows for model validation without the need to gather another set of data for comparison.

The "*cv*" function from the "*lmvar*" library in R was used to perform the k-fold cross validation for the six models. A k value of 5 was selected for this validation procedure as this value leads to error estimates with neither excessively high variance or high bias (Kassambara, 2018). Using the selected function in R, the cross-validation procedure results in three error measures from each data set, including:

- Mean absolute error (MAE), which is the average of the absolute differences between the predicted values and the observed values for a model (i.e., the average of the absolute value of the residuals);
- Mean squared error (MSE), which is the average of the squared residuals; and
- Root mean squared error (RMSE), which is the square root of the MSE.

The values of the error measures computed in cross validation are the average of the MAE, MSE, and RMSE across the *k* calibrated models.

The same three error measures were computed for each of the $\log_{10}$ AADT regression models and were compared to the values obtained from the cross-validation procedure. These error measures cannot be compared between the different regression models because of the difference in calibration data sets; instead, the error measures must be examined within each model individually. The results of the cross-validation and the same measures for the regression models are shown in Table 4.12, along with the absolute difference between both values.

Table 4.12: Error Measures from k-fold cross validation (k = 5) and Regression Models

Error measure	Source	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Mean absolute error (MAE)	Regression Model	0.074	0.099	0.107	0.085	0.127	0.143
	Cross Validation	0.076	0.102	0.108	0.086	0.129	0.144
	Absolute Difference	**0.002**	**0.003**	**0.002**	**0.002**	**0.002**	**0.001**
Mean squared error (MSE)	Regression Model	0.010	0.019	0.023	0.014	0.027	0.033
	Cross Validation	0.011	0.020	0.024	0.015	0.028	0.034
	Absolute Difference	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
Root mean squared error (RMSE)	Regression Model	0.102	0.137	0.151	0.119	0.166	0.183
	Cross Validation	0.105	0.142	0.153	0.121	0.168	0.184
	Absolute Difference	**0.002**	**0.004**	**0.002**	**0.002**	**0.002**	**0.001**

The differences between the error measures for the regression models and the cross-validation procedure were found to be small for all six regression models. This suggested that the regression models were robust and were not overfitting the data, thus validating the models' ability to predict AADT values for legs. The error measures from the k-fold analysis were also found to always be greater than those of the regression models', which could be explained by the use of less data per calibration of each model for each fold.

In addition to the k-fold cross-validation, the adjusted R-squared values were compared to the literature to identify how other multiple linear regression models used for AADT estimation fit. Mohamad et al. (1998) observed an R-squared value of 0.7726 for their $\log_{10}$ AADT estimation model, while Dixon et al.

(2012) observed adjusted R-squared values of 0.7088 and 0.6683 for their minor log(AADT) estimation models (by leg), with and without parallel facilities, respectively. The adjusted R-squared of the six regression models are near or within those in the literature, suggesting that they are reasonably fitted.

4.4.2 Model Application

As was performed in Table 4.1 for the calibration data, the 963 legs that were missing AADT values and thus required an estimate of AADT were categorized in six mutually exclusive groups based on the model that would be used to estimate the AADT for the leg. The model was selected based on the availability of data for the leg, as shown in Table 4.13.

Table 4.13: Classification of AADT estimation models for the application set

Model	AADT for at least one other leg at the intersection	Upstream location		Number of legs to which model was applied
		AADT	Number of lanes	
1	X	X	X	8
2	X		X	128
3	X			309
4		X	X	24
5			X	259
6				235

NB: "X" indicates that a characteristic is available for a leg.

The six validated models were applied to estimate AADT values for the remainder of the legs in the dataset according to the categorization of the legs in Table 4.13, resulting in the full Niagara Region signalized intersection data set, that was then used for the application of the three pedestrian risk evaluation methods. The AADT values for all intersections are provided in Appendix B: AADT Values for Signalized Intersections in Niagara Region (2017).

5. Analysis of Methods for Pedestrian Safety Risk Evaluation

5.1 Application of Methods to a Sample Intersection

The required data inputs for each of the three pedestrian safety risk evaluation methods were assembled for each of the 438 intersections, and the methods applied to each location. The steps in each method are summarized in the following sections. The intersection of Glenridge Avenue and Glendale Avenue in St. Catharines (shown in Figure 3.3) was selected to demonstrate the application of each of the methods. The scores provided by all methods considered are provided in Appendix C: Pedestrian Safety Risk Evaluation Scores for Signalized Intersections in Niagara Region.

5.1.1 NCHRP ActiveTrans Priority Tool Application

The NCHRP ActiveTrans Priority Tool (APT) produces a prioritization score that can be used to rank locations. The APT consists of ten steps that are grouped into two phases (Figure 5.1), summarized in Table 5.1.

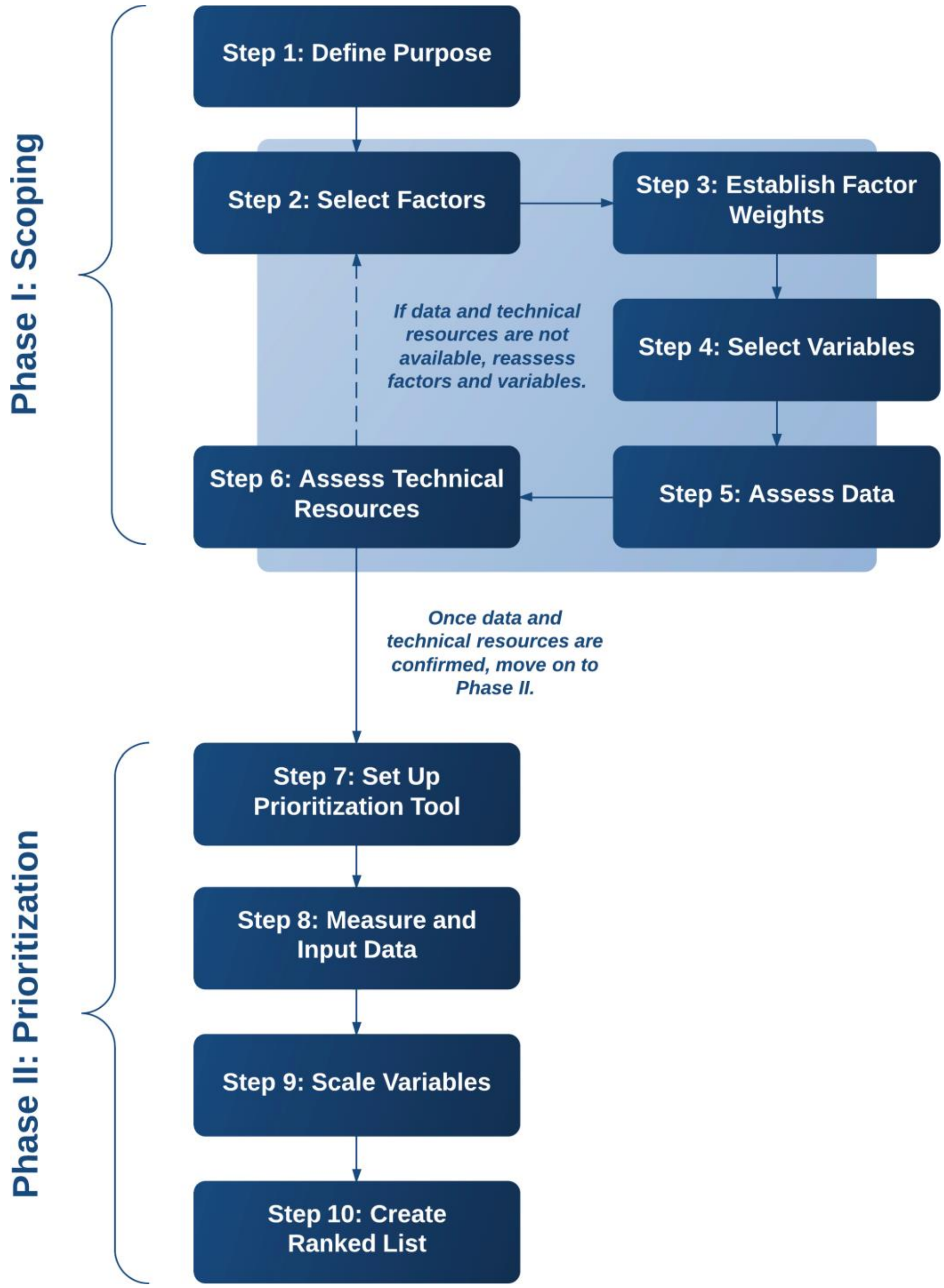


Figure 5.1: Summary of phases and steps in the ActiveTrans Priority Tool (Lagerwey et al., 2015)

Table 5.1: Description of ActiveTrans Priority Tool steps (modified from Lagerwey et al., 2015)

Phase	Step	Step name	Description
1: Scoping	1	Define purpose	The user identifies the mode for which safety will be prioritized, the location type to which the prioritization rankings will be applied (whole intersections, individual leg crossings, or midblocks), and which locations will be prioritized.
	2	Select factors	The user selects the general category of factors (from a supplied list) which will be used to determine the prioritization score for each location.
	3	Establish factor weights	The user selects how much each factor category contributes to the prioritization score for each location.
	4	Select variables	The user selects variables to represent each factor, choosing from the suggested variables or their own choice.
	5	Assess data	The user assesses the availability and quality of the data for each variable for each location.
	6	Assess technical resources	The user assesses the resources available to collect and process the data. If neither the data itself or ability to collect the required data is available, the user should return to Step 3 and reconsider which factors and variables to use.
2: Prioritization	7	Set up prioritization tool	The user prepares the prioritization tool, using either the programmed spreadsheet supplied by the NCHRP, or using their own program.
	8	Measure and input data	The user assembles and inputs the data for each variable for each location.
	9	Scale variables	The values of each variable are scaled to the amount they will contribute to each score, either using predetermined scheme (e.g., proportionate scaling, inverse proportionate scaling) or manually assigned values.
	10	Create ranked list	The scores for each location are calculated and a ranked list is produced, where a higher score indicates higher rank and priority for safety improvement relative to other locations which have been scored.

For Niagara Region signalized intersections, the APT was applied to whole intersections. The selected factors were "Safety," "Existing Conditions," and "Demand" because they included the variables that were identified from the literature review. A total of nine variables were included, as shown in Table 3.2. Several of these variables were modified to represent the intersection as opposed to just the leg. Two types of factor weightings were initially considered, the first scheme (S1) being where each variable was equally weighted, and a second scheme (S2) where the factor categories were equally weighted. After assembling the data for all locations, all variables but one were scaled using proportional scaling (relative to available values for a given variable; also known as linear scaling) to determine the score contribution out of 10 points (i.e., higher values of a variable indicate higher risk). The presence of a raised median was the only variable with inverse proportional scaling (i.e., presence of the feature results in a decreased score contribution), as the presence of the feature was associated with increased pedestrian safety (as was also found in Stipancic et al., 2020). Proportional scaling was chosen for ease of interpretation. Once the variables were scaled, the factor weights were applied to the variables and the sum of weighted scores taken to obtain a Prioritization Score out of 10 points. Table 5.2 summarizes the factors, weighting schemes, variables, variable modifications, and scaling scheme used in the application of the APT to Niagara Region, while Table 5.3 demonstrates the calculation of the score for the aforementioned intersection. The 85^{th} percentile speed was extrapolated from a Halton Region study for 85^{th} percentile vehicle speeds on Halton Regional roads based on posted speed limits (Halton Region, 2016) .

Table 5.2: Application of ActiveTrans Priority Tool to Niagara Region Signalized Intersections

Factor	Input variable	Value or modification	Minimum value	Maximum value	Units	Scaling	S1: Equal variable weighting	S2: Equal factor weighting
Safety	Total pedestrian crashes (2012-2018)	No modification	0	11	Crashes	Proportionate	0.111	0.333
Existing conditions	ADT	Average AADT of all legs	2,725	25,568	Vehicles per day	Proportionate	0.111	0.006
	Traffic speed	Average 85th percentile speed of all legs	47.6	87.8	Kilometres per hour	Proportionate	0.111	0.006
	Total crossing distance	Average crossing distance of all available legs	4.3	34.8	Metres	Proportionate	0.111	0.006
	Number of right-turn lanes	Average number of right turn lanes across all legs	0.0	1.3	Lanes	Proportionate	0.111	0.006
	Number of vehicle through lanes	Average number of through lanes across all legs	0.3	2.3	Lanes	Proportionate	0.111	0.006
	Presence of raised median	If more than zero medians, 1, else use a value of 0	0.0	1.0	n/a	Inverse Proportionate	0.111	0.006
Demand	Population density	No modification	18.5	4,814.3	People per square kilometre	Proportionate	0.111	0.167
	Number of bus stops	Total number of stops	0.0	6.0	Stops	Proportionate	0.111	0.167
					Maximum prioritization score		10	10

Table 5.3: Application of ActiveTrans Priority Tool to Intersection of Glenridge Avenue and Glendale Avenue, St. Catharines

Factor	Input variable		Leg value				Intersection average value	Units	S1: Equal variable weighting	S2: Equal factor weighting
			North	South	West	East				
Safety	Total pedestrian crashes (2012-2018)		n/a				2	Crashes	0.202	0.606
Existing Conditions	AADT		9,800	9,300	16,200	14,800	12,525	Vehicles per day	0.477	0.238
	Traffic speed	Speed limit	50	50	50	50	50	Kilometres per hour	0.556	0.278
		85^{th} percentile speed	67.7	67.7	67.7	67.7	67.7			
	Total crossing distance		30	28	33	26	29.3	Metres	0.910	0.455
	Number of right-turn lanes		1	1	1	1	1.0	Lanes	0.833	0.417
	Number of vehicle through lanes		2	2	3	2	2.25	Lanes	0.397	0.198
	Presence of raised median		1	1	1	1	1	n/a	0.000	0.000
Demand	Population density		n/a				1,732.8	People per square kilometre	0.397	0.596
	Number of bus stops		0	2	2	0	4	Stops	0.741	1.111
								Prioritization score	4.513	3.899

The prioritization score of this intersection ranked the intersection 29^{th} out of 438 in the first scheme and 28^{th} out of 438 in the second scheme.

5.1.2 FHWA Pedestrian Intersection Safety Index Application

The FHWA Pedestrian Safety Index (Ped ISI) is a value generated by a multi-variable regression equation that provides an index of safety risk for individual leg crossings at intersections. The higher the index, the higher the risk to pedestrians. To generate the index, the equation is applied to each crossing (i.e., each intersection leg) using the site's input value for each variable. Because the index applies only to an individual crossing, the average index for all legs was calculated as a measure of safety risk for the entire intersection, as suggested by the developers of the Ped ISI and as performed by the City of Ottawa in their modified Ped ISI guide. The equation, inputs, and values for the Ped ISI are shown in Table 5.4, while the application of the Ped ISI to the selected intersection is demonstrated in Table 5.5. As was done for the APT, the 85th percentile traffic speed values were taken from the Halton Region 2016 study.

Table 5.4: FHWA Ped ISI Equation and Variables (modified from Carter et al., 2006)

Ped ISI equation	**Ped ISI** = 2.372 – 1.867 **SIGNAL** – 1.807 **STOP** + 0.335 **THRULNS** + 0.018 **SPEED** + 0.006 (**MAINADT** * **SIGNAL**) + 0.238 **COMM**	
Input variable	**Definition and/or modification**	**Units**
SIGNAL	Binary variable indicating a signal-controlled crossing.	0 indicates "no", 1 indicates "yes"
STOP	Binary variable indicating a stop-controlled crossing.	0 indicates "no", 1 indicates "yes"
THRULNS	Total number of through lanes on the street being crossed (both approaching and outbound lanes).	Lanes
SPEED	85th percentile speed of leg being crossed.	Miles per hour
MAINADT	Traffic volume of the street being crossed.	Thousands of vehicles per day (e.g., 2000 vehicles/day would be input as 2)
COMM	Binary variable indicating if the predominant land use of the surrounding area is commercial development, including retail and restaurants.	0 indicates "no", 1 indicates "yes"

Table 5.5: Application of Ped ISI to Intersection of Glenridge Avenue and Glendale Avenue, St. Catharines (modified from Carter et al., 2006)

Ped ISI Equation	**Ped ISI** = 2.372 – 1.867 **SIGNAL** – 1.807 **STOP** + 0.335 **THRULNS** + 0.018 **SPEED** + 0.006 (**MAINADT** * **SIGNAL**) + 0.238 **COMM**								
Input Variable	**Leg Value**				**Units**	**Contribution to Ped ISI**			
Leg Direction	**N**	**S**	**W**	**E**		**N**	**S**	**W**	**E**
SIGNAL	1	1	1	1		-1.867	-1.867	-1.867	-1.867
STOP	0	0	0	0		0	0	0	0
THRULNS	2	2	3	2	Lanes	0.67	0.67	1.005	0.67
Speed Limit	50	50	50	50	km/h				
SPEED	42.1	42.1	42.1	42.1	mi/h	0.7571	0.7571	0.7571	0.7571
MAINADT	9.8	9.3	1.62	1.48	1,000 vehicles per day	0.0588	0.0558	0.0972	0.0888
COMM	1	1	1	1		0.238	0.238	0.238	0.238
					Leg Ped ISI Value	2.2289	2.2259	2.6023	2.2589
			Intersection Average Ped ISI Value			**2.329**			

The average Ped ISI score resulted in this intersection being ranked 161 out of 438 intersections.

5.1.3 ODOT Pedestrian Intersection Risk Score

The ODOT Pedestrian Intersection Risk Score method computes a risk score by assigning different numbers of points to an intersection based on the level of several input variables. The higher the total number of points, the higher the risk to pedestrians relative to intersections with a lower value. In order to apply the ODOT risk score with the Niagara Region data, several modifications to the inputs were required. The population density values for Niagara Region were converted from population per square kilometre to population per square mile. As well, the average AADT of the two legs forming the major direction was used for the Major AADT value. The input variables, assignment of points, and modifications to the inputs for Niagara Region is shown in Table 5.6, with the application of the method to the aforementioned intersection shown in Table 5.7.

Table 5.6: ODOT Pedestrian Intersection Risk Score Levels (modified from Monsere et al., 2017)

Variable	Levels	Risk score
Total population density (per square mile)	≤ 1,000	0
	(1,001, 3,000)	5
	(3,001, 5,000)	8
	(5,001, 7,000)	13
	> 7,000	21
Number of transit lines with routes through intersection	0	0
	1	6
	2	8
	3	12
	>3	25
Major AADT	≤ 5,000	0
	(5,001, 10,000)	5
	(10,001, 15,000)	7
	(15,001, 20,000)	10
	(20,001, 25,000)	13
	> 25,000	18
Presence of median on major road	Yes	0
	No	13
Minor road, presence of right-turn lanes	Yes	0
	No	15
Major road, presence of right-turn lanes	No	0
	Yes	8
	Maximum possible score	100

Table 5.7: Application of ODOT Pedestrian Intersection Risk Score to Intersection of Glenridge Avenue and Glendale Avenue, St. Catharines (modified from Monsere et al., 2017)

Variable	Location Value	Levels	Risk Score
Total population density (per square mile)	4,488.05	≤ 1,000	0
		(1,001, 3,000)	5
		(3,001, 5,000)	**8**
		(5,001, 7,000)	13
		> 7,000	21
Number of transit lines with routes through intersection	5	0	0
		1	6
		2	8
		3	12
		>3	**25**
Major AADT	15,500	≤ 5,000	0
		(5,001, 10,000)	5
		(10,001, 15,000)	7
		(15,001, 20,000)	**10**
		(20,001, 25,000)	13
		> 25,000	18
Presence of median on major road	Yes	**Yes**	**0**
		No	13
Minor road, presence of right-turn lanes	Yes	**Yes**	**0**
		No	15
Major road, presence of right-turn lanes	Yes	No	0
		Yes	**8**
		Intersection risk score	**51**
NB: **Bolded** values indicate levels for the selected intersection			

Once risk scores were computed, the intersections were ranked from highest score to lowest score, with 1 being the highest rank. Because the methodology results in risk scores with whole numbers, there were several intersections with tied risk scores. Within tied ranks, intersections were ranked from largest to smallest major AADT, on the assumption that intersections with larger traffic volumes would present greater risk given that there is more vehicular exposure. Consequently, the resulting ranking did not have ties. The intersection in Table 5.7 ranked 167 out of 438 according to this risk evaluation methodology. It is noted that in this method, the presence of a right-turn lane on the major road increases the number of risk score points (i.e., indicates more risk), while the presence of a right-turn lane on the minor road does not increase the number of points (i.e., indicates less risk). This is in contrast to the APT, which suggests the presence of any right turn lanes indicates more risk.

5.1.4 Potential Safety Improvement (PSI) Method

While it was noted that the development of safety performance functions (SPFs) for PSI was not reliable for pedestrian collisions given the lack of sufficient data, an attempt to calibrate an SPF to determine the potential for safety improvement (PSI) for Niagara Region pedestrian collisions at signalized locations was nonetheless undertaken to provide a benchmark for comparing the prioritization rankings from the three selected methods.

The PSI method consists of three main elements. The first is a safety performance function (SPF) which is a function relating the crash frequency *C* (the dependent variable) of a particular roadway location to traffic volume and potentially other characteristics. For intersections, a common form of this function is

$$C = a(F_{major} + F_{minor})^b \quad \textbf{(5.1)}$$

where F_{major} is the AADT on the major roadway, F_{minor} is the AADT on minor roadway, and *a* and *b* are coefficients. Typically, SPFs are calibrated separately for crashes of different severity categories and for intersections with different geometry (e.g., three legs versus four legs) and controls (e.g., signalized versus stop-controlled).

The second element is the use of the empirical Bayes (EB) approach, in which the expected crash frequency is computed as the weighted average of the crash frequency predicted by the SPF (i.e., *C*) and the observed crash frequency at the specific site in question. The weight applied to the crash frequency predicted by the SPF is inversely proportional to the variance of the SPF (i.e., when the SPF explains only a small amount of the variance in the observed crash data, then the weight is very small).

The last element is the calculation of the potential for safety improvement (PSI) which is the difference between the expected crash frequency (resulting from the EB) and the crash frequency predicted by the SPF, subject to the constraint that PSI must be greater than or equal to zero. The greater the difference between expected and predicted crashes (relative to the difference found for other locations), the greater the excess expected crash frequency and the greater priority for safety improvement because the location is found to be experiencing more collisions than expected.

Further details on this method of ranking intersections are available in the literature including in the Highway Safety Manual (American Association of State Highway and Transportation Officials, 2010) (note that in the Highway Safety Manual, PSI is called "excess expected average crash frequency"). In this thesis, due to the limited number of observed crashes involving pedestrians, a single SPF was calibrated[1] for all severity types and all intersection geometries.

5.2 Comparison of Prioritization Rankings

5.2.1 Rank Error Analysis

Once the four methodologies were applied, the prioritization ranking results were compared to determine the level of similarity between the method outputs. To quantify the level of similarity between methods, the method of rank error and relative rank error proposed by Hellinga and Zarei (2020)[2] was applied. The rank error (RE) is a metric that measures the number of sites that are different between the top *n* sites selected from *N* total sites for two different ranking methodologies, and is computed as

$$RE_n = n - m, \tag{5.2}$$

where *m* is the number of sites that are included by both methods in the top *n* ranked sites.

The relative rank error (RRE) is the fraction of the top *n* sites that are different between two different ranking methodologies, and is computed as

$$RRE_n = \frac{RE_n}{n} = \frac{(n-m)}{n}. \tag{5.3}$$

Both RE and RRE are computed for a given value of *n*. In practice, jurisdictions are only interested in the sites that appear in the top *n* ranked sites where *n* is typically in the range of 20 - 100. To overcome this uncertainty and provide an overall measure of difference between two ranking methods, a weighted average of the RE and RRE can be computed. In these weighted averages, more weight is assigned to smaller values of *n* as jurisdictions are more likely to consider fewer sites, given limited resources. For the ranking of *N* sites by two different methods, the rank error weighted average (RE_{wa}) is computed as

[1] PhD Candidate Mohammad Zarei completed the calibration of the SPF and produced PSI values on which the rankings were made.
[2] Draft paper is currently under review.

$$RE_{wa} = \frac{\sum_{n=1}^{N} \frac{RE_n}{n}}{\sum_{n=1}^{N} \frac{1}{n}} \tag{5.4}$$

while the relative rank error weighted average (RRE_{wa}) is computed as

$$RRE_{wa} = \frac{\sum_{n=1}^{N} \frac{RRE_n}{n}}{\sum_{n=1}^{N} \frac{1}{n}} \tag{5.5}$$

For RE, RRE, and their respective weighted averages, lower values indicate greater similarity in site prioritization ranking, which may suggest more similarity between two given prioritization methodologies. RRE_{wa} has units of percent and reflects the fraction of sites that would be expected to be different when comparing the rankings from two methods. As an example, if RRE_{wa} was equal to 25% and a municipality would typically conduct a more detailed safety audit of the top 40 ranked intersections, then one would expect there would be 10 sites out of the top 40 sites that would be different between the two ranking methods, while 30 of the top 40 sites would be the same.

The RRE_{wa} for the prioritization rankings of 438 Niagara Region signalized intersections from the APT with equal variable weighting, APT with equal factor weighting, Ped ISI, ODOT pedestrian intersection risk score, and PSI methods were computed. The APT weighting scheme in which weighting of factor categories was equal (S2) was compared among the remaining methods because this APT weight scheme was found to have the lowest RRE_{wa} with respect to the ODOT ranking results, as determined through a sensitivity analysis of the APT ranking (Table 5.8) using five different variable and category weighting schemes (Table 5.9). The results among the four methods are shown in Table 5.10.

Table 5.8: Sensitivity Analysis of RRE_{wa} for Different APT Weight Schemes

APT weight scheme	Input variable									RRE_{wa} of APT weight scheme compared to ODOT ranking
	Safety factor	Existing conditions factor						Demand factor		
	Total pedestrian crashes	AADT (average of all legs)	Traffic speed (85th percentile)	Total crossing distance	Number of right-turn lanes	Average number of through lanes on leg, both directions	Presence of raised median	Population density	Number of bus stops	
S1	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	68%
S2	0.333	0.056	0.056	0.056	0.056	0.056	0.056	0.167	0.167	61%
S3	0.500	0.042	0.042	0.042	0.042	0.042	0.042	0.125	0.125	62%
S4	0.100	0.075	0.075	0.075	0.075	0.075	0.075	0.225	0.225	68%
S5	0.000	0.200	0.000	0.000	0.200	0.000	0.200	0.200	0.200	71%

Table 5.9: Description of APT Weight Schemes for Sensitivity Analysis

APT Weight Scheme	Description of Weight Scheme
S1	Equal variable weight
S2	Equal factor weight
S3	Factor weights: Safety 50%, Existing conditions 25%, Demand 25%
S4	Factor weights: Safety 10%, Existing conditions 45%, Demand 45%
S5	Variable weights similar to ODOT method, including only ODOT variables: AADT, Right-turn lanes, Median, Population density, and Bus stops each 20%

Table 5.10: Comparison of Pedestrian Safety Risk Evaluation Methods (RRE_{wa})

	APT (S2)	Ped ISI	ODOT
Ped ISI	81%		
ODOT	61%	85%	
PSI	34%	88%	71%

The results in Table 5.10 show that the four intersection risk evaluation methods all provide substantially different prioritization rankings. The most similar rankings are obtained for the APT and PSI methods (RRE_{wa} = 34%). The rest of the methods exhibit relative rank errors exceeding 60%. This result reveals a significant problem for practitioners because although all three methods (Ped ISI, APT, and ODOT) have a similar goal of providing prioritization rankings for pedestrian safety at intersections, they each provide very different results. While a difference in prioritization ranking is expected, the amount of difference that was observed through the rank error analysis was much larger than expected. To determine the cause of the differences in rankings, further examination of the methodologies was conducted.

5.2.2 Risk Contribution Analysis

Each of the pedestrian safety evaluation methods considered had the same aim of prioritizing intersections by the anticipated level of risk, as predicted by the input characteristics for each of the methods. Thus, it was hypothesised that differences in the presence and weighting of input characteristics between methods could explain the amount of difference in ranking results between methods. These differences could be considered the difference in importance that each method places on factors influencing risk at an intersection if a score is considered the quantification of pedestrian safety risk.

First, the presence of input characteristics for each of the methods were compared. Although the methods used different variables, there appeared to be some overlap between certain variables. As well, several different variables between methods seemed to be attempting to capture similar effects, in effect acting as surrogates for the same type of characteristic. For example, population density and commercial land use both appear to be representing the effects of different land use surrounding a location. Several categories of characteristics were identified on the basis of engineering judgement, and the key input variables for each of the methods (as adapted for application to Niagara Region data) were grouped into these categories, which allowed for identification of shared variables and suspected effects between methods. The categories and groupings are shown in Table 5.11, where an “X” indicates the inclusion of a variable for a particular method.

Table 5.11: Comparison of Variables Between Pedestrian Safety Evaluation Methods

Characteristic category	Variable	Method			
		APT	Ped ISI	ODOT	PSI
Collisions	Total pedestrian collisions	X			X
Traffic volume	AADT (average for all legs)	X	X		
	Major AADT			X	X
	Minor AADT				X
Speed	85th percentile speed	X	X		
Pedestrian crossing distance	Total crossing distance	X			
	Number of through lanes crossed (both directions)	X	X		
Right turn lanes	Number of right turn lanes	X			
	Presence of right-turn lanes on minor street			X	
	Presence of right-turn lanes on major street			X	
Median	Presence of raised median	X			
	Presence of raised median on major street			X	
Land use	Average population density	X		X	
	Commercial Land Use		X		
Transit activity	Number of bus stops	X			
	Number of transit lines passing through intersection			X	
NB: “X” indicates presence of variable in a method.					

From Table 5.11, several similarities and differences can be seen. Only the APT and PSI methods use the number of pedestrian collisions as an input, potentially indicating why these two methods exhibited the greatest similarity in the intersection rankings. All methods use some measure of exposure in terms of traffic volumes. APT and Ped ISI use (effectively) the average AADT for all legs, while the ODOT method uses only the major direction AADT and the PSI uses the AADT from the major and minor direction AADT. In the remainder of categories, PSI does not use a corresponding input variable, as it only considers major and minor direction AADT and the number of collisions. Of the three other methods, ODOT is the only method not to include speed or pedestrian crossing distance. The Ped ISI does not consider the effect of right-turn lanes, medians, or transit activity, while the APT and ODOT methods do. From identifying the difference in the input characteristics between the methods, it becomes clear that some of the differences between prioritization scores could be attributed to the presence or lack of certain input variables.

While shared input characteristics were anticipated to capture similar effects, the similarity of effects required confirmation. It was hypothesised that strongly correlated variables would contribute similar effects to their respective methods, while poorly correlated variables would contribute to different effects. While poor correlation between variables from different characteristic categories might be expected given that they should represent different effects, variables in shared categories that are poorly correlated present an intriguing result since although the variables may have been intended to act as surrogates for the same effects in different methods, they actually result in entirely different effects due to lack of correlation. The correlations between all input variables for the selected methods was computed (Appendix D: Correlation of Prioritization Method Variables), with selected correlations in specific characteristic categories discussed in Table 5.12.

Table 5.12: Correlations Between Selected Variables for Pedestrian Safety Evaluation Methods

Characteristic category	Variable	Method				Correlation observation
		APT	Ped ISI	ODOT	PSI	
Collisions	Total pedestrian collisions	X			X	
Traffic volume	AADT (average for all legs)	X	X			Average AADT is very strongly correlated with both major and minor AADT (0.96 and 0.87 respectively).
	Major AADT			X	X	
	Minor AADT				X	
Speed	85th percentile speed	X	X			
Pedestrian crossing distance	Average total crossing distance	X				Average total crossing distance and number of through lanes is moderately correlated (0.61).
	Number of through lanes crossed (both directions)	X	X			
Right turn lanes	Number of right turn lanes	X				Number of right-turn lanes is relatively strongly correlated with the presence of major and minor right-turn lanes (0.74 and 0.72, respectively)
	Presence of right-turn lanes on minor street			X		
	Presence of right-turn lanes on major street			X		
Median	Presence of raised median	X				The presence of a raised median at the intersection and the presence of a raised median on the major street is highly correlated (0.90).
	Presence of raised median on major street			X		
Land use	Average population density	X		X		Average population density has very poor correlation with commercial land use (0.10).
	Commercial Land Use		X			
Transit activity	Number of bus stops	X				The number of bus stops at the intersection is very poorly correlated with the number of transit lines passing through the intersection (0.25)
	Number of transit lines passing through intersection			X		

NB: "X" indicates presence of variable in a method.

From the correlations listed in Table 5.12, it appears that the variables related to pedestrian crossing distance are only moderately correlated and the variables related to land use and transit activity are very poorly correlated, which suggests the variables in these categories may be contributing to the difference in prioritization scores between the methods. In other words, though these variables are attempting to capture the same aspect of pedestrian risk, the variables used by the different methods have very different values for the same intersection and therefore provide different indicators of the level of risk. The low correlation between the number of transit stops and the number of transit routes was much lower than expected, but might have been attributable to the limited search radius around intersections (50 metres) during data collection for bus stops (i.e., bus stops which may have been associated with an intersection would not have been counted if they were beyond the search radius).

In addition to the differences in the presence and effects of the variables between methods, consideration must be given to the impact that each input has on each prioritization score within each method. If a variable does not have a large impact on differences for a particular prioritization score (i.e., between the top and bottom ranked sites), then it can also be considered less important of a risk factor for pedestrian safety according a particular method. Conversely, a variable that contributes more to the differences of a prioritization score within a method could be considered having more importance in influencing the pedestrian safety risk for a location. In other words, should it be found that a variable's contribution does not change significantly between the top and bottom ranked locations, the variable's role in influencing the rank order of that intersection is relatively minor.

To analyze the differences in contribution by the variables to each method's prioritization score, the 25 top and 25 bottom ranked sites in each method were examined. The number of sites, 25, was chosen to represent a reasonable number of sites that a municipality might consider improving after applying a particular safety prioritization method. The quantity of points contributed by each input variable to each site's risk score was assembled for each site in Niagara Region, and the average quantity of points for the top and bottom 25 sites was computed. The difference in the average quantity of points between the top and bottom ranked number of points was also found. The average contribution and differences in each variable between top and bottom 25 sites were calculated for the APT (Table 5.13, Figure 5.2), Ped ISI (Table 5.14, Figure 5.3), and ODOT methods (Table 5.15, Figure 5.4).

Table 5.13: Average Variable Contribution and Difference Between Top and Bottom Ranked Sites from APT

	Score contribution									
	Safety factor	Existing conditions factor						Demand factor		Average total score
	Total pedestrian crashes	AADT (average of all legs)	Traffic speed (85th percentile)	Total crossing distance	Number of right-turn lanes	Average number of through lanes on leg, both directions	Presence of raised median	Population density	Number of bus stops	
Top 25	1.11	0.25	0.18	0.28	0.10	0.24	0.47	0.92	0.82	4.37
Bottom 25	0.00	0.11	0.19	0.27	0.10	0.21	0.06	0.10	0.02	1.07
Difference	1.11	0.14	-0.01	0.01	-0.01	0.03	0.41	0.82	0.80	3.31

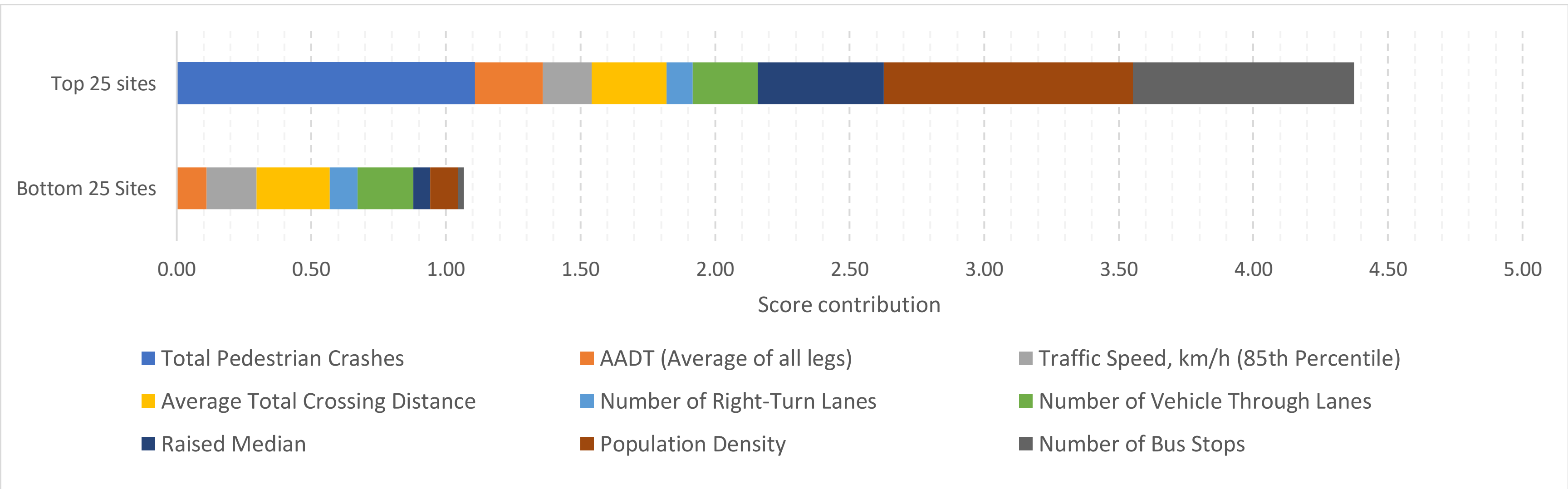


Figure 5.2: Average variable contribution for top and bottom ranked sites from APT

Table 5.14: Average Variable Contribution and Difference Between Top and Bottom Ranked Sites from Ped ISI (All Legs)

	Score contribution				Average total score (total of all legs)
	Number of through lanes, both directions	Traffic speed (85th percentile)	AADT	Presence of commercial area	
Top 25	4.99	3.03	0.37	0.91	9.29
Bottom 25	2.23	2.66	0.16	0.00	5.04
Difference	2.76	0.37	0.21	0.91	4.24

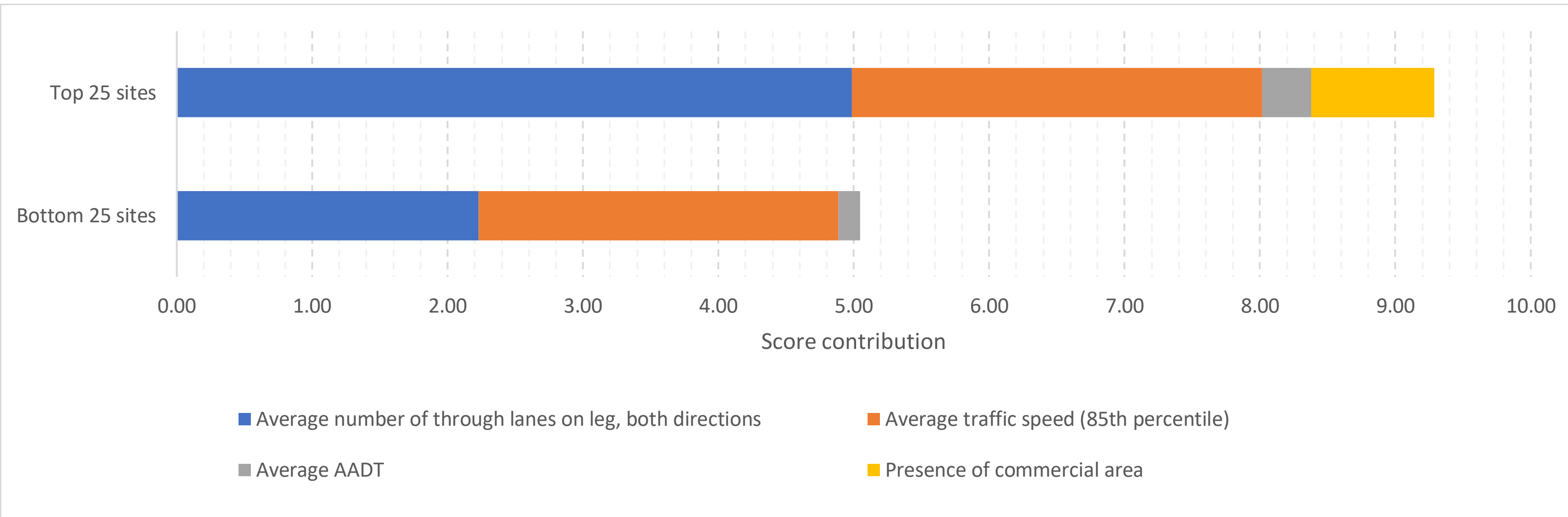


Figure 5.3: Average variable contribution for top and bottom ranked sites from Ped ISI (all legs)

Table 5.15: Average Variable Contribution and Difference Between Top and Bottom Ranked Sites from ODOT

	Score contribution						
	Population density	Number of transit lines	Major AADT	Presence of median, major street	Presence of right-turn lane, minor direction	Presence of right-turn lane, major direction	Average total score
Top 25	5.77	6.27	6.38	9.00	7.50	3.08	9.29
Bottom 25	10.04	9.23	6.42	10.50	10.38	4.00	5.04
Difference	4.27	2.96	0.04	1.50	2.88	0.92	4.24

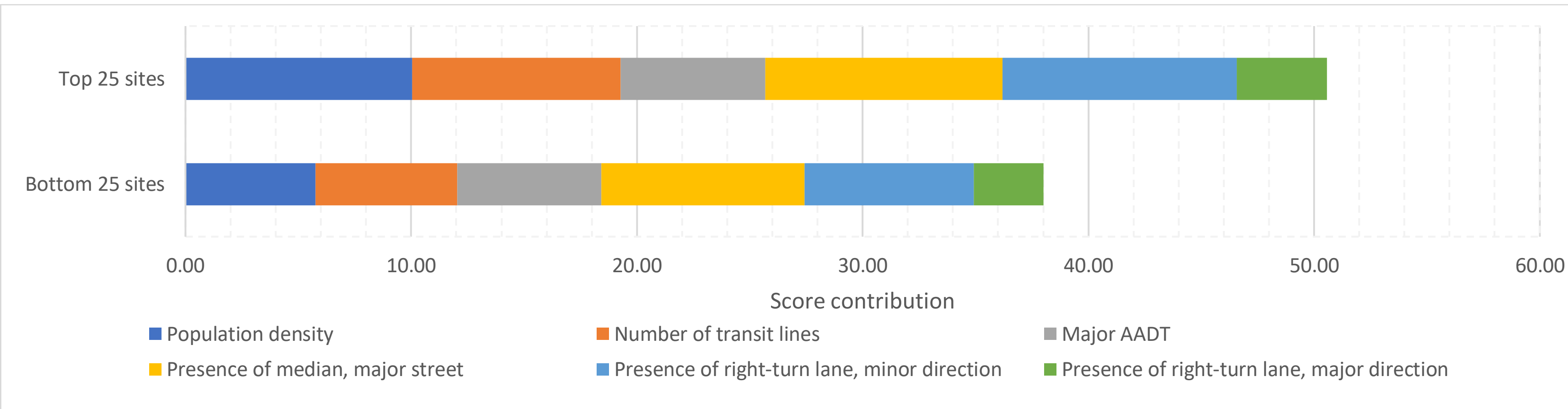


Figure 5.4: Average variable contribution for top and bottom ranked sites from ODOT method

The contribution differences were compiled across the three methods and the largest differences identified within each method (bolded) in Table 5.16 by considering the values and visual inspection of the figures. The identification of the variables most important to determining differences in scores within a method, combined with the correlation of these variable with other variables in the same characteristic category, was used to confirm that a particular variable was indeed contributing to the difference between methods. This in turn allowed for identification of the particular risk factors that distinguished each method from one another. It should be emphasised that these score differences are not of the same scoring unit, and so values within one method can only be compared relative to other variables within the same method to determine the largest contributors to difference in each method.

Table 5.16: Absolute difference in score contribution between top and bottom ranked sites by risk scoring method

Characteristic category	Variable	Absolute difference in score contribution between top and bottom ranked sites				Correlation observation
		APT	Ped ISI	ODOT	PSI	
Collisions	Total pedestrian collisions	**1.11**			X	
AADT	AADT (average for all legs)	0.14	0.21			Average AADT is very strongly correlated with both major and minor AADT (0.96 and 0.87 respectively).
	Major AADT			0.04	X	
	Minor AADT				X	
Speed	85th percentile speed	0.01	0.37			
Pedestrian crossing distance	Average crossing distance	0.01				Total crossing distance and number of through lanes is moderately correlated (0.61).
	Number of through lanes crossed (both directions)	0.03	**2.76**			
Right turn lanes	Number of right turn lanes	0.01				Number of right-turn lanes is relatively strongly correlated with the presence of major and minor right-turn lanes (0.74 and 0.72, respectively)
	Presence of right-turn lanes on minor street			**2.88**		
	Presence of right-turn lanes on major street			0.92		
Median	Presence of raised median	**0.41**				The presence of a raised median at the intersection and the presence of a raised median on the major street is highly correlated (0.90).
	Presence of raised median on major street			**1.50**		
Land use	Population density	**0.82**		**4.27**		Average population density has very poor correlation with commercial land use (0.10).
	Commercial Land Use		**0.91**			
Transit activity	Number of bus stops	**0.80**				The number of bus stops at the intersection is very poorly correlated with the number of transit lines passing through the intersection (0.25)
	Number of transit lines passing through intersection			**2.36**		

NB: **Bolded** values indicate largest differences in score contribution within a method

In the APT using equal factor weight, the largest differences in risk score between the top and bottom ranked sites came from the following variables:

- total pedestrian crashes (1.11)
- population density (0.82)
- number of bus stops (0.80)
- the presence of a raised median (0.41)

The following variables did not have a large difference in risk score between the top and bottom ranked sites for the APT method:

- average AADT (0.14)
- average number of through lanes (0.03)
- traffic speed (0.01)
- average total crossing distance (0.01)
- number of right turn lanes (0.01)

In the Ped ISI, the largest differences in risk scoring between top and bottom ranked sites came from the following variables:

- number of through lanes crossed (2.76)
- commercial land use (0.91)

The smallest differences in the Ped ISI method came from the following variables:

- 85^{th} percentile speed (0.37)
- AADT (0.21)

In the ODOT method, the largest differences between top and bottom ranked sites came from:

- population density (4.27)
- the presence of minor right-turn lanes (2.88)
- the number of transit lines passing through the intersection (2.36)
- the presence of a median on the major street (1.50)

The smallest differences between top and bottom ranked sites in the ODOT method came from

- the presence of major right-turn lanes (0.92)

- the major AADT (0.04)

From identifying the largest contributors to difference within each method and comparing the correlation of these variables to others within the same characteristic category, explanations for differences in ranking results between the pedestrian risk safety methods could be proposed. Because the Ped ISI method does not include a variable indicating presence of a median, transit activity, or pedestrian collisions, it is likely that these variables contributed to the difference between the ranking results of the APT and Ped ISI methods. While both the APT and Ped ISI included population density and commercial land use respectively as factors involving land use, these two variables were poorly correlated, thus these two variables contribute to the difference between the APT and Ped ISI. Both the APT and Ped ISI include the number of through lanes, which is not important to the APT but is important to the Ped ISI ranking, thus contributing to further differences between the two methods.

The ranking results between the APT and ODOT methods were expected to be more similar than between the APT and Ped ISI methods since they shared more characteristics that were correlated with one another, including the presence of a raised median, population density, AADT, and presence of right-turn lanes. Between the APT and ODOT methods, the number of bus stops contributed a large difference since the correlation between the number of stops and number of transit lines is poor. As well, the effect of right-turn lanes on pedestrian risk is a source of difference between the two methods, as the presence of right turn lanes increases risk for any crossing in the APT, while for the ODOT method, minor right-turn lanes decrease risk and major right-turn lanes increase risk. Overall, however, the APT and ODOT provided more similar results than for the APT and Ped ISI methods, as the RRE_{wa} shown in Table 5.10 for APT and Ped ISI was 81%, compared to the smaller relative error between APT and ODOT of 61%. These are still relatively large ranking errors, however.

When the Ped ISI and ODOT methods are compared with one another, there appears to be even fewer shared characteristics between these two methods, with AADT being the only shared variable and one that was found not to be important in determining the risk in either method. The Ped ISI and ODOT methods share a land use characteristic, which are commercial land use and population density, respectively, but these have already been found very different from one another. The Ped ISI considers the speed and number of through lanes crossed, while the ODOT method does not. The ODOT method considers the presence of right-turn lanes, medians, and number of transit lines, unlike the Ped ISI. Given these differences, it is reasonable that the RRE_{wa} between the Ped ISI and ODOT methods is the highest of the pairings between the three methods at 87%.

When the PSI method is considered, the RRE_{wa} between the APT and PSI is the lowest of any pairing at 34%, with the Ped ISI and ODOT methods having higher errors of 87% and 71%, respectively. This result is reasonable, given that the PSI is the only other method to include pedestrian crashes as a variable. The PSI, like all three other methods, includes measures of AADT. Though the measures of AADT differ, all (average, major, and minor AADT) are highly correlated with one another, and consequently, the AADT measures are likely not contributing to large differences between the other methods.

By completing this analysis of differences, the input characteristics leading to differences between scores were identified for each method. Although each of the selected prioritization methods provides a manner in which to prioritize signalized intersections on the basis of risk to pedestrians, there are clearly differences in terms of which characteristics each method considers significant to determining pedestrian safety risk, and this resulted in drastically different prioritization rankings when the methods were applied to Niagara Region. This is problematic because the lack of consensus raises the obvious question of which method is most accurate. We are not able to answer this question fully.

The PSI method conforms most closely to the recommended approach for conducting network screening, and under ideal conditions is considered the most accurate method. However, as discussed earlier in the thesis, crashes involving pedestrians occur relatively infrequently and therefore it is frequently not feasible to calibrate safety performance functions separately for different crash severity types and for different intersection geometries. As a result, the calibrated safety performance function typically does not explain a large amount of the variance exhibited by the crash data, and the final rankings are largely determined on the basis of observed crash frequencies. This also explains why the APT method, which is the only other method to use crash frequencies as in input, provides rankings that are most similar to the PSI method, with an RRE_{wa} of 34%.

The PSI method ranks sites on the basis of the potential for improving safety (i.e., reducing crash frequency) and not the basis of the crash frequency itself. While this can be a useful metric for improving road safety, it is not clear that this is consistent with the objectives of the other three methods, as they attempt to rank intersections on the basis of pedestrian risk, not the potential to improve safety. Consequently, it may be valuable to expand on the analysis carried out in this thesis to consider network screening by ranking intersections on the basis of expected crash frequency from the EB method rather than on the basis of PSI.

If a municipality requires a justifiable turnkey method of prioritizing risk, the APT and ODOT methods appear to provide prioritization results that are easily interpretable. The ODOT method has the advantage of using a set of predetermined inputs, though it does require collection of variables that are not normally already available (i.e., identification of major and minor streets at intersections, and the presence of right-turn lanes and medians). The APT method provides flexibility allowing municipalities to choose characteristics based on the data available or that can be collected. This flexibility, however, also lends itself to uncertainty with which factors, factor weights, and variables to consider, and considerable engineering judgment is required to justify the chosen structure of the APT scoring methodology. Both methods provide ranking results that can be justified by their respective structures, however the result they provide can be drastically different as shown by the high RRE_{wa} values which were calculated. While the FHWA Ped ISI has the advantage of having the fewest number of inputs making it simple to interpret and apply, the use of so few inputs also means likely fails to capture several important risk effects which the other methods consider.

While this analysis has considered the prioritization of risk for all locations of a particular type in a municipality (i.e., all intersections which are signalized), it is acknowledged that it is rarely the case that a municipality will require the prioritization of all locations of a particular type. More likely, a municipality will preliminarily screen a subset of locations for prioritization, as it is unfeasible and usually unnecessary to consider all locations of a particular type for safety evaluation. For example, screening all unsignalized intersections in a municipality using one of the aforementioned methods would be unnecessary, but all unsignalized intersections with at least one pedestrian collision in the past five years could be considered for further screening.

6. Conclusions and Recommendations

6.1 Conclusions

This research was focused on two main goals: the development and evaluation of AADT prediction models, and the application and comparison of pedestrian safety risk evaluation methods for a Canadian municipality.

The geometric, operational, and land-use characteristics of signalized intersections in Niagara Region were used to develop a suite of significant proposed multi-variable models for estimating AADT for intersection legs. When evaluated, these models had reasonable explanatory power and could be validated using k-fold cross-validation, demonstrating the feasibility of multi-variable regression models for AADT estimation. While these models were not specifically tested for other jurisdictions, there is no reason to believe that these models cannot be used by other municipalities, or that a similar development process cannot be performed for other regions.

Four score-based intersection ranking methods (the APT, Ped ISI, ODOT, and PSI methods) were applied to Niagara Region and their results examined. An analysis of rank error showed that the methods provided widely different site priority ranking results among one another. Through the analysis of method inputs, it was shown that the differences were due to the inclusion of different risk characteristics, different weights that each method's input characteristics contributed to a score, and a lack of correlation between surrogate input characteristics between methods. The APT method was shown to be not highly sensitive to the selected weight and was found to provide rankings most similar to the PSI method. The question of which method to select could not be answered at this time, given the inconsistency in the methods' results, the combination of factors contributing to this inconsistency, and the difficulty in confirming the accuracy of these methods.

Overall, this thesis has demonstrated that in order to protect pedestrians, our roads' most vulnerable users, there is an urgent need to expand research, data collection, and tool development in the field of pedestrian road safety. Available methods for determining pedestrian safety risk by site characteristics were found to be subjective and ambiguous across prioritization ranking results, which makes safety evaluation inconsistent and places lives at risk. A recommended avenue for further research is the development of a robust method to prioritize intersections for pedestrian safety improvements based on location characteristics. This systematized method for prioritizing pedestrian safety improvements is necessary in order to create a safer future for all.

6.2 Recommendations

From the research completed in this thesis, the following recommendations are made:

1. In order to investigate and confirm the transferability of the developed AADT estimation models to other jurisdictions, the models should be validated using data from another region.
2. The current analysis should be expanded by comparing the intersection ranking methods examined in the thesis with a network screening process in which the ranking is done on the basis of the expected crash frequency from the EB method rather than on the basis of PSI, as crash frequency may be a more representative metric of pedestrian safety.

3. Municipalities should exercise caution when choosing to apply the APT, Ped ISI, or ODOT methods for prioritizing signalized intersections on the basis of pedestrian safety risk because these three methods emphasize different safety factors and have been shown to provide very different prioritization results.
4. Additional work is recommended to develop a robust method for prioritizing intersections on the basis of pedestrian safety risk using site characteristics.

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Appendices

Appendix A: Correlation Matrices for Model Calibration Data Sets

Correlation Matrix for Model 1 Data Set

	Leg_AADT	Ln_Leg_AADT	Log10_Leg_AADT	Upstream_AADT	Log10_Upstream_AADT	Upstream_NumLanes	UpstreamIntDistance	Leg_NumberOfLanes	AvgAADT_PerLeg	Log10_AvgAADT_PerLeg	AvgNumLanes_PerLeg	AvgAADT_PerLane	Log10_AvgAADT_PerLane	Leg_SpeedLimit	AvgPopDens16	MuniPopulation2016	NumberOfTransitStops	NumberTransitLines	NumberOfMedians	NumberOfSlipLanes	MedianAtIntersection	MedianOnLeg	SlipLaneAtIntersection	TransitStopPresence	TransitStopOnApproach	MajorRd_Leg	Arterial	RT2	OneWayLeg	UrbanLandType	CommercialArea	FourLeg
Leg_AADT	1.00																															
Ln_Leg_AADT	0.94	1.00																														
Log10_Leg_AADT	0.94	1.00	1.00																													
Upstream_AADT	0.80	0.77	0.77	1.00																												
Log10_Upstream_AADT	0.77	0.82	0.82	0.92	1.00																											
Upstream_NumLanes	0.53	0.49	0.49	0.58	0.52	1.00																										
UpstreamIntDistance	-0.33	-0.40	-0.40	-0.30	-0.34	-0.24	1.00																									
Leg_NumberOfLanes	0.52	0.48	0.48	0.44	0.39	0.56	-0.12	1.00																								
AvgAADT_PerLeg	0.69	0.64	0.64	0.53	0.50	0.38	-0.23	0.43	1.00																							
Log10_AvgAADT_PerLeg	0.65	0.66	0.66	0.52	0.52	0.36	-0.25	0.39	0.95	1.00																						
AvgNumLanes_PerLeg	0.35	0.32	0.32	0.28	0.25	0.43	-0.04	0.83	0.40	0.38	1.00																					
AvgAADT_PerLane	0.51	0.51	0.51	0.39	0.40	0.14	-0.23	-0.08	0.78	0.78	-0.21	1.00																				
Log10_AvgAADT_PerLane	0.48	0.51	0.51	0.38	0.40	0.12	-0.24	-0.09	0.77	0.83	-0.19	0.95	1.00																			
Leg_SpeedLimit	-0.22	-0.22	-0.22	-0.20	-0.22	-0.05	0.46	0.05	-0.21	-0.20	0.07	-0.26	-0.25	1.00																		
AvgPopDens16	0.12	0.18	0.18	0.15	0.19	-0.03	-0.28	-0.21	0.13	0.18	-0.25	0.31	0.34	-0.40	1.00																	
MuniPopulation2016	0.30	0.29	0.29	0.29	0.27	0.18	-0.26	0.11	0.32	0.31	0.07	0.29	0.28	-0.34	0.37	1.00																
NumberOfTransitStops	0.18	0.17	0.17	0.17	0.16	0.14	-0.11	0.14	0.19	0.19	0.12	0.10	0.12	-0.20	0.24	0.40	1.00															
NumberTransitLines	0.23	0.20	0.20	0.20	0.18	0.22	-0.25	0.20	0.21	0.20	0.22	0.07	0.10	-0.17	0.20	0.29	0.29	1.00														
NumberOfMedians	0.27	0.21	0.21	0.20	0.15	0.39	-0.11	0.66	0.30	0.27	0.74	-0.14	-0.14	0.03	-0.26	0.07	0.08	0.25	1.00													
NumberOfSlipLanes	-0.05	-0.01	-0.01	-0.06	-0.03	-0.05	0.09	0.06	-0.05	-0.01	0.15	-0.11	-0.09	0.09	0.01	0.06	0.04	0.01	0.08	1.00												
MedianAtIntersection	0.28	0.23	0.23	0.20	0.14	0.34	-0.11	0.61	0.32	0.28	0.64	-0.08	-0.08	0.08	-0.24	0.07	0.03	0.18	0.88	0.08	1.00											
MedianOnLeg	0.37	0.31	0.31	0.29	0.25	0.44	-0.13	0.69	0.32	0.28	0.63	-0.06	-0.07	0.03	-0.24	0.09	0.08	0.20	0.87	0.02	0.85	1.00										
SlipLaneAtIntersection	-0.06	-0.02	-0.02	-0.09	-0.05	-0.05	0.07	0.08	-0.07	-0.03	0.18	-0.16	-0.14	0.10	-0.04	0.08	0.00	0.07	0.12	0.91	0.11	0.06	1.00									
TransitStopPresence	0.16	0.15	0.15	0.14	0.12	0.18	-0.14	0.18	0.18	0.17	0.17	0.06	0.07	-0.22	0.15	0.33	0.81	0.28	0.08	0.02	0.02	0.08	-0.02	1.00								
TransitStopOnApproach	0.07	0.05	0.05	0.08	0.07	0.05	-0.06	0.06	0.10	0.10	0.05	0.06	0.07	-0.12	0.13	0.24	0.59	0.21	0.06	0.02	0.02	0.06	0.01	0.48	1.00							
MajorRd_Leg	0.35	0.39	0.39	0.30	0.32	0.17	-0.24	0.15	0.06	0.04	-0.14	0.14	0.11	-0.13	0.10	0.07	0.02	0.00	-0.10	-0.17	-0.03	0.09	-0.19	0.02	0.02	1.00						
Arterial	0.13	0.20	0.20	0.12	0.19	0.11	-0.10	0.18	0.06	0.08	0.08	0.03	0.04	0.05	-0.01	0.02	0.03	-0.06	0.01	0.11	-0.02	0.08	0.13	0.04	-0.02	0.16	1.00					
RT2	0.01	0.02	0.02	0.02	0.04	0.05	-0.01	0.03	-0.05	-0.05	-0.04	-0.01	-0.02	-0.01	0.03	0.00	-0.07	0.01	-0.06	0.05	-0.10	-0.01	0.06	-0.02	-0.10	0.09	0.35	1.00				
OneWayLeg	-0.13	-0.11	-0.11	-0.09	-0.06	-0.14	-0.10	-0.25	-0.14	-0.14	-0.24	0.01	0.03	-0.07	0.22	-0.04	-0.09	0.34	-0.13	-0.06	-0.12	-0.14	-0.05	-0.12	-0.01	0.00	-0.29	0.02	1.00			
UrbanLandType	0.26	0.31	0.31	0.24	0.27	0.15	-0.48	0.05	0.28	0.32	0.03	0.30	0.32	-0.71	0.46	0.35	0.24	0.21	0.05	0.03	0.00	0.05	0.00	0.24	0.15	0.14	-0.02	-0.04	0.09	1.00		
CommercialArea	0.23	0.24	0.24	0.20	0.22	0.11	-0.28	0.12	0.24	0.25	0.10	0.19	0.21	-0.35	0.18	0.13	0.26	0.30	0.12	0.03	0.05	0.11	0.01	0.24	0.17	0.02	0.03	0.00	0.16	0.51	1.00	
FourLeg	0.05	0.01	0.01	0.02	-0.01	0.05	0.09	0.18	0.05	0.01	0.14	-0.08	-0.07	0.05	-0.05	-0.05	0.22	0.18	0.14	0.09	0.05	0.10	0.06	0.22	0.10	-0.11	0.00	-0.04	0.08	-0.08	0.18	1.00

Correlation Matrix for Model 2 Data Set

	Leg_AADT	Ln_Leg_AADT	Log10_Leg_AADT	Upstream_AADT	Log10_Upstream_AADT	Upstream_NumLanes	UpstreamIntDistance	Leg_NumberOfLanes	AvgAADT_PerLeg	Log10_AvgAADT_PerLeg	AvgNumLanes_PerLeg	AvgAADT_PerLane	Log10_AvgAADT_PerLane	Leg_SpeedLimit	AvgPopDens16	MuniPopulation2016	NumberOfTransitStops	NumberTransitLines	NumberOfMedians	NumberOfSlipLanes	MedianAtIntersection	MedianOnLeg	SlipLaneAtIntersection	TransitStopPresence	TransitStopOnApproach	MajorRd_Leg	Arterial	RT2	OneWayLeg	UrbanLandType	CommercialArea	FourLeg
Leg_AADT	1.00																															
Ln_Leg_AADT	0.94	1.00																														
Log10_Leg_AADT	0.94	1.00	1.00																													
Upstream_AADT	0.73	0.70	0.70	1.00																												
Log10_Upstream_AADT	0.29	0.30	0.30	0.66	1.00																											
Upstream_NumLanes	0.54	0.51	0.51	0.55	0.25	1.00																										
UpstreamIntDistance	-0.31	-0.39	-0.39	-0.25	-0.08	-0.23	1.00																									
Leg_NumberOfLanes	0.51	0.47	0.47	0.39	0.14	0.56	-0.13	1.00																								
AvgAADT_PerLeg	0.69	0.64	0.64	0.50	0.21	0.39	-0.23	0.42	1.00																							
Log10_AvgAADT_PerLeg	0.66	0.66	0.66	0.48	0.21	0.37	-0.25	0.39	0.95	1.00																						
AvgNumLanes_PerLeg	0.36	0.32	0.32	0.28	0.14	0.44	-0.05	0.83	0.40	0.38	1.00																					
AvgAADT_PerLane	0.51	0.50	0.50	0.35	0.13	0.14	-0.22	-0.09	0.78	0.77	-0.21	1.00																				
Log10_AvgAADT_PerLane	0.48	0.50	0.50	0.34	0.13	0.13	-0.24	-0.10	0.77	0.83	-0.19	0.96	1.00																			
Leg_SpeedLimit	-0.20	-0.20	-0.20	-0.16	-0.03	-0.04	0.45	0.06	-0.19	-0.18	0.07	-0.24	-0.24	1.00																		
AvgPopDens16	0.09	0.15	0.15	0.11	0.00	-0.06	-0.29	-0.23	0.12	0.17	-0.26	0.30	0.33	-0.40	1.00																	
MuniPopulation2016	0.29	0.28	0.28	0.24	0.05	0.18	-0.26	0.10	0.32	0.31	0.06	0.29	0.29	-0.34	0.38	1.00																
NumberOfTransitStops	0.16	0.16	0.16	0.16	0.06	0.11	-0.11	0.11	0.18	0.18	0.10	0.09	0.12	-0.19	0.25	0.40	1.00															
NumberTransitLines	0.20	0.18	0.18	0.13	-0.04	0.19	-0.26	0.18	0.22	0.21	0.20	0.09	0.11	-0.17	0.24	0.31	0.27	1.00														
NumberOfMedians	0.26	0.20	0.20	0.18	0.06	0.39	-0.11	0.66	0.29	0.26	0.74	-0.15	-0.15	0.03	-0.27	0.06	0.04	0.23	1.00													
NumberOfSlipLanes	-0.05	-0.02	-0.02	-0.07	-0.03	-0.05	0.07	0.07	-0.05	-0.01	0.16	-0.12	-0.11	0.07	0.00	0.06	0.03	0.00	0.10	1.00												
MedianAtIntersection	0.28	0.23	0.23	0.19	0.08	0.35	-0.10	0.62	0.31	0.28	0.64	-0.08	-0.09	0.08	-0.26	0.06	0.00	0.16	0.88	0.10	1.00											
MedianOnLeg	0.36	0.30	0.30	0.26	0.08	0.45	-0.13	0.69	0.32	0.28	0.63	-0.06	-0.08	0.04	-0.25	0.08	0.04	0.19	0.87	0.04	0.85	1.00										
SlipLaneAtIntersection	-0.06	-0.03	-0.03	-0.09	-0.04	-0.04	0.05	0.09	-0.07	-0.03	0.19	-0.15	-0.14	0.09	-0.03	0.08	0.00	0.06	0.14	0.91	0.12	0.07	1.00									
TransitStopPresence	0.16	0.14	0.14	0.16	0.11	0.16	-0.14	0.16	0.17	0.16	0.16	0.06	0.07	-0.21	0.17	0.33	0.81	0.26	0.05	0.00	0.00	0.05	-0.03	1.00								
TransitStopOnApproach	0.06	0.05	0.05	0.06	0.01	0.02	-0.06	0.05	0.10	0.09	0.04	0.06	0.07	-0.12	0.15	0.25	0.61	0.20	0.03	0.01	0.00	0.04	0.00	0.49	1.00							
MajorRd_Leg	0.35	0.40	0.40	0.27	0.11	0.20	-0.23	0.17	0.07	0.06	-0.11	0.14	0.11	-0.11	0.06	0.07	0.01	-0.02	-0.07	-0.15	-0.01	0.11	-0.18	0.01	0.02	1.00						
Arterial	0.14	0.20	0.20	0.15	0.14	0.14	-0.07	0.20	0.06	0.08	0.10	0.01	0.02	0.07	-0.04	0.00	0.03	-0.09	0.03	0.10	0.02	0.09	0.12	0.04	-0.04	0.19	1.00					
RT2	0.02	0.04	0.04	0.03	0.04	0.03	0.00	0.01	-0.03	-0.03	-0.04	0.01	0.00	0.02	0.04	0.00	-0.05	0.02	-0.08	0.01	-0.11	-0.03	0.02	-0.01	-0.08	0.07	0.34	1.00				
OneWayLeg	-0.15	-0.14	-0.14	-0.11	-0.10	-0.17	-0.11	-0.26	-0.13	-0.12	-0.25	0.03	0.04	-0.08	0.25	-0.02	-0.07	0.34	-0.14	-0.07	-0.14	-0.14	-0.05	-0.11	0.01	-0.06	-0.37	0.02	1.00			
UrbanLandType	0.23	0.28	0.28	0.19	0.03	0.12	-0.49	0.04	0.26	0.30	0.03	0.28	0.30	-0.71	0.47	0.35	0.23	0.22	0.05	0.03	-0.01	0.05	0.00	0.23	0.15	0.13	-0.04	-0.04	0.09	1.00		
CommercialArea	0.21	0.22	0.22	0.16	0.05	0.10	-0.29	0.11	0.23	0.24	0.10	0.19	0.21	-0.35	0.19	0.14	0.25	0.32	0.12	0.03	0.05	0.11	0.00	0.23	0.17	0.00	0.00	-0.02	0.17	0.51	1.00	
FourLeg	0.05	0.01	0.01	0.01	-0.02	0.05	0.08	0.19	0.05	0.02	0.15	-0.09	-0.07	0.06	-0.05	-0.05	0.21	0.18	0.15	0.10	0.07	0.11	0.07	0.21	0.09	-0.11	-0.02	-0.04	0.08	-0.08	0.18	1.00

Correlation Matrix for Model 3 Data Set

	Leg_AADT	Ln_Leg_AADT	Log10_Leg_AADT	Upstream_AADT	Log10_Upstream_AADT	Upstream_NumLanes	UpstreamIntDistance	Leg_NumberOfLanes	AvgAADT_PerLeg	Log10_AvgAADT_PerLeg	AvgNumLanes_PerLeg	AvgAADT_PerLane	Log10_AvgAADT_PerLane	Leg_SpeedLimit	AvgPopDens16	MuniPopulation2016	NumberOfTransitStops	NumberTransitLines	NumberOfMedians	NumberOfSlipLanes	MedianAtIntersection	MedianOnLeg	SlipLaneAtIntersection	TransitStopPresence	TransitStopOnApproach	MajorRd_Leg	Arterial	RT2	OneWayLeg	UrbanLandType	CommercialArea	FourLeg
Leg_AADT	1.00																															
Ln_Leg_AADT	0.93	1.00																														
Log10_Leg_AADT	0.93	1.00	1.00																													
Upstream_AADT	0.71	0.69	0.69	1.00																												
Log10_Upstream_AADT	0.30	0.35	0.35	0.69	1.00																											
Upstream_NumLanes	0.52	0.52	0.52	0.61	0.45	1.00																										
UpstreamIntDistance	-0.31	-0.37	-0.37	-0.24	-0.09	-0.21	1.00																									
Leg_NumberOfLanes	0.52	0.46	0.46	0.37	0.13	0.49	-0.12	1.00																								
AvgAADT_PerLeg	0.68	0.63	0.63	0.50	0.23	0.39	-0.23	0.42	1.00																							
Log10_AvgAADT_PerLeg	0.65	0.64	0.64	0.48	0.22	0.36	-0.25	0.39	0.95	1.00																						
AvgNumLanes_PerLeg	0.36	0.31	0.31	0.26	0.12	0.37	-0.05	0.84	0.40	0.39	1.00																					
AvgAADT_PerLane	0.50	0.49	0.49	0.36	0.16	0.17	-0.23	-0.09	0.78	0.77	-0.22	1.00																				
Log10_AvgAADT_PerLane	0.47	0.49	0.49	0.34	0.16	0.15	-0.24	-0.10	0.77	0.83	-0.19	0.96	1.00																			
Leg_SpeedLimit	-0.21	-0.24	-0.24	-0.18	-0.08	-0.08	0.44	0.05	-0.20	-0.19	0.07	-0.25	-0.24	1.00																		
AvgPopDens16	0.10	0.17	0.17	0.11	0.02	-0.04	-0.29	-0.23	0.11	0.16	-0.26	0.31	0.33	-0.41	1.00																	
MuniPopulation2016	0.29	0.29	0.29	0.25	0.08	0.19	-0.26	0.10	0.32	0.31	0.06	0.30	0.29	-0.34	0.38	1.00																
NumberOfTransitStops	0.15	0.15	0.15	0.15	0.06	0.11	-0.11	0.11	0.17	0.16	0.09	0.09	0.11	-0.20	0.26	0.41	1.00															
NumberTransitLines	0.20	0.18	0.18	0.15	0.02	0.21	-0.25	0.17	0.22	0.20	0.19	0.10	0.12	-0.18	0.24	0.31	0.28	1.00														
NumberOfMedians	0.27	0.21	0.21	0.18	0.07	0.35	-0.11	0.67	0.30	0.27	0.74	-0.14	-0.14	0.01	-0.27	0.07	0.03	0.22	1.00													
NumberOfSlipLanes	-0.05	-0.01	-0.01	-0.06	-0.03	-0.05	0.07	0.07	-0.05	-0.01	0.16	-0.12	-0.11	0.05	0.00	0.07	0.05	0.00	0.10	1.00												
MedianAtIntersection	0.29	0.24	0.24	0.19	0.09	0.32	-0.11	0.63	0.32	0.29	0.64	-0.08	-0.08	0.05	-0.25	0.06	0.00	0.16	0.88	0.09	1.00											
MedianOnLeg	0.37	0.31	0.31	0.27	0.11	0.42	-0.13	0.69	0.32	0.28	0.63	-0.06	-0.07	0.02	-0.24	0.09	0.04	0.18	0.87	0.04	0.85	1.00										
SlipLaneAtIntersection	-0.06	-0.03	-0.03	-0.09	-0.05	-0.05	0.06	0.09	-0.06	-0.03	0.19	-0.15	-0.14	0.07	-0.03	0.08	0.01	0.06	0.13	0.91	0.11	0.06	1.00									
TransitStopPresence	0.15	0.13	0.13	0.16	0.10	0.15	-0.14	0.16	0.17	0.15	0.15	0.06	0.07	-0.20	0.17	0.33	0.80	0.27	0.05	0.01	0.00	0.05	-0.02	1.00								
TransitStopOnApproach	0.05	0.03	0.03	0.06	0.02	0.03	-0.06	0.04	0.09	0.09	0.04	0.06	0.06	-0.12	0.14	0.24	0.60	0.20	0.03	0.01	-0.01	0.03	-0.01	0.49	1.00							
MajorRd_Leg	0.37	0.43	0.43	0.29	0.17	0.23	-0.22	0.17	0.08	0.07	-0.11	0.16	0.12	-0.13	0.08	0.08	0.01	0.00	-0.06	-0.16	0.00	0.12	-0.18	0.02	0.01	1.00						
Arterial	0.15	0.21	0.21	0.15	0.13	0.13	-0.05	0.19	0.06	0.08	0.09	0.01	0.02	0.06	-0.03	0.01	0.04	-0.08	0.04	0.09	0.03	0.10	0.12	0.05	-0.03	0.21	1.00					
RT2	0.02	0.03	0.03	0.02	0.02	0.02	0.00	0.01	-0.03	-0.03	-0.04	0.01	0.00	0.02	0.04	-0.01	-0.05	0.02	-0.08	0.01	-0.11	-0.03	0.02	-0.01	-0.08	0.07	0.33	1.00				
OneWayLeg	-0.14	-0.12	-0.12	-0.09	-0.06	-0.13	-0.11	-0.25	-0.12	-0.12	-0.24	0.03	0.05	-0.08	0.24	-0.02	-0.07	0.34	-0.13	-0.06	-0.13	-0.14	-0.05	-0.10	0.01	-0.05	-0.36	0.02	1.00			
UrbanLandType	0.24	0.29	0.29	0.20	0.07	0.14	-0.48	0.05	0.26	0.30	0.03	0.29	0.31	-0.71	0.47	0.36	0.23	0.22	0.06	0.04	0.01	0.06	0.00	0.23	0.15	0.13	-0.02	-0.04	0.09	1.00		
CommercialArea	0.21	0.22	0.22	0.19	0.10	0.14	-0.28	0.12	0.23	0.24	0.11	0.18	0.20	-0.35	0.18	0.15	0.25	0.31	0.13	0.03	0.06	0.12	0.00	0.23	0.15	0.01	0.00	-0.02	0.17	0.51	1.00	
FourLeg	0.04	-0.01	-0.01	0.01	-0.01	0.05	0.06	0.18	0.04	0.01	0.14	-0.08	-0.07	0.06	-0.03	-0.05	0.21	0.18	0.14	0.10	0.04	0.12	0.06	0.21	0.09	-0.11	-0.03	-0.04	0.08	-0.08	0.17	1.00

Correlation Matrix for Model 4 Data Set

	Leg_AADT	Ln_Leg_AADT	Log10_Leg_AADT	Upstream_AADT	Log10_Upstream_AADT	Upstream_NumLanes	UpstreamIntDistance	Leg_NumberOfLanes	AvgAADT_PerLeg	Log10_AvgAADT_PerLeg	AvgNumLanes_PerLeg	AvgAADT_PerLane	Log10_AvgAADT_PerLane	Leg_SpeedLimit	AvgPopDens16	MuniPopulation2016	NumberOfTransitStops	NumberTransitLines	NumberOfMedians	NumberOfSlipLanes	MedianAtIntersection	MedianOnLeg	SlipLaneAtIntersection	TransitStopPresence	TransitStopOnApproach	MajorRd_Leg	Arterial	RT2	OneWayLeg	UrbanLandType	CommercialArea	FourLeg
Leg_AADT	1.00																															
Ln_Leg_AADT	0.94	1.00																														
Log10_Leg_AADT	0.94	1.00	1.00																													
Upstream_AADT	0.80	0.77	0.77	1.00																												
Log10_Upstream_AADT	0.76	0.81	0.81	0.92	1.00																											
Upstream_NumLanes	0.52	0.49	0.49	0.58	0.52	1.00																										
UpstreamIntDistance	-0.32	-0.40	-0.40	-0.30	-0.34	-0.25	1.00																									
Leg_NumberOfLanes	0.51	0.47	0.47	0.44	0.39	0.56	-0.12	1.00																								
AvgAADT_PerLeg	0.69	0.65	0.65	0.53	0.50	0.37	-0.23	0.42	1.00																							
Log10_AvgAADT_PerLeg	0.65	0.66	0.66	0.51	0.52	0.36	-0.24	0.38	0.95	1.00																						
AvgNumLanes_PerLeg	0.35	0.32	0.32	0.28	0.25	0.43	-0.04	0.83	0.40	0.38	1.00																					
AvgAADT_PerLane	0.51	0.51	0.51	0.39	0.40	0.14	-0.23	-0.08	0.78	0.78	-0.21	1.00																				
Log10_AvgAADT_PerLane	0.48	0.51	0.51	0.37	0.39	0.12	-0.24	-0.09	0.77	0.83	-0.19	0.95	1.00																			
Leg_SpeedLimit	-0.21	-0.22	-0.22	-0.20	-0.22	-0.05	0.46	0.05	-0.20	-0.19	0.07	-0.25	-0.25	1.00																		
AvgPopDens16	0.12	0.18	0.18	0.15	0.19	-0.04	-0.28	-0.22	0.12	0.18	-0.25	0.31	0.34	-0.40	1.00																	
MuniPopulation2016	0.30	0.28	0.28	0.29	0.27	0.18	-0.26	0.10	0.32	0.31	0.07	0.29	0.28	-0.34	0.37	1.00																
NumberOfTransitStops	0.18	0.17	0.17	0.17	0.16	0.14	-0.11	0.13	0.19	0.19	0.12	0.10	0.12	-0.20	0.24	0.40	1.00															
NumberTransitLines	0.22	0.19	0.19	0.20	0.18	0.21	-0.25	0.20	0.21	0.20	0.22	0.07	0.09	-0.17	0.20	0.30	0.28	1.00														
NumberOfMedians	0.27	0.21	0.21	0.20	0.15	0.39	-0.11	0.66	0.30	0.27	0.74	-0.13	-0.13	0.03	-0.26	0.07	0.08	0.25	1.00													
NumberOfSlipLanes	-0.04	-0.01	-0.01	-0.06	-0.03	-0.05	0.09	0.06	-0.05	-0.01	0.15	-0.11	-0.09	0.10	0.00	0.06	0.04	0.00	0.08	1.00												
MedianAtIntersection	0.28	0.23	0.23	0.20	0.14	0.34	-0.11	0.62	0.32	0.28	0.64	-0.08	-0.08	0.08	-0.24	0.07	0.03	0.18	0.88	0.08	1.00											
MedianOnLeg	0.37	0.31	0.31	0.29	0.25	0.44	-0.13	0.69	0.32	0.28	0.63	-0.06	-0.07	0.03	-0.24	0.09	0.08	0.20	0.87	0.02	0.85	1.00										
SlipLaneAtIntersection	-0.05	-0.02	-0.02	-0.08	-0.05	-0.05	0.07	0.08	-0.07	-0.03	0.17	-0.15	-0.13	0.10	-0.04	0.08	0.00	0.07	0.12	0.91	0.11	0.06	1.00									
TransitStopPresence	0.17	0.15	0.15	0.14	0.12	0.18	-0.14	0.18	0.18	0.17	0.17	0.07	0.07	-0.22	0.15	0.32	0.81	0.27	0.08	0.02	0.02	0.08	-0.02	1.00								
TransitStopOnApproach	0.07	0.05	0.05	0.08	0.07	0.04	-0.06	0.06	0.10	0.10	0.05	0.06	0.07	-0.12	0.13	0.24	0.59	0.21	0.06	0.02	0.02	0.06	0.01	0.48	1.00							
MajorRd_Leg	0.35	0.39	0.39	0.31	0.32	0.17	-0.24	0.15	0.06	0.04	-0.13	0.15	0.11	-0.13	0.09	0.06	0.02	-0.01	-0.09	-0.16	-0.03	0.09	-0.18	0.02	0.02	1.00						
Arterial	0.13	0.20	0.20	0.12	0.19	0.11	-0.10	0.19	0.06	0.09	0.08	0.04	0.05	0.05	-0.02	0.01	0.03	-0.07	0.01	0.11	-0.01	0.08	0.13	0.04	-0.02	0.17	1.00					
RT2	0.01	0.02	0.02	0.02	0.04	0.05	-0.01	0.03	-0.05	-0.05	-0.04	-0.01	-0.02	-0.01	0.03	0.00	-0.07	0.01	-0.06	0.05	-0.10	-0.01	0.06	-0.02	-0.10	0.09	0.34	1.00				
OneWayLeg	-0.13	-0.11	-0.11	-0.09	-0.06	-0.14	-0.10	-0.25	-0.14	-0.14	-0.24	0.01	0.03	-0.07	0.22	-0.04	-0.09	0.33	-0.13	-0.06	-0.12	-0.13	-0.05	-0.12	-0.01	0.00	-0.29	0.02	1.00			
UrbanLandType	0.25	0.31	0.31	0.24	0.27	0.15	-0.48	0.05	0.27	0.31	0.03	0.30	0.32	-0.71	0.46	0.35	0.23	0.21	0.05	0.03	-0.01	0.05	0.00	0.23	0.15	0.14	-0.02	-0.04	0.08	1.00		
CommercialArea	0.23	0.25	0.25	0.19	0.21	0.11	-0.28	0.12	0.25	0.25	0.11	0.20	0.21	-0.35	0.17	0.12	0.26	0.29	0.12	0.03	0.05	0.11	0.01	0.25	0.18	0.02	0.04	0.00	0.16	0.50	1.00	
FourLeg	0.05	0.01	0.01	0.02	-0.01	0.05	0.09	0.17	0.05	0.01	0.14	-0.08	-0.06	0.05	-0.04	-0.05	0.22	0.17	0.13	0.10	0.04	0.09	0.07	0.22	0.10	-0.12	-0.01	-0.04	0.08	-0.08	0.18	1.00

Correlation Matrix for Model 5 Data Set

	Leg_AADT	Ln_Leg_AADT	Log10_Leg_AADT	Upstream_AADT	Log10_Upstream_AADT	Upstream_NumLanes	UpstreamIntDistance	Leg_NumberOfLanes	AvgAADT_PerLeg	Log10_AvgAADT_PerLeg	AvgNumLanes_PerLeg	AvgAADT_PerLane	Log10_AvgAADT_PerLane	Leg_SpeedLimit	AvgPopDens16	MuniPopulation2016	NumberOfTransitStops	NumberTransitLines	NumberOfMedians	NumberOfSlipLanes	MedianAtIntersection	MedianOnLeg	SlipLaneAtIntersection	TransitStopPresence	TransitStopOnApproach	MajorRd_Leg	Arterial	RT2	OneWayLeg	UrbanLandType	CommercialArea	FourLeg
Leg_AADT	1.00																															
Ln_Leg_AADT	0.94	1.00																														
Log10_Leg_AADT	0.94	1.00	1.00																													
Upstream_AADT	0.73	0.70	0.70	1.00																												
Log10_Upstream_AADT	0.28	0.30	0.30	0.66	1.00																											
Upstream_NumLanes	0.54	0.51	0.51	0.55	0.25	1.00																										
UpstreamIntDistance	-0.31	-0.38	-0.38	-0.25	-0.08	-0.23	1.00																									
Leg_NumberOfLanes	0.51	0.47	0.47	0.39	0.14	0.56	-0.13	1.00																								
AvgAADT_PerLeg	0.69	0.64	0.64	0.50	0.21	0.39	-0.23	0.42	1.00																							
Log10_AvgAADT_PerLeg	0.66	0.66	0.66	0.48	0.21	0.37	-0.25	0.38	0.95	1.00																						
AvgNumLanes_PerLeg	0.36	0.32	0.32	0.28	0.14	0.44	-0.05	0.83	0.40	0.38	1.00																					
AvgAADT_PerLane	0.51	0.50	0.50	0.35	0.13	0.14	-0.22	-0.09	0.78	0.77	-0.21	1.00																				
Log10_AvgAADT_PerLane	0.48	0.50	0.50	0.34	0.13	0.13	-0.23	-0.10	0.77	0.83	-0.19	0.96	1.00																			
Leg_SpeedLimit	-0.20	-0.20	-0.20	-0.16	-0.03	-0.04	0.45	0.06	-0.19	-0.18	0.07	-0.24	-0.23	1.00																		
AvgPopDens16	0.09	0.15	0.15	0.11	0.00	-0.06	-0.29	-0.23	0.11	0.16	-0.26	0.30	0.33	-0.40	1.00																	
MuniPopulation2016	0.29	0.28	0.28	0.23	0.05	0.17	-0.26	0.09	0.31	0.30	0.06	0.29	0.28	-0.34	0.38	1.00																
NumberOfTransitStops	0.16	0.16	0.16	0.15	0.06	0.11	-0.11	0.11	0.18	0.18	0.10	0.09	0.12	-0.19	0.25	0.40	1.00															
NumberTransitLines	0.20	0.18	0.18	0.12	-0.03	0.19	-0.26	0.18	0.22	0.21	0.20	0.09	0.11	-0.17	0.24	0.31	0.27	1.00														
NumberOfMedians	0.26	0.20	0.20	0.18	0.06	0.39	-0.11	0.66	0.29	0.26	0.74	-0.14	-0.15	0.03	-0.28	0.06	0.04	0.23	1.00													
NumberOfSlipLanes	-0.04	-0.01	-0.01	-0.06	-0.03	-0.06	0.07	0.07	-0.05	-0.01	0.16	-0.12	-0.10	0.07	0.00	0.06	0.03	0.00	0.10	1.00												
MedianAtIntersection	0.28	0.23	0.23	0.19	0.08	0.35	-0.10	0.62	0.31	0.28	0.64	-0.08	-0.09	0.08	-0.26	0.05	0.00	0.16	0.88	0.10	1.00											
MedianOnLeg	0.36	0.30	0.30	0.26	0.08	0.45	-0.13	0.69	0.32	0.28	0.63	-0.06	-0.08	0.04	-0.25	0.08	0.04	0.19	0.87	0.04	0.86	1.00										
SlipLaneAtIntersection	-0.05	-0.02	-0.02	-0.09	-0.04	-0.05	0.05	0.09	-0.06	-0.03	0.19	-0.15	-0.14	0.09	-0.04	0.08	-0.01	0.06	0.14	0.91	0.11	0.07	1.00									
TransitStopPresence	0.16	0.14	0.14	0.15	0.10	0.16	-0.13	0.16	0.18	0.17	0.16	0.07	0.08	-0.21	0.16	0.32	0.81	0.25	0.05	0.00	0.00	0.05	-0.03	1.00								
TransitStopOnApproach	0.06	0.05	0.05	0.06	0.01	0.02	-0.06	0.04	0.10	0.10	0.04	0.06	0.07	-0.12	0.15	0.25	0.61	0.20	0.03	0.01	-0.01	0.03	-0.01	0.49	1.00							
MajorRd_Leg	0.35	0.40	0.40	0.27	0.11	0.20	-0.23	0.17	0.07	0.06	-0.11	0.14	0.11	-0.11	0.05	0.06	0.01	-0.02	-0.06	-0.15	0.00	0.11	-0.17	0.01	0.01	1.00						
Arterial	0.15	0.21	0.21	0.15	0.14	0.14	-0.07	0.20	0.07	0.08	0.10	0.01	0.02	0.07	-0.05	0.00	0.03	-0.09	0.03	0.10	0.02	0.10	0.12	0.05	-0.03	0.20	1.00					
RT2	0.02	0.04	0.04	0.03	0.04	0.03	0.00	0.01	-0.03	-0.03	-0.04	0.01	0.00	0.02	0.04	0.00	-0.05	0.02	-0.08	0.01	-0.11	-0.03	0.02	-0.01	-0.08	0.07	0.34	1.00				
OneWayLeg	-0.15	-0.14	-0.14	-0.11	-0.10	-0.17	-0.11	-0.26	-0.13	-0.12	-0.25	0.03	0.04	-0.08	0.25	-0.02	-0.07	0.34	-0.14	-0.06	-0.14	-0.14	-0.05	-0.11	0.01	-0.06	-0.37	0.02	1.00			
UrbanLandType	0.23	0.27	0.27	0.19	0.04	0.12	-0.49	0.04	0.26	0.30	0.03	0.28	0.30	-0.71	0.47	0.35	0.23	0.22	0.05	0.03	-0.01	0.05	0.00	0.23	0.15	0.13	-0.04	-0.04	0.09	1.00		
CommercialArea	0.21	0.22	0.22	0.16	0.05	0.09	-0.28	0.11	0.23	0.24	0.10	0.19	0.21	-0.35	0.19	0.13	0.25	0.31	0.12	0.03	0.05	0.11	0.00	0.24	0.17	0.00	0.00	-0.02	0.17	0.50	1.00	
FourLeg	0.05	0.01	0.01	0.01	-0.02	0.04	0.08	0.18	0.05	0.01	0.15	-0.08	-0.07	0.06	-0.04	-0.06	0.22	0.18	0.14	0.10	0.06	0.10	0.07	0.21	0.09	-0.12	-0.03	-0.04	0.08	-0.08	0.18	1.00

Correlation Matrix for Model 6 Data Set

	Leg_AADT	Ln_Leg_AADT	Log10_Leg_AADT	Upstream_AADT	Log10_Upstream_AADT	Upstream_NumLanes	UpstreamIntDistance	Leg_NumberOfLanes	AvgAADT_PerLeg	Log10_AvgAADT_PerLeg	AvgNumLanes_PerLeg	AvgAADT_PerLane	Log10_AvgAADT_PerLane	Leg_SpeedLimit	AvgPopDens16	MuniPopulation2016	NumberOfTransitStops	NumberTransitLines	NumberOfMedians	NumberOfSlipLanes	MedianAtIntersection	MedianOnLeg	SlipLaneAtIntersection	TransitStopPresence	TransitStopOnApproach	MajorRd_Leg	Arterial	RT2	OneWayLeg	UrbanLandType	CommercialArea	FourLeg
Leg_AADT	1.00																															
Ln_Leg_AADT	0.93	1.00																														
Log10_Leg_AADT	0.93	1.00	1.00																													
Upstream_AADT	0.70	0.68	0.68	1.00																												
Log10_Upstream_AADT	0.30	0.35	0.35	0.69	1.00																											
Upstream_NumLanes	0.51	0.51	0.51	0.61	0.45	1.00																										
UpstreamIntDistance	-0.31	-0.36	-0.36	-0.24	-0.09	-0.21	1.00																									
Leg_NumberOfLanes	0.51	0.46	0.46	0.37	0.13	0.49	-0.12	1.00																								
AvgAADT_PerLeg	0.68	0.63	0.63	0.50	0.23	0.38	-0.23	0.42	1.00																							
Log10_AvgAADT_PerLeg	0.65	0.65	0.65	0.48	0.22	0.36	-0.25	0.39	0.95	1.00																						
AvgNumLanes_PerLeg	0.36	0.31	0.31	0.26	0.12	0.37	-0.05	0.84	0.40	0.39	1.00																					
AvgAADT_PerLane	0.50	0.50	0.50	0.36	0.16	0.17	-0.22	-0.09	0.78	0.77	-0.21	1.00																				
Log10_AvgAADT_PerLane	0.47	0.49	0.49	0.34	0.15	0.15	-0.24	-0.10	0.77	0.83	-0.19	0.96	1.00																			
Leg_SpeedLimit	-0.20	-0.23	-0.23	-0.17	-0.08	-0.08	0.46	0.05	-0.20	-0.19	0.07	-0.25	-0.25	1.00																		
AvgPopDens16	0.10	0.17	0.17	0.11	0.02	-0.04	-0.29	-0.23	0.11	0.16	-0.26	0.30	0.33	-0.42	1.00																	
MuniPopulation2016	0.29	0.29	0.29	0.24	0.08	0.19	-0.26	0.10	0.32	0.31	0.06	0.30	0.29	-0.34	0.38	1.00																
NumberOfTransitStops	0.15	0.15	0.15	0.15	0.06	0.10	-0.11	0.10	0.17	0.16	0.09	0.09	0.11	-0.19	0.26	0.40	1.00															
NumberTransitLines	0.20	0.18	0.18	0.15	0.02	0.21	-0.25	0.17	0.22	0.20	0.19	0.10	0.12	-0.19	0.24	0.32	0.27	1.00														
NumberOfMedians	0.27	0.21	0.21	0.18	0.06	0.35	-0.11	0.67	0.30	0.27	0.74	-0.14	-0.14	0.01	-0.27	0.06	0.03	0.22	1.00													
NumberOfSlipLanes	-0.04	-0.01	-0.01	-0.06	-0.03	-0.05	0.07	0.07	-0.05	-0.01	0.16	-0.12	-0.10	0.05	0.00	0.07	0.05	0.00	0.10	1.00												
MedianAtIntersection	0.29	0.24	0.24	0.19	0.09	0.32	-0.11	0.63	0.32	0.29	0.64	-0.08	-0.08	0.05	-0.26	0.06	0.00	0.16	0.88	0.09	1.00											
MedianOnLeg	0.37	0.31	0.31	0.27	0.11	0.42	-0.13	0.69	0.32	0.28	0.63	-0.06	-0.07	0.02	-0.24	0.09	0.04	0.18	0.87	0.04	0.85	1.00										
SlipLaneAtIntersection	-0.05	-0.02	-0.02	-0.09	-0.05	-0.05	0.06	0.09	-0.06	-0.02	0.19	-0.15	-0.14	0.06	-0.04	0.08	0.01	0.06	0.13	0.91	0.11	0.06	1.00									
TransitStopPresence	0.16	0.13	0.13	0.15	0.10	0.15	-0.13	0.16	0.17	0.15	0.15	0.06	0.07	-0.20	0.17	0.33	0.81	0.26	0.05	0.01	0.00	0.05	-0.02	1.00								
TransitStopOnApproach	0.05	0.03	0.03	0.06	0.02	0.03	-0.06	0.04	0.09	0.09	0.04	0.06	0.06	-0.12	0.15	0.24	0.60	0.20	0.02	0.01	-0.01	0.03	-0.01	0.49	1.00							
MajorRd_Leg	0.37	0.43	0.43	0.30	0.17	0.24	-0.22	0.17	0.08	0.07	-0.11	0.16	0.13	-0.14	0.07	0.07	0.01	0.00	-0.05	-0.15	0.01	0.12	-0.17	0.02	0.00	1.00						
Arterial	0.15	0.21	0.21	0.15	0.13	0.13	-0.05	0.20	0.07	0.08	0.09	0.02	0.03	0.03	-0.03	0.01	0.04	-0.08	0.04	0.10	0.03	0.10	0.12	0.06	-0.03	0.21	1.00					
RT2	0.02	0.03	0.03	0.02	0.02	0.02	0.00	0.01	-0.03	-0.03	-0.04	0.01	0.00	0.02	0.04	-0.01	-0.05	0.02	-0.08	0.01	-0.11	-0.03	0.02	-0.01	-0.08	0.07	0.33	1.00				
OneWayLeg	-0.14	-0.12	-0.12	-0.09	-0.06	-0.13	-0.11	-0.25	-0.12	-0.12	-0.24	0.03	0.05	-0.08	0.24	-0.02	-0.07	0.34	-0.13	-0.06	-0.13	-0.14	-0.05	-0.10	0.01	-0.05	-0.36	0.02	1.00			
UrbanLandType	0.24	0.28	0.28	0.20	0.07	0.14	-0.48	0.05	0.26	0.30	0.03	0.28	0.30	-0.73	0.47	0.36	0.23	0.22	0.06	0.04	0.01	0.06	0.00	0.23	0.15	0.13	-0.02	-0.04	0.09	1.00		
CommercialArea	0.21	0.22	0.22	0.19	0.10	0.14	-0.28	0.12	0.23	0.24	0.11	0.18	0.20	-0.37	0.18	0.14	0.25	0.30	0.13	0.03	0.06	0.12	0.00	0.24	0.16	0.00	0.00	-0.02	0.17	0.50	1.00	
FourLeg	0.04	-0.01	-0.01	0.01	-0.01	0.04	0.06	0.17	0.04	0.01	0.14	-0.08	-0.07	0.06	-0.03	-0.05	0.21	0.17	0.13	0.10	0.04	0.11	0.07	0.21	0.09	-0.11	-0.03	-0.04	0.08	-0.08	0.17	1.00

Appendix B: AADT Values for Signalized Intersections in Niagara Region (2017)

Appendix B: AADT Values for Signalized Intersections in Niagara Region

#	GeoID	Intersection	Municipality	Leg AADT			
				North	South	West	East
1	00009	King Street @ Ontario Street	LINCOLN	14700		9500	11200
2	00010	King Street @ Mountain Street/Central Avenue	LINCOLN	6288	5700	11200	7100
3	00022	Niagara Street @ Seaway Mall	WELLAND	17400	17400	15220	13374
4	00040	Burgar Street @ Division Street	WELLAND	3200	5098	5100	8330
5	00041	Division Street @ Hellems Avenue	WELLAND	7391	6510	7300	5100
6	00042	Cross Street @ Division Street	WELLAND	6880	7166	7300	7300
7	00059	Corbett Avenue & Scullers Way @ Main Street	ST. CATHARINES	7209	7209	7900	7900
8	00066	Lake Street @ Lakeshore Road	ST. CATHARINES	11359	11154	11300	14600
9	00070	Geneva Street @ Lakeshore Road	ST. CATHARINES	11223	11408	14600	11200
10	00075	Lakeshore Road @ Vine Street	ST. CATHARINES	8641	9530	11200	9000
11	00094	Griffin Street @ RR20/St Catharines Street	WEST LINCOLN		7000	9200	8200
12	00127	Baker Road North/Baker Road South @ Main Street East	GRIMSBY	11490	10421	13300	13300
13	00129	Bartlett Avenue @ Main Street East	GRIMSBY	11800	11800	13800	11600
14	00148	Christie Street @ Clarke Street/South Service Road	GRIMSBY	14400	14400	6700	6100
15	00149	Bartlett Avenue @ Ramp/South Service Road	GRIMSBY	11800	11800	4800	4300
16	00165	Fly Road @ Victoria Avenue	LINCOLN	10800	8700	3100	
17	00185	King Street @ Victoria Avenue	LINCOLN	11000	10800	6300	5800
18	00189	Niagara Street @ Parnell Road	ST. CATHARINES	8200	8200	7297	7297
19	00190	Lakeshore Road @ Niagara Street	ST. CATHARINES	6273	8200	9000	8700
20	00204	Arthur Street @ Lakeshore Road	ST. CATHARINES	8553		9000	9000
21	00216	Lakeport Road @ Lock Street	ST. CATHARINES	8100	9800		6939
22	00226	Lakeport Road @ Lakeshore Road/Ontario Street	ST. CATHARINES	11300	16700	9800	10557
23	00235	Linwell Road @ Ontario Street	ST. CATHARINES	16700	20200		13558
24	00241	Carlton Street & North Service Road @ Geneva Street	ST. CATHARINES	15108	15267	7068	12100
25	00254	Division Street @ King Street	WELLAND	7900	7819	8200	7300
26	00260	Broadway/Ontario Road @ Prince Charles Drive South	WELLAND	17500	12300	10906	12701
27	00261	Maple Avenue @ Prince Charles Drive North	WELLAND	18200	18200	4677	12361
28	00263	Fitch Street @ Prince Charles Drive North	WELLAND	16400	18800	14526	13174
29	00265	Rice Road @ Woodlawn Road	WELLAND	7700	12500	9200	14000
30	00266	Prince Charles Drive North @ Thorold Road	WELLAND	12500	16400	14825	11724
31	00276	Church Street @ Niagara Street	WELLAND	12400	12400	9754	9754
32	00289	Niagara Street @ Thorold Road	WELLAND	21700	12400	12552	13840
33	00291	Aqueduct Street @ Niagara Street	WELLAND	21700	21700	16154	14194
34	00293	Niagara Street @ Woodlawn Road	WELLAND	17400	21700	14900	19200
35	00294	Lancaster Drive @ Niagara Street	WELLAND	17400	17400	12128	13374

Appendix B: AADT Values for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	Municipality	Leg AADT			
				North	South	West	East
36	00299	East Main Street @ Wallace Avenue	WELLAND	10585	10585	14300	14300
37	00302	Crowland Avenue @ East Main Street	WELLAND		11989	13800	14300
38	00304	Duncan Street @ East Main Street	WELLAND		9373	13800	13800
39	00307	East Main Street @ Ross Street/Division Street	WELLAND	10394	8279	13800	13800
40	00308	Burgar Street/River Road @ East Main Street	WELLAND	5936	3200	8400	13800
41	00309	East Main Street @ Hellems Avenue/Dorothy Street	WELLAND	8108	7882	7500	8400
42	00310	Cross Street @ East Main Street	WELLAND	7106	7638	7500	7500
43	00311	East Main Street @ King Street/The Boardwalk	WELLAND	5708	7900	9000	7500
44	00312	Niagara Sreet & Division Street @ West Main Street	WELLAND	12400	8200	9900	9000
45	00316	Denistoun Street @ West Main Street	WELLAND	8689	8689	9900	9900
46	00318	Prince Charles Drive North @ West Main Street	WELLAND	18800	18400		9900
47	00353	Highway 140/ Elizabeth Street @ Main Street East/ Main Street West	PORT COLBORNE	7800	6714	12000	7000
48	00354	Main Street East @ Wellington Street	PORT COLBORNE	8967	8967	12500	12000
49	00358	Main Street East @ Welland Street / Barber Drive	PORT COLBORNE	7181	5400	12200	12500
50	00361	Main Street West @ Mellanby Avenue	PORT COLBORNE	6841	3600	11800	12200
51	00364	King Street @ Main St West	PORT COLBORNE		10285	13100	11800
52	00365	Elm Street @ Main Street West	PORT COLBORNE	9707	11114	11900	13100
53	00368	Main Street West @ Steele Street	PORT COLBORNE	9011	9701	10200	11900
54	00373	Highway 58 / Westside Road @ Main Street West	PORT COLBORNE	11100	10941	6700	10200
55	00386	Glenridge Avenue @ Sir Isaac Brock Way	ST. CATHARINES	9300	6500	14907	11100
56	00387	Schmon Parkway/John Macdonnel Street @ Sir Isaac Brock Way	ST. CATHARINES	9774	8422	11100	11100
57	00388	Highway 406 Off Ramp @ Sir Isaac Brock Way	ST. CATHARINES		5605	11100	10923
58	00389	Highway 20 East @ Rice Road	PELHAM	8342	7000	16600	21100
59	00399	Merrittville Highway @ Schmon Parkway	THOROLD	6500	6500		8455
60	003WLM	Garrison Road @ Walmart Entrance	FORT ERIE	13077	10755	17500	17500
61	00412	Thorold Stone Road/Highway 58 @ Thorold Townline Road/Taylor Road	THOROLD	5400	6500	19411	19700
62	00418	Decew Road @ Merrittville Highway	THOROLD	6500	6500	5725	6313
63	00424	Merritt Road @ Merrittville Highway/Niagara Street	WELLAND	6300	15100	6621	9500
64	00428	Lundy's Lane @ Thorold Townline Road	THOROLD	2900	2800	12600	12200
65	00429	Highway 20 @ Highway 58/Allanport Road	THOROLD	5500	3400	10700	12600
66	00440	Highway 20 @ Merrittville Highway	THOROLD	5600	6000	21100	18900
67	00441	Cataract Road @ Highway 20	THOROLD	13150	10449	21100	21100
68	00454	Highway 20 @ Vineland Townline Road	PELHAM	9200	8100	5300	13700
69	00488	Pelham Street @ Quaker Road	PELHAM	8241	11230	2660	5041
70	00491	Bacon Lane/Spruceside Crescent @ Pelham Street	PELHAM	7512	8192	4122	4122
71	00492	John Street/Pancake Lane @ Pelham Street	PELHAM	7143	7186	3897	3897
72	00494	Pelham Street @ Port Robinson Road \ Brock Street	PELHAM	7327	7162	3911	4681

Appendix B: AADT Values for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	Municipality	Leg AADT			
				North	South	West	East
73	00502	Church Hill @ Pelham Street	PELHAM	9832	8781	6265	
74	00504	Highway 20 @ Pelham Street	PELHAM	11414	11539	15500	16600
75	00509	Haist Street @ Highway 20	PELHAM	11136	11136	15500	15500
76	00511	Highway 20 East @ Station Street	PELHAM	11841	11841	16600	16600
77	00521	Effingham Street @ Highway 20	PELHAM	9259	9259	13700	15500
78	00522	Highway 20 West @ Lookout Street	PELHAM	10099	11493	15500	15500
79	00526	Linwell Road @ Niagara Street	ST. CATHARINES	8200	9200	9556	8666
80	00527	Niagara Street @ Scott Street	ST. CATHARINES	9200	11600	15695	14625
81	00533	Carlton Street @ Vine Street	ST. CATHARINES	9917	9108	12100	6900
82	00539	Carlton Street @ Grantham Avenue	ST. CATHARINES	10878	10490	13200	11600
83	00543	Carlton Street @ Niagara Street	ST. CATHARINES	11600	14800	6900	13200
84	00549	Bunting Road @ Carlton Street	ST. CATHARINES	13505	13756	11600	6600
85	00559	Eastchester Avenue/Westchester Crescent @ Queenston Street	ST. CATHARINES	14003	12000	11425	9900
86	00572	Highway 406 East Ramp @ Westchester Avenue	ST. CATHARINES		11139	19600	13500
87	00575	Niagara Stone Road & Taylor Road @ Queenston Street & York Rd	NIAGARA-ON-THE-LAKE	6600	8500	8700	5900
88	00590	Corporate Park Drive & South Service Road @ Martindale Road	ST. CATHARINES	6600	16200	4800	7151
89	00592	Fourth Avenue / Welland Avenue @ Ontario Street	ST. CATHARINES	21200	10700	24300	12800
90	00604	Forks Road @ Highway 3/Townline Road	WAINFLEET	6100	3750	4500	3600
91	00639	Henley Drive / Meadowvale Drive @ Ontario Street	ST. CATHARINES	20200	20200	15399	12665
92	00641	Niagara Street @ Vine Street / Facer Street	ST. CATHARINES	14800	25400	13744	12456
93	00644	Dunkirk Road @ Welland Avenue	ST. CATHARINES	14636	14600	6634	6974
94	00645	Carlton Street @ Lake Street	ST. CATHARINES	14227	11601	9300	5800
95	00646	Lake Street @ Welland Avenue	ST. CATHARINES	11206	11602	12800	11900
96	00647	Geneva Street @ Welland Avenue	ST. CATHARINES	17723	19652	11900	13200
97	00656	Seventh Street Louth @ South Service Road	ST. CATHARINES	4800	3400	1200	2700
98	00668	Ontario Street @ QEW South Ramp	ST. CATHARINES	20200	26200	14194	11674
99	00670	Ontario Street @ Scott Street West	ST. CATHARINES	26200	19200	15129	13294
100	00673	Carlton Street @ Ontario Street	ST. CATHARINES	19200	21200		9300
101	00679	Queen Street @ Welland Avenue	ST. CATHARINES		10994	12800	12800
102	00680	Clark Street / George Street @ Welland Avenue	ST. CATHARINES	9709	10706	11900	11900
103	00687	Niagara Street @ Russell Avenue	ST. CATHARINES	16500	16500	12237	13927
104	00695	First Street Louth @ St. Paul Street West	ST. CATHARINES	8212	6412	7500	7500
105	00697	Fourth Avenue @ Third Street Louth	ST. CATHARINES	5528	5852	5700	5700
106	00700	First Street Louth @ Fourth Avenue	ST. CATHARINES	8898	10081	5700	17300
107	00711	Louth Street @ Rykert Street	ST. CATHARINES	6900	6900	7108	7108
108	00715	Glendale Avenue/Nash Street @ Pelham Road	ST. CATHARINES	12118	10900	15084	16200
109	00729	Fourth Avenue @ Vansickle Road	ST. CATHARINES	13522	10893	17300	17300

Appendix B: AADT Values for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	Municipality	Leg AADT			
				North	South	West	East
110	00730	Fourth Avenue @ Louth Street/Martindale Road	ST. CATHARINES	13700	14900	17300	31800
111	00731	Benfield Drive/Vintage Crescent @ Louth Street	ST. CATHARINES	9938	10959	14900	14900
112	00734	Hartzel Road @ Queenston Street	ST. CATHARINES		12178	9900	13200
113	00745	Glendale Avenue @ Mountain Street	ST. CATHARINES	16029	16029	27000	27000
114	00747	Glendale Avenue @ Glenridge Avenue	ST. CATHARINES	9800	9300	16200	14800
115	00748	Glendale Avenue @ Marsdale Drive	ST. CATHARINES	10340	10340	16200	16200
116	00752	North Service Road @ QEW Off-Ramp	LINCOLN		4668	3600	3600
117	00755	Ontario Street @ QEW Off Ramp	LINCOLN	12112	18102	3752	
118	00764	East and West Line @ Niagara Stone Road	NIAGARA-ON-THE-LAKE	8900	14100	8100	8100
119	00766	Hunter Road @ Niagara Stone Road	NIAGARA-ON-THE-LAKE	8900	8900	7944	
120	00772	Garrison Village Drive @ Niagara Stone Road	NIAGARA-ON-THE-LAKE	8900	8900	7244	7244
121	00785	Mary Street @ Niagara Stone Rd/Mississauga Street	NIAGARA-ON-THE-LAKE	11994	8900	3700	7656
122	00800	Glendale Avenue @ Tremont Drive	ST. CATHARINES	14868	13484	14800	21000
123	00801	Pelham Road @ St. Paul Street West	ST. CATHARINES		10201	9200	11600
124	00811	Glendale Avenue @ Highway 406 West Ramp	ST. CATHARINES	12181	12181	21000	21000
125	00812	Burleigh Hill Drive/Glengarry Road @ Glendale Avenue	ST. CATHARINES	11668	7500	28500	27000
126	00813	Glendale Avenue @ Highway 406 East Ramp	ST. CATHARINES	12295	13558	21000	28500
127	00816	Blain Place @ Westchester Crescent	ST. CATHARINES	9883	9883	13500	13500
128	00818	Oakdale Avenue @ Westchester Crescent	ST. CATHARINES	9832	9524	13500	12000
129	00835	Brown Road/Primeway Drive @ Woodlawn Road	WELLAND	13357	10985	15400	15400
130	00836	River Road @ Woodlawn Road	WELLAND	12280	12280	19200	15400
131	00837	Seaway Drive @ Woodlawn Road	WELLAND	14658		19200	19200
132	00838	Niagara Street @ Quaker Road	WELLAND	15100	17400	11651	11651
133	00841	First Avenue @ Woodlawn Road	WELLAND	12133	10836	14000	14900
134	00842	Champlain Avenue @ Woodlawn Road	WELLAND	10649	10649	14000	14000
135	00848	Clare Avenue @ Woodlawn Road	WELLAND	7905	7499	9200	9200
136	00850	South Pelham Road @ Thorold Road	WELLAND	12100	9400	16876	17724
137	00853	South Pelham Road @ Woodlawn Road	WELLAND	14242	12100		9200
138	00855	Humberstone Road/Townline Tunnel Road @ Prince Charles Drive South/Highway 58	WELLAND	12300	10900	1500	5300
139	00859	Lincoln Street @ Prince Charles Drive North/Prince Charles Drive South	WELLAND	18200	17500	10900	15260
140	00867	South Pelham Road @ Webber Road	WELLAND	9400	9049	5200	8500
141	00871	East Main St/Schisler Rd @ Moyer Road/Doans Ridge Road	WELLAND	5800	1400	12500	7200
142	00873	East Main Street @ Farr Road/Highway 140	WELLAND	9034	13200	18900	12500
143	00875	East Main Street @ Wellington Street/Wellington Street North	WELLAND	12768	12089	14300	18900
144	00876	East Main Street @ St Andrews Avenue	WELLAND		10591	14300	14300
145	00881	Highway 406 West Ramp @ Westchester Avenue	ST. CATHARINES	11573	11573	19600	19600
146	00882	Bond Street/Race Street/Ramp @ Geneva Street	ST. CATHARINES	23100	9700	12838	12838

Appendix B: AADT Values for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	Municipality	Leg AADT			
				North	South	West	East
147	00883	Geneva Street @ Westchester Avenue/Westchester Crescent	ST. CATHARINES	9700	10621	16500	19600
148	00885	Glenridge Avenue @ Westchester Crescent	ST. CATHARINES		12200	17400	16500
149	00887	Glen Morris Drive @ Glenridge Avenue	ST. CATHARINES	12200	9800		9606
150	00899	Glendale Avenue @ Niagara-on-the-Green Boulevard	NIAGARA-ON-THE-LAKE		9398	11900	11900
151	00900	Glendale Avenue @ Taylor Avenue	NIAGARA-ON-THE-LAKE	6300	8400	11900	18000
152	00906	Glendale Avenue @ QEW North Ramp	NIAGARA-ON-THE-LAKE	18000	18000	14586	11996
153	00917	Airport Road @ York Road	NIAGARA-ON-THE-LAKE	6100	4798	5900	5900
154	00919	Glendale Avenue @ York Road	NIAGARA-ON-THE-LAKE	11871	18000	5900	9100
155	00929	Caroline Street @ Glendale Avenue	ST. CATHARINES	10214		14800	14800
156	00937	Glenridge Avenue @ Norman Road/University Road East	ST. CATHARINES	9300	9300	9367	7704
157	00938	Bunting Road @ Queenston Street	ST. CATHARINES	12007	9132	13200	7900
158	00943	Court Street @ Welland Avenue	ST. CATHARINES		11021	11900	11900
159	00945	Niagara Street @ Welland Avenue	ST. CATHARINES	16500	12400	13200	14000
160	00952	Glenridge Avenue @ Rockcliffe Road	ST. CATHARINES	12200	12200	9376	9376
161	00959	Erion Road @ Martindale Road	ST. CATHARINES	16200	16200	11951	10838
162	00962	Grapeview Drive @ Martindale Road	ST. CATHARINES	13700	13700	9703	9703
163	00970	Elderwood Drive @ Martindale Road	ST. CATHARINES	13700	13700	10371	
164	00972	Fourth Avenue @ Highway 406 Ramps	ST. CATHARINES	24300	31800	17574	17574
165	01001	Lake Street @ Ontario Street	ST. CATHARINES	9414		10700	9600
166	01004	King Street @ Ontario Street	ST. CATHARINES	11368		10100	12400
167	01006	Ontario Street/Westchester Crescent @ St. Paul Street/St. Paul Street West	ST. CATHARINES	9648	11600	12400	17400
168	01008	King Street @ William Street	ST. CATHARINES	11434	13291	7181	7181
169	01012	Church Street @ Geneva Street	ST. CATHARINES	19214	15600	9946	8800
170	01013	Church Street @ Niagara Street	ST. CATHARINES	12400	12400	8800	8515
171	01014	Geneva Street @ Niagara Street/Queenston Street/St. Paul Street	ST. CATHARINES	15600	23100	13944	12400
172	01019	Vine Street South @ Welland Avenue	ST. CATHARINES	11035	11035	14000	14600
173	01024	Dunlop Drive/Dunkirk Road @ Niagara Street	ST. CATHARINES	16500	16500	13428	9690
174	01025	Dieppe Road/North Service Road/Ramp @ Niagara Street	ST. CATHARINES	25400	16500	14793	11843
175	01027	Queenston Street @ Welland Canals Parkway	ST. CATHARINES	7487	8566	8700	8700
176	01029	Cushman Road @ Queenston Street	ST. CATHARINES	7862		7900	8700
177	01061	Four Mile Creek Road @ Niagara Stone Road	NIAGARA-ON-THE-LAKE	7750	6400	11800	14100
178	01064	Line 1 Road/Penner Street @ Niagara Stone Road	NIAGARA-ON-THE-LAKE	14100	14100	9530	9530
179	01072	Glendale Avenue @ Welland Canals Parkway	ST. CATHARINES	10241		12900	10900
180	01082	Hyundai Dealership Entrance @ Ontario Street	ST. CATHARINES	19200	19200	13712	13712
181	01085	Fourth Avenue @ Ridley Square Plaza Entrance	ST. CATHARINES	19336	19336	31800	31800
182	01100	Main Street East @ Wentworth Drive	GRIMSBY	10779	10779	13300	13300
183	01101	Main Street East @ Nelles Road North/Nelles Road South	GRIMSBY	10867	10695	13300	13300

Appendix B: AADT Values for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	Municipality	Leg AADT			
				North	South	West	East
184	01105	Main Street East @ Maple Avenue	GRIMSBY	9987		13700	13300
185	01110	Elm Street @ Main Street East	GRIMSBY		11449	11000	13700
186	01112	Elm Street @ Mountain Street	GRIMSBY	7900	9100	8632	8366
187	01115	Christie Street/Mountain Street @ Main Street	GRIMSBY	14400	7900	12900	11000
188	01117	Livingston Avenue @ Murray Street	GRIMSBY	8652	8652	10900	10900
189	01122	Kidd Avenue @ Livingston Avenue	GRIMSBY	10640	8479	10900	10900
190	01129	Kerman Avenue @ Livingston Avenue	GRIMSBY	9004	8165	9100	10900
191	01137	Highland Avenue @ Lundy's Lane	NIAGARA FALLS	13857	15769	23200	23200
192	01139	Drummond Road @ Lundy's Lane	NIAGARA FALLS	14173	13677	23200	16500
193	01142	Ferry Street/Lundy's Lane @ Main Street	NIAGARA FALLS	11529	12865	16500	12600
194	01148	Ferry Street @ Stanley Avenue	NIAGARA FALLS	18200	16300	12600	13256
195	01155	Montrose Road @ Rysdale Street	NIAGARA FALLS	12100	12100	8928	
196	01157	Highway 420 @ Montrose Road/Ramp/Watson Street	NIAGARA FALLS	12800	12100	10417	14456
197	01161	Bertie Street/Ramp @ Thompson Road	FORT ERIE	3700	9400	12056	12517
198	01162	Bertie Street @ Central Avenue	FORT ERIE	5700	5500	5803	5803
199	01168	Gilmore Road @ Thompson Road	FORT ERIE	3300	3700	3400	4000
200	01178	Central Avenue @ Gilmore Road	FORT ERIE	4000	5700	3900	1900
201	01179	Livingston Avenue @ Roberts Road	GRIMSBY	7930	7595	9100	9100
202	01191	Casablanca Boulevard @ Ramp/South Service Road	GRIMSBY	12928	12000	4100	6700
203	01200	Greenlane @ Ontario Street	LINCOLN	20800	14700	11950	11950
204	01279	Frederick Avenue @ Victoria Avenue	LINCOLN	12600	12600	9252	
205	01280	May Street/Serena Drive @ Ontario Street	LINCOLN	14700	14700	10783	10783
206	01286	Christie Street @ QEW Off Ramp	GRIMSBY	5300	14400	8012	8012
207	01287	Christie Street/Lakeview Avunue @ Olive Street	GRIMSBY	6707	5300	3751	3751
208	01307	John Street & Alyssa Drive @ Ontario Street	LINCOLN	14700	14700	12381	12926
209	01317	Ontario Street @ South Service Road	LINCOLN	15655	20800	4300	1400
210	01319	Friesen Boulevard @ Ontario Street	LINCOLN	14700	14700	11331	
211	01330	South Service Road @ Victoria Avenue	LINCOLN	9357	12600	1400	1200
212	01375	Grimsby Road @ Highway 20	WEST LINCOLN	4800		6700	9700
213	01396	Canborough Road @ Regional Road 27/Wellandport Road	WEST LINCOLN	4100	2500	1500	2800
214	01408	Bridge Street @ Fourth Avenue	NIAGARA FALLS	7974	7689	7900	7900
215	01412	Bridge Street @ Victoria Avenue	NIAGARA FALLS	8459	9472	7900	2700
216	01417	Chorozy Street @ Montrose Road	NIAGARA FALLS	15500	15500	9648	12935
217	01421	Montrose Road @ Thorold Stone Road	NIAGARA FALLS	3000	15500	22200	32800
218	01422	QEW West Ramp @ Thorold Stone Road	NIAGARA FALLS	16289	13397	32800	23100
219	01423	QEW East Ramp @ Thorold Stone Road	NIAGARA FALLS	11938	14515	23100	23100
220	01426	Dorchester Road @ Thorold Stone Road	NIAGARA FALLS	15595	17078	23100	18000

Appendix B: AADT Values for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	Municipality	Leg AADT			
				North	South	West	East
221	01428	St James Avenue @ Thorold Stone Road	NIAGARA FALLS	11612	11612	18000	18000
222	01432	Drummond Road / Portage Road @ Thorold Stone Road	NIAGARA FALLS	15272	12379	18000	15300
223	01435	Stanley Avenue @ Thorold Stone Road	NIAGARA FALLS		15300	15300	15300
224	01437	Montrose Road @ South Wood Drive	NIAGARA FALLS	3000	3000	3077	2981
225	01449	Mountain Road @ St Paul Avenue	NIAGARA FALLS	9700	10939	9100	2600
226	01451	Dorchester Road @ Mountain Road	NIAGARA FALLS	7742	9036	12500	9100
227	01462	Farr Avenue @ Gorham Road/Ridgeway Road	FORT ERIE	8501	6979	3810	3810
228	01467	Dominion Road @ Gorham Road	FORT ERIE	9000	10452	7057	4600
229	01473	Dominion Road @ Ridge Road North	FORT ERIE	5466	5182	4600	4600
230	01501	Garner Road @ Lundy's Lane	NIAGARA FALLS	8088	9368	12200	12200
231	01502	Kalar Road @ Lundy's Lane	NIAGARA FALLS	12415	16495	12200	23400
232	01504	Garner Road @ Thorold Stone Road	NIAGARA FALLS	10259	10529	19700	19700
233	01505	Kalar Road @ Thorold Stone Road	NIAGARA FALLS	9626	15092	19700	22200
234	01507	Brookdale Drive / Cardinal Drive @ Thorold Stone Road	NIAGARA FALLS	13865	13325	22200	22200
235	01542	Biggar Road & Lyons Creek Road @ Montrose Road	NIAGARA FALLS	6200	10400	5069	8000
236	01561	Marineland Parkway @ Stanley Avenue	NIAGARA FALLS		4600	15000	15285
237	01562	Marineland Parkway @ Stanley Avenue/Thundering Waters Boulevard	NIAGARA FALLS	8400	8626	14700	15000
238	01563	McLeod Road @ Montrose Road	NIAGARA FALLS	8900	4400	20426	26800
239	01564	McLeod Road @ Oakwood Drive/Ramp	NIAGARA FALLS	14749	17933	26800	24400
240	01566	Dorchester Road @ McLeod Road	NIAGARA FALLS	13921	15015	24400	18600
241	01573	Drummond Road @ McLeod Road	NIAGARA FALLS	12950	11275	18600	14700
242	01579	Livingstone Street @ Stanley Avenue	NIAGARA FALLS	8400	8400	8698	7154
243	01581	Dunn Street @ Stanley Avenue	NIAGARA FALLS	11200	8400	8570	9450
244	01584	Dixon Street & Main Street @ Stanley Avenue	NIAGARA FALLS	11200	11200	8376	9956
245	01587	Murray Street @ Stanley Avenue	NIAGARA FALLS	12300	11200	9587	13904
246	01591	Robinson Street @ Stanley Avenue	NIAGARA FALLS	16300	12300	10698	9702
247	01594	Lundy's Lane @ Montrose Road	NIAGARA FALLS	12100	8900	23400	22500
248	01595	Belmont Avenue @ Lundy's Lane	NIAGARA FALLS	13104	18131	22500	22500
249	01596	Lundy's Lane @ Royal Manor Drive	NIAGARA FALLS	13145	13145	22500	22500
250	01599	Dorchester Road @ Lundy's Lane	NIAGARA FALLS	16581	12763	22500	23200
251	01606	Central Avenue @ Wintemute Street	FORT ERIE	4000	4000	4893	4893
252	01613	Central Avenue @ Jarvis Street	FORT ERIE	3700	4000	4404	4404
253	01629	Falls Avenue & Highway 420 @ Stanley Avenue	NIAGARA FALLS	13200	18200	42700	9300
254	01633	Stanley Avenue @ Valley Way	NIAGARA FALLS	13200	13200	10730	10201
255	01634	Montrose Road @ Preakness Street	NIAGARA FALLS	12800	12800	10459	10459
256	01640	Morrison Street @ Stanley Avenue	NIAGARA FALLS	13200	13200	10518	11622
257	01648	Bridge Street @ Stanley Avenue	NIAGARA FALLS	15300	13200		7900

Appendix B: AADT Values for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	Municipality	Leg AADT			
				North	South	West	East
258	01673	Gorham Road @ Highway 3	FORT ERIE	8300	9000	8200	10200
259	01676	Garrison Road @ Municipal Centre Drive	FORT ERIE	13150	10359	14100	14100
260	01681	Garrison Road @ Pettit Road / Daytona Drive	FORT ERIE	10125	10125	14100	17500
261	01725	Garrison Road @ Helena Street/Thompson Road	FORT ERIE	9400	1300	17500	13000
262	01728	Concession Road @ Garrison Road	FORT ERIE	11360	9785	13000	10700
263	01730	Garrison Road @ King Street	FORT ERIE	8211	8211	10700	10700
264	01745	East Main Street/West Main Street @ Stevensville Road	FORT ERIE	9800	9500	7526	7526
265	01826	Central Avenue @ Garrison Road/Veterans Way	FORT ERIE	7100	2600	10700	8240
266	01827	Sims Avenue @ Thompson Road	FORT ERIE	9400	9400	8233	8233
267	01828	Central Avenue @ QEW East Off-Ramp	FORT ERIE	5500	5500	5603	
268	020SBY	Highway 20 @ Sobey Entrance	PELHAM	11978	13208	16600	16600
269	03000	Clairmont Street @ Ormond Street South	THOROLD	12118	10498	5644	6755
270	03127	Burleigh Hill Dr/Collier Rd N @ St David's Rd	ST. CATHARINES	7500	4400	6217	6217
271	03131	Ormond Street North @ Regent Street	THOROLD	11010	11210	5125	5125
272	03707	Clare Avenue @ Thorold Road	WELLAND	5057	4795	9828	9881
273	040SSR	South Service Road @ Superstore/Rona	GRIMSBY		6880	6700	6700
274	04220	Burbank Drive @ First Street Louth	ST. CATHARINES	12373	10152	7513	5245
275	042ANC	Anchor Pointe @ Ontario Street	ST. CATHARINES	16700	16700		12956
276	05097	First Street Louth @ Third Avenue Louth	ST. CATHARINES	8564	9794	5537	5537
277	050PLZ	Glenridge Avenue @ Glenridge Plaza Entrance	ST. CATHARINES	12200	12200	11764	11764
278	05178	Erion Road @ First Street Louth	ST. CATHARINES		7200	8476	10364
279	05650	Davis Road @ Highway 58	THOROLD	11981	10300	20000	25747
280	05691	Collier Road South @ Richmond Street	THOROLD	4400	4700	6726	7477
281	05705	Pine Street South @ Richmond Street	THOROLD	10530	4790	5689	7495
282	05817	Clarence Street @ Steele Street	PORT COLBORNE	9749	8092	4372	5741
283	05820	Clarence Street @ Elm Street	PORT COLBORNE	6889	4954	7661	8859
284	05823	Clarence Street @ King Street	PORT COLBORNE	6896	4954	7661	9731
285	05830	Clarence Street @ Welland Street	PORT COLBORNE		5198	6717	8039
286	05939	Killaly Street West @ Steele Street	PORT COLBORNE	7457	8100	7500	6200
287	05943	Elm Street @ Killaly Street West	PORT COLBORNE	5185	4886	6200	6200
288	05947	Killaly Street West @ King Street	PORT COLBORNE	6653	7148	6200	6200
289	06011	Mellanby Avenue @ Welland Street	PORT COLBORNE	5400	7436	3600	
290	06140	Northland Avenue @ West Side Road	PORT COLBORNE	9150	11100	8658	8658
291	06163	Highway 140 @ Second Concession Road	PORT COLBORNE	7800	7800	6645	6285
292	06256	Colborne Street @ Forks Road	WELLAND	3968		5523	6137
293	06280	Canal Bank Street @ Highway 58A/Townline Tunnel Road	WELLAND	6971	6345	5300	7750
294	06333	Broadway & Ontario Road @ Canal Bank Street	WELLAND	4188	6990	6477	10510

Appendix B: AADT Values for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	Municipality	Leg AADT			
				North	South	West	East
295	06336	King Street @ Ontario Road	WELLAND	6674		8873	11732
296	06340	Dain Avenue/Plymouth Road @ Ontario Road	WELLAND	6533	5058	7823	9367
297	06346	Ontario Road @ Wright Street	WELLAND	6551	5474	10132	11796
298	06348	Ontario Road @ Southworth Street	WELLAND	7341	5879	9093	9093
299	06454	King Street @ Third Street	WELLAND	10046	8051		5206
300	06517	King Street @ Lincoln Street	WELLAND	7901	7974	17700	12194
301	06522	Denistoun Street @ Lincoln Street	WELLAND	5293		11712	10450
302	06527	Hellems Avenue/Plymouth Road @ Lincoln Street	WELLAND	5663	6837	9193	10946
303	06534	Lincoln Street @ Wavell Court	WELLAND	5398	5398	11534	11701
304	06535	Crowland Avenue/Southworth Street @ Lincoln Street	WELLAND	8289	7919	11534	10517
305	06541	Classic Avenue @ Lincoln Street/Scholfield Avenue	WELLAND	5106	5106	9115	9115
306	06606	King Street @ Regent Street	WELLAND	9505	11310	6097	6097
307	06615	Crowland Avenue @ Hagar Street	WELLAND	8889	10540	4802	4802
308	06745	Fitch Street @ Willson Road	WELLAND	6558	6558	10142	11504
309	06949	First Avenue @ Thorold Road	WELLAND	8149	6556	9052	11696
310	070NIA	Niagara College @ Taylor Road	NIAGARA-ON-THE-LAKE	8400	8400		7659
311	070WHT	South Service Road @ Taylor Road	NIAGARA-ON-THE-LAKE	6300	6300	8116	7360
312	07126	Eastwood Drive @ Rice Road/Talbot Trail	WELLAND	7700	7700	6775	7470
313	07129	First Avenue @ Woodgate Dr./Niagara College	WELLAND	7115	9682	5977	4173
314	077HSP	Fourth Avenue @ Hospital Entrance	ST. CATHARINES		7647	5700	5700
315	07917	King Street @ Queen Street	ST. CATHARINES	12705	7354	6221	6221
316	07930	Church Street @ Queen Street	ST. CATHARINES	11306	9621	6221	7412
317	07951	Carlisle Street @ St. Paul Street	ST. CATHARINES	10006	9577	11630	11630
318	07952	James Street @ King Street	ST. CATHARINES	12769	12705	7445	7445
319	07972	Church Street @ James Street	ST. CATHARINES	11567	11449	7445	9184
320	07976	Carlisle Street @ King Street	ST. CATHARINES	12058	13255	7797	9500
321	07990	Carlisle Street/Lyman Street @ Church Street	ST. CATHARINES	8096	8202	8039	12760
322	08012	James Street @ Lake Street	ST. CATHARINES	16693	11710		10614
323	08036	Prince Street @ Queenston Street	ST. CATHARINES	6052		9360	10161
324	08059	Oakdale Avenue/Tasker Street @ Queenston Street	ST. CATHARINES	6807	6807	10724	12259
325	08110	Beech Street @ Lake Street	ST. CATHARINES	11597	13972	7325	7325
326	08170	Lake Street @ Russell Avenue	ST. CATHARINES	11662	10445	6385	7252
327	08186	Geneva Street @ Russell Avenue	ST. CATHARINES	14240	14220	6431	7461
328	08222	Dieppe Rd @ Welland Avenue	ST. CATHARINES	10451	13987	4885	5134
329	08266	Grantham Avenue @ Welland Avenue	ST. CATHARINES	8178	8717	16134	14144
330	08325	Dunlop Drive @ Geneva Street	ST. CATHARINES	9522	8618	5800	3774
331	08333	Lake Street @ Springdale Avenue/Dunlop Drive	ST. CATHARINES	16063	13186	4952	7475

Appendix B: AADT Values for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	Municipality	Leg AADT			
				North	South	West	East
332	08397	Facer Street @ Grantham Avenue	ST. CATHARINES	10557	10561	5810	5810
333	08416	North Service Road @ YMCA Drive	ST. CATHARINES	7938	11210	17584	14693
334	08421	Lake Street @ Meadowvale Drive/North Service Road	ST. CATHARINES	20283	22369	11194	13249
335	08466	Lake Street @ Scott Street	ST. CATHARINES	17825	22219	7724	9286
336	08475	Hill Park Lane @ Vine Street	ST. CATHARINES	11974	12445	6044	
337	08507	Scott Street @ Secord Drive	ST. CATHARINES	9171		12036	12892
338	08540	Geneva Street @ Scott Street	ST. CATHARINES	12755	15905	6948	8405
339	08549	Lake Street @ Secord Drive	ST. CATHARINES	14293	17270	7544	8078
340	08598	Lake Street @ Lakeport Road	ST. CATHARINES	15401	19078		6640
341	08613	Scott Street @ Tabor Drive	ST. CATHARINES	5951		11015	12316
342	08637	Scott Street @ Vine Street	ST. CATHARINES	9848	10014	13566	14256
343	08671	Lakeport Road @ Linwell Road	ST. CATHARINES	9718	11388	13395	14408
344	08696	Lake Street @ Linwell Road	ST. CATHARINES	13401	14138	8554	9732
345	08740	Grantham Avenue @ Scott Street	ST. CATHARINES	10688	11329	6911	8251
346	08777	Geneva Street @ Linwell Road	ST. CATHARINES	9873	12207	6678	8005
347	08871	Linwell Road @ Vine Street	ST. CATHARINES	10642	12076	7513	8115
348	08931	Linwell Road @ Maplewood Drive	ST. CATHARINES		5513	8526	10346
349	089PND	Glendale Avenue @ Pen Centre Entrance	ST. CATHARINES	12445	12445	14800	14800
350	09740	Kalar Road @ McLeod Road	NIAGARA FALLS	11391	6968	12898	17783
351	09775	Coventry Road @ Kalar Road	NIAGARA FALLS	16373	13430		5139
352	09807	Forestview Boulevard & Rideau Street @ Kalar Road	NIAGARA FALLS	16736	14963	6234	4352
353	10020	Highway 58 @ Niagara Falls Road/Beaverdams Road	THOROLD	10300	5500	5907	6852
354	10172	Glendale Avenue @ Merritt Street	ST. CATHARINES	16135	13391	27000	12900
355	10209	Chestnut Street East @ Merritt Street	ST. CATHARINES	11227	12549	6164	6164
356	10250	Merritt Street @ Oakdale Avenue	ST. CATHARINES	10764	11998	6122	
357	10299	Hartzel Road/Merritt Street @ Rockwood Avenue	ST. CATHARINES	13572	12165	7143	7143
358	10330	Admiral Road @ Hartzel Road	ST. CATHARINES	13695	13743	5969	5969
359	10380	Dunvegan Road @ Hartzel Road	ST. CATHARINES	10850	13529	5969	5969
360	10455	Hartzel Road @ Keswick Street/Lincoln Avenue	ST. CATHARINES	11362	12639	7617	6364
361	10571	Eastchester Avenue @ Grantham Avenue South	ST. CATHARINES	4777	4777	11268	8842
362	10634	Bunting Road @ Eastchester Avenue	ST. CATHARINES	13000	9937	5779	
363	10648	Bunting Road @ Dunkirk Road	ST. CATHARINES	14247	11642	5713	4773
364	10651	Bunting Road @ Dieppe Road	ST. CATHARINES	16598	15856	5405	5405
365	10673	Neilson Avenue @ Welland Avenue	ST. CATHARINES	6825	6825	12632	11637
366	10681	Bunting Road @ Welland Avenue	ST. CATHARINES	14584	17087	6702	6702
367	10703	Bunting Road @ Roehampton Avenue	ST. CATHARINES	10395	14579	5779	5779
368	10917	Bunting Road @ Scott Street	ST. CATHARINES	12275	10210	6876	6876

Appendix B: AADT Values for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	Municipality	Leg AADT			
				North	South	West	East
369	11754	Montrose Road @ Niagara Square Drive	NIAGARA FALLS	4400	4400	4902	5541
370	11809	McLeod Road @ Pin Oak Drive	NIAGARA FALLS	6944	6944	14836	22130
371	11816	McLeod Road @ Niagara Square Drive/Ramp	NIAGARA FALLS	15151	12906	26800	26800
372	11818	McLeod Road @ QEW Ramp East	NIAGARA FALLS		15151	26800	26800
373	11910	Fraser Hill @ Niagara River Parkway	NIAGARA FALLS	10799	8207	4444	
374	11976	Dorchester Road @ Dunn Street	NIAGARA FALLS	8685	8972	4771	6349
375	11994	Drummond Road @ Dunn Street	NIAGARA FALLS	14272	10795	7151	9362
376	12006	Dunn Street @ Fallsview Boulevard	NIAGARA FALLS	10886	11781	5961	
377	12016	Fallsview Boulevard @ Main Street/Portage Road	NIAGARA FALLS	9283	7740	9085	9085
378	12089	Allendale Avenue @ Main Street/Murray Street	NIAGARA FALLS	5457	9326	11046	12932
379	12099	Fallsview Boulevard @ Murray Street	NIAGARA FALLS	13013	13219	7030	8414
380	12211	Ellen Avenue/Clark Avenue @ Ferry Street	NIAGARA FALLS	4908	4908	12260	10416
381	12215	Clifton Hill @ Niagara River Parkway/River Road	NIAGARA FALLS	8416		13013	10873
382	12248	Clifton Hill @ Falls Avenue	NIAGARA FALLS	8686	11627	5874	8541
383	12299	Clifton Hill & Centre Street @ Victoria Avenue	NIAGARA FALLS	6031	7534	10873	10625
384	12324	Main Street/Portage Road @ North Street	NIAGARA FALLS	10075	10164	6488	7338
385	12329	Hiram Street @ River Road	NIAGARA FALLS	9433	9085	5874	
386	12332	Bender Street & Blondin Avenue & Rainbow Bridge @ Falls Avenue	NIAGARA FALLS	6100	6100	6062	7179
387	12346	Victoria Avenue @ Walnut Street	NIAGARA FALLS	5000	5000	7733	12046
388	12348	Dorchester Road @ Frederica Street/Royal Manor Drive	NIAGARA FALLS	15892	12835	4765	8168
389	12350	Blondin Avenue @ Hiram Street	NIAGARA FALLS	4908	6994	10873	7591
390	12355	Bender Street @ Ontario Avenue	NIAGARA FALLS	4908	8671	10873	11850
391	12368	Bender Street @ Victoria Avenue	NIAGARA FALLS	10936	9931		8864
392	12378	Drummond Road @ Frederica Street	NIAGARA FALLS	9613	13030	5941	
393	12440	Falls Avenue @ MacDonald Avenue	NIAGARA FALLS	8048	8175	9300	9300
394	12475	Dorchester Road @ Ramp	NIAGARA FALLS	17214	17308	6589	
395	12493	Drummond Road @ Valley Way	NIAGARA FALLS	10854	13851	5196	7115
396	12504	Portage Road @ Valley Way	NIAGARA FALLS	9348	9478	4907	6773
397	12533	McRae Street/Kincald Place @ Victoria Avenue	NIAGARA FALLS	10437	11505	6228	6228
398	12561	Dawson Street @ Dorchester Road	NIAGARA FALLS	19237	21547	7615	6363
399	12607	Jepson Street @ Victoria Avenue	NIAGARA FALLS	10763	10755	6464	6464
400	12674	Simcoe Street @ Victoria Avenue	NIAGARA FALLS	11233	11281	6847	6847
401	12713	Dorchester Road @ Morrison Street	NIAGARA FALLS	13696	18833	9016	9603
402	12716	Drummond Road @ Morrison Street	NIAGARA FALLS	8761	8231	9056	10526
403	12727	Morrison Street @ Portage Road	NIAGARA FALLS	5236	7796	11600	10927
404	12737	Fourth Avenue @ Morrison Street	NIAGARA FALLS	7482	6277	11618	12944
405	12744	Morrison Street @ Valley Way	NIAGARA FALLS	12367	11440	6932	8924

Appendix B: AADT Values for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	Municipality	Leg AADT			
				North	South	West	East
406	12745	Morrison Street @ Victoria Avenue	NIAGARA FALLS	4873	11961	6432	6432
407	12764	Valley Way @ Victoria Avenue	NIAGARA FALLS	7843	7898	12811	10704
408	12954	Dorchester Road @ Freeman Street	NIAGARA FALLS	13084	12969	5027	5027
409	13144	Portage Road @ St John Street	NIAGARA FALLS	16456	14881	6921	
410	13179	Colborne Street @ Portage Road	NIAGARA FALLS	19736	17715	6121	7326
411	13194	Niagara River Parkway @ Victoria Avenue	NIAGARA FALLS		6443	3562	8612
412	13196	Keith Street @ Portage Road	NIAGARA FALLS	15408	19179	8464	7072
413	13256	Dorchester Road @ O'Neil Street	NIAGARA FALLS	7941	11389		6699
414	13267	O'Neil Street/Portage Road @ Saint Paul Street	NIAGARA FALLS	10478	16789	6840	4174
415	14194	Rebstock Road @ Ridgeway Road	FORT ERIE	8368	7428	4803	4803
416	14736	Highway 3 @ Ridge Road North	FORT ERIE	8815	7912	10200	11200
417	14869	Central Avenue @ QEW East Off-Ramp	FORT ERIE	5500	7100	5401	
418	14959	Bertie Street @ Concession Road/Ramp	FORT ERIE	9289	10363	6006	5391
419	15673	Cummington square west/Willoughby Drive @ Main Street	NIAGARA FALLS	9930	7239	6420	5365
420	15720	Portage Road @ Upper Rapids Road	NIAGARA FALLS	6037	6037	12939	9000
421	17208	Killaly Street West @ Mellanby Avenue	PORT COLBORNE	3600	6200	5980	5997
422	17281	Crossroads Drive @ Prince of Wales Avenue/Ramp	FORT ERIE	7640	7640	4128	4128
423	17282	Bertie Street @ Prince of Wales Avenue	FORT ERIE		6929	9144	9651
424	17884	Louth Street & Pelham Road @ MacTurnbull Drive/Pelham Road	ST. CATHARINES	6900	5400	6708	10900
425	17985	Louth Street @ St. Paul Street West	ST. CATHARINES	14900	6900	7500	9200
426	18202	Cabernet Street @ Main Street East	GRIMSBY	10770	9463	11600	11600
427	18219	Bunting Road/Welland Canals Parkway @ Lakeshore Road	ST. CATHARINES	7687	9419	8700	9600
428	18807	Rockwood Avenue @ Welland Canals Parkway	ST. CATHARINES	8339	8962	4842	
429	20275	Louth Street @ Walmart Plaza	ST. CATHARINES	14900	14900	13956	
430	20277	Fairview Mall @ Geneva Street	ST. CATHARINES	17561	20199	9329	6513
431	20278	Glendale Avenue @ Plaza Keg Sobeys	ST. CATHARINES	20114	16543	27000	27000
432	20279	Garrison Road @ Sobeys Entrance	FORT ERIE	11759	11759	13000	13000
433	20280	General Motors Plant 2 @ Glendale Avenue	ST. CATHARINES		11247	10900	10900
434	20423	Stanley Avenue @ Thorold Stone Road	NIAGARA FALLS	4300	12305	15300	15300
435	420VCT	Falls Avenue Ramp @ Victoria Avenue	NIAGARA FALLS	11711	12611	9300	6100
436	900038	Fourth Avenue @ Walmart Plaze	ST. CATHARINES	14911	14911	17300	17300
437	int10073	Thorold Townline Road @ Walker Brothers Quarries Ltd.	NIAGARA FALLS	6500	6500	6785	
438	MCKPRT	Macklem Street @ Portage Road	NIAGARA FALLS	6915	4877	9028	9586

Appendix C: Pedestrian Safety Risk Evaluation Scores for Signalized Intersections in Niagara Region

Appendix C: Pedestrian Safety Risk Prioritization Scores for Signalized Intersections in Niagara Region

#	GeoID	Intersection	APT (S2)	North Ped ISI	South Ped ISI	West Ped ISI	East Ped ISI	Average Ped ISI	ODOT Risk Score	PSI
1	00009	King Street @ Ontario Street	2.785	1.923		2.227	2.237	2.129	33	0.665
2	00010	King Street @ Mountain Street/Central Avenue	1.877	1.873	2.204	2.237	2.213	2.132	46	0.000
3	00022	Niagara Street @ Seaway Mall	1.387	2.944	2.944	2.372	2.585	2.711	55	0.000
4	00040	Burgar Street @ Division Street	1.876	2.189	2.201	1.866	2.220	2.119	71	0.000
5	00041	Division Street @ Hellems Avenue	2.130	2.214	2.209	2.214	2.201	2.210	79	0.000
6	00042	Cross Street @ Division Street	1.476	2.211	2.213	2.214	2.214	2.213	71	0.000
7	00059	Corbett Avenue & Scullers Way @ Main Street	1.740	1.975	1.975	1.979	1.979	1.977	47	0.000
8	00066	Lake Street @ Lakeshore Road	4.169	2.238	2.237	2.238	2.258	2.243	64	0.660
9	00070	Geneva Street @ Lakeshore Road	3.831	2.237	2.239	2.258	2.237	2.243	64	0.132
10	00075	Lakeshore Road @ Vine Street	3.034	1.984	1.989	1.999	1.986	1.990	64	0.000
11	00094	Griffin Street @ RR20/St Catharines Street	1.443		1.877	2.225	1.884	1.996	18	0.215
12	00127	Baker Road North/Baker Road South @ Main Street East	2.408	2.001	1.995	2.012	2.012	2.005	56	0.000
13	00129	Bartlett Avenue @ Main Street East	1.962	2.673	2.673	2.685	2.672	2.676	35	0.000
14	00148	Christie Street @ Clarke Street/South Service Road	1.723	2.688	2.688	1.972	1.969	2.329	30	0.154
15	00149	Bartlett Avenue @ Ramp/South Service Road	2.037	2.673	3.008	2.185	2.033	2.475	23	0.000
16	00165	Fly Road @ Victoria Avenue	1.747	2.147	2.134	1.840		2.040	26	0.000
17	00185	King Street @ Victoria Avenue	1.892	1.901	2.235	2.208	1.870	2.053	43	0.200
18	00189	Niagara Street @ Parnell Road	2.348	1.981	1.981	1.976	1.976	1.979	34	0.218
19	00190	Lakeshore Road @ Niagara Street	1.877	1.970	1.981	1.986	1.984	1.980	46	0.000
20	00204	Arthur Street @ Lakeshore Road	2.005	1.983		1.986	1.986	1.985	53	0.000
21	00216	Lakeport Road @ Lock Street	1.506	2.219	2.229		1.877	2.108	47	0.000
22	00226	Lakeport Road @ Lakeshore Road/Ontario Street	2.881	2.238	2.270	2.229	2.230	2.242	64	0.657
23	00235	Linwell Road @ Ontario Street	2.597	2.367	2.388		1.678	2.145	52	0.000
24	00241	Carlton Street & North Service Road @ Geneva Street	4.449	2.931	2.597	2.212	2.243	2.496	76	2.294
25	00254	Division Street @ King Street	3.770	2.217	2.217	2.219	2.214	2.217	64	1.039
26	00260	Broadway/Ontario Road @ Prince Charles Drive South	2.486	2.372	2.081	1.997	2.008	2.115	54	0.644
27	00261	Maple Avenue @ Prince Charles Drive North	3.079	2.949	2.949	2.198	2.244	2.585	57	0.631
28	00263	Fitch Street @ Prince Charles Drive North	3.029	2.938	2.953	2.592	2.249	2.683	39	0.001
29	00265	Rice Road @ Woodlawn Road	1.728	1.978	2.007	2.657	2.351	2.248	26	0.000
30	00266	Prince Charles Drive North @ Thorold Road	3.562	2.915	2.938	2.259	2.240	2.588	47	1.203
31	00276	Church Street @ Niagara Street	2.378	2.006	2.006	1.991	1.991	1.999	60	0.000
32	00289	Niagara Street @ Thorold Road	2.523	2.970	2.914	2.245	2.588	2.680	53	0.612
33	00291	Aqueduct Street @ Niagara Street	2.223	2.970	2.970	1.707	2.255	2.476	29	0.000
34	00293	Niagara Street @ Woodlawn Road	2.134	3.279	2.970	2.929	2.955	3.034	40	0.000
35	00294	Lancaster Drive @ Niagara Street	1.780	2.944	2.944	2.243	2.250	2.596	23	0.019

Appendix C: Pedestrian Safety Risk Prioritization Scores for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	APT (S2)	North Ped ISI	South Ped ISI	West Ped ISI	East Ped ISI	Average Ped ISI	ODOT Risk Score	PSI
36	00299	East Main Street @ Wallace Avenue	1.645	1.899	2.234	2.256	2.256	2.161	36	0.000
37	00302	Crowland Avenue @ East Main Street	1.924		1.907	2.253	2.256	2.139	34	0.103
38	00304	Duncan Street @ East Main Street	1.321		2.230	2.253	2.253	2.245	43	0.000
39	00307	East Main Street @ Ross Street/Division Street	1.563	1.897	1.885	2.253	2.253	2.072	36	0.000
40	00308	Burgar Street/River Road @ East Main Street	2.627	2.206	1.854	2.220	2.588	2.217	66	0.208
41	00309	East Main Street @ Hellems Avenue/Dorothy Street	2.224	2.219	2.217	1.880	2.220	2.134	56	0.218
42	00310	Cross Street @ East Main Street	2.133	2.213	2.216	2.215	2.215	2.215	71	0.221
43	00311	East Main Street @ King Street/The Boardwalk	2.176	1.869	2.217	2.224	2.550	2.215	71	0.219
44	00312	Niagara Sreet & Division Street @ West Main Street	2.642	2.579	2.219	1.894	1.889	2.146	58	0.188
45	00316	Denistoun Street @ West Main Street	2.530	1.984	1.984	1.991	1.991	1.988	66	0.197
46	00318	Prince Charles Drive North @ West Main Street	2.123	2.715	2.712		1.656	2.361	43	0.000
47	00353	Highway 140/ Elizabeth Street @ Main Street East/ Main Street West	2.577	2.776	2.210	2.577	2.212	2.444	32	0.000
48	00354	Main Street East @ Wellington Street	2.084	2.230	2.230	2.245	2.242	2.237	46	0.000
49	00358	Main Street East @ Welland Street / Barber Drive	1.961	2.213	2.202	2.243	2.245	2.226	41	0.182
50	00361	Main Street West @ Mellanby Avenue	2.049	2.211	2.192	2.241	2.243	2.222	49	0.659
51	00364	King Street @ Main St West	1.837		1.897	2.249	2.241	2.129	34	0.148
52	00365	Elm Street @ Main Street West	1.717	2.228	2.237	2.241	2.249	2.239	41	0.147
53	00368	Main Street West @ Steele Street	2.330	2.224	2.228	2.231	2.241	2.231	54	0.000
54	00373	Highway 58 / Westside Road @ Main Street West	2.351	2.572	2.236	2.210	2.231	2.312	41	0.184
55	00386	Glenridge Avenue @ Sir Isaac Brock Way	1.859	2.896	2.879	2.929	2.907	2.903	60	0.000
56	00387	Schmon Parkway/John Macdonnel Street @ Sir Isaac Brock Way	1.429	2.229	2.556	2.907	2.907	2.649	60	0.000
57	00388	Highway 406 Off Ramp @ Sir Isaac Brock Way	1.432		1.966	2.669	3.003	2.546	60	0.000
58	00389	Highway 20 East @ Rice Road	1.274	2.220	2.212	2.940	3.042	2.603	36	0.000
59	00399	Merrittville Highway @ Schmon Parkway	1.727	2.209	2.209		2.221	2.213	63	0.000
60	003WLM	Garrison Road @ Walmart Entrance	1.359	2.584	2.235	2.945	2.945	2.677	45	0.000
61	00412	Thorold Stone Road/Highway 58 @ Thorold Townline Road/Taylor Road	1.753	2.114	2.196	2.943	2.945	2.549	45	0.000
62	00418	Decew Road @ Merrittville Highway	1.335	2.046	2.046	2.041	2.045	2.044	58	0.000
63	00424	Merritt Road @ Merrittville Highway/Niagara Street	1.522	2.380	2.433	1.972	1.989	2.193	43	0.000
64	00428	Lundy's Lane @ Thorold Townline Road	1.823	2.174	2.173	2.232	2.230	2.202	43	0.000
65	00429	Highway 20 @ Highway 58/Allanport Road	1.866	2.190	2.177	1.996	2.232	2.149	28	0.000
66	00440	Highway 20 @ Merrittville Highway	1.519	2.115	2.118	2.804	2.790	2.457	21	0.000
67	00441	Cataract Road @ Highway 20	1.308	2.011	1.995	2.804	2.804	2.403	34	0.000
68	00454	Highway 20 @ Vineland Townline Road	2.067	2.137	2.130	2.188	2.239	2.174	26	0.000
69	00488	Pelham Street @ Quaker Road	1.640	1.982	1.999	1.948	1.962	1.973	47	0.000
70	00491	Bacon Lane/Spruceside Crescent @ Pelham Street	2.070	1.977	1.981	1.992	1.322	1.818	47	0.000
71	00492	John Street/Pancake Lane @ Pelham Street	1.876	1.975	1.975	1.992	1.992	1.984	44	0.000
72	00494	Pelham Street @ Port Robinson Road \ Brock Street	1.418	1.976	1.975	1.956	1.960	1.967	44	0.000

Appendix C: Pedestrian Safety Risk Prioritization Scores for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	APT (S2)	North Ped ISI	South Ped ISI	West Ped ISI	East Ped ISI	Average Ped ISI	ODOT Risk Score	PSI
73	00502	Church Hill @ Pelham Street	1.681	2.229	2.223	2.230		2.227	47	0.000
74	00504	Highway 20 @ Pelham Street	1.909	2.239	2.239	2.263	2.270	2.253	43	0.065
75	00509	Haist Street @ Highway 20	2.195	2.237	2.237	2.263	2.263	2.250	52	0.080
76	00511	Highway 20 East @ Station Street	1.735	2.241	2.241	2.270	2.270	2.255	49	0.000
77	00521	Effingham Street @ Highway 20	1.748	2.062	2.062	2.164	2.025	2.078	49	0.000
78	00522	Highway 20 West @ Lookout Street	1.513	1.993	1.776	2.025	2.025	1.955	52	0.000
79	00526	Linwell Road @ Niagara Street	3.319	1.981	1.987	1.989	1.984	1.985	43	0.000
80	00527	Niagara Street @ Scott Street	3.922	2.225	2.240	2.264	2.258	2.247	75	0.648
81	00533	Carlton Street @ Vine Street	4.558	2.230	2.225	2.243	2.211	2.227	62	1.577
82	00539	Carlton Street @ Grantham Avenue	3.454	1.997	1.995	2.011	2.002	2.001	56	0.663
83	00543	Carlton Street @ Niagara Street	2.927	2.575	2.259	2.211	2.249	2.324	49	0.000
84	00549	Bunting Road @ Carlton Street	3.640	2.251	2.253	2.240	2.210	2.238	49	0.138
85	00559	Eastchester Avenue/Westchester Crescent @ Queenston Street	6.157	2.254	2.242	2.239	2.229	2.241	81	3.290
86	00572	Highway 406 East Ramp @ Westchester Avenue	2.477		1.329	2.720	2.683	2.244	37	0.058
87	00575	Niagara Stone Road & Taylor Road @ Queenston Street & York Rd	1.457	2.047	2.058	2.544	2.192	2.210	32	0.000
88	00590	Corporate Park Drive & South Service Road @ Martindale Road	1.789	2.880	2.937	2.199	2.213	2.557	41	0.000
89	00592	Fourth Avenue / Welland Avenue @ Ontario Street	3.071	2.059	1.996	2.078	2.009	2.036	37	0.000
90	00604	Forks Road @ Highway 3/Townline Road	1.629	2.044	2.364	2.034	2.029	2.118	27	0.000
91	00639	Henley Drive / Meadowvale Drive @ Ontario Street	2.849	2.961	2.961	2.262	2.246	2.608	29	0.000
92	00641	Niagara Street @ Vine Street / Facer Street	4.140	2.259	2.657	2.253	2.245	2.353	63	0.565
93	00644	Dunkirk Road @ Welland Avenue	1.941	2.355	2.690	1.972	1.974	2.248	65	0.000
94	00645	Carlton Street @ Lake Street	4.740	2.255	2.240	2.226	2.205	2.231	45	0.665
95	00646	Lake Street @ Welland Avenue	3.367	2.237	2.575	2.247	2.241	2.325	53	0.142
96	00647	Geneva Street @ Welland Avenue	4.060	2.276	2.623	2.241	2.249	2.348	69	0.593
97	00656	Seventh Street Louth @ South Service Road	1.183	1.961	1.952	1.939	1.948	1.950	28	0.000
98	00668	Ontario Street @ QEW South Ramp	1.459	2.961	2.997	1.920	1.905	2.446	32	0.000
99	00670	Ontario Street @ Scott Street West	2.926	2.997	2.955	2.036	2.250	2.560	55	0.506
100	00673	Carlton Street @ Ontario Street	2.809	2.620	2.632		2.561	2.604	60	0.003
101	00679	Queen Street @ Welland Avenue	3.091		1.992	2.009	2.009	2.003	64	0.137
102	00680	Clark Street / George Street @ Welland Avenue	2.870	2.228	2.234	2.241	2.241	2.236	81	0.000
103	00687	Niagara Street @ Russell Avenue	3.858	2.939	2.939	2.243	2.029	2.538	65	0.620
104	00695	First Street Louth @ St. Paul Street West	1.506	2.206	2.195	1.977	1.977	2.089	33	0.000
105	00697	Fourth Avenue @ Third Street Louth	1.424	2.040	2.042	2.041	2.376	2.125	19	0.000
106	00700	First Street Louth @ Fourth Avenue	2.205	2.223	2.231	2.874	2.944	2.568	30	0.000
107	00711	Louth Street @ Rykert Street	3.220	1.973	1.973	1.640	1.975	1.890	51	0.224
108	00715	Glendale Avenue/Nash Street @ Pelham Road	2.244	2.243	2.235	2.261	2.342	2.270	50	0.000
109	00729	Fourth Avenue @ Vansickle Road	1.695	2.027	2.235	2.944	2.944	2.537	38	0.000

Appendix C: Pedestrian Safety Risk Prioritization Scores for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	APT (S2)	North Ped ISI	South Ped ISI	West Ped ISI	East Ped ISI	Average Ped ISI	ODOT Risk Score	PSI
110	00730	Fourth Avenue @ Louth Street/Martindale Road	2.410	2.922	2.929	3.279	3.031	3.040	49	0.000
111	00731	Benfield Drive/Vintage Crescent @ Louth Street	1.802	2.230	2.236	2.929	2.929	2.581	35	0.000
112	00734	Hartzel Road @ Queenston Street	2.806		1.670	1.991	2.011	1.891	53	0.000
113	00745	Glendale Avenue @ Mountain Street	3.366	2.266	2.266	3.002	3.002	2.634	57	1.070
114	00747	Glendale Avenue @ Glenridge Avenue	3.807	2.229	2.226	2.602	2.259	2.329	51	0.649
115	00748	Glendale Avenue @ Marsdale Drive	1.974	1.994	1.994	2.029	2.029	2.012	46	0.000
116	00752	North Service Road @ QEW Off-Ramp	0.906		1.625	1.954	1.954	1.844	21	0.000
117	00755	Ontario Street @ QEW Off Ramp	1.309	2.675	2.711	1.285		2.223	10	0.180
118	00764	East and West Line @ Niagara Stone Road	2.344	2.135	2.166	2.205	2.205	2.178	26	0.179
119	00766	Hunter Road @ Niagara Stone Road	1.661	2.135	2.135	1.980		2.083	39	0.000
120	00772	Garrison Village Drive @ Niagara Stone Road	1.823	2.135	2.135	1.976	1.976	2.055	39	0.000
121	00785	Mary Street @ Niagara Stone Rd/Mississauga Street	1.683	2.242	2.223	2.192	2.216	2.218	54	0.000
122	00800	Glendale Avenue @ Tremont Drive	2.010	2.594	2.586	2.929	2.966	2.769	48	0.000
123	00801	Pelham Road @ St. Paul Street West	1.828		1.896	2.225	2.240	2.120	40	0.000
124	00811	Glendale Avenue @ Highway 406 West Ramp	2.030	1.573	1.908	3.636	3.301	2.605	51	0.000
125	00812	Burleigh Hill Drive/Glengarry Road @ Glendale Avenue	2.503	2.240	2.215	3.011	3.002	2.617	66	0.000
126	00813	Glendale Avenue @ Highway 406 East Ramp	1.427	1.909	1.581	2.966	3.346	2.451	24	0.000
127	00816	Blain Place @ Westchester Crescent	2.601	1.991	1.991	2.683	2.683	2.337	49	0.000
128	00818	Oakdale Avenue @ Westchester Crescent	3.398	2.229	2.227	2.921	2.912	2.572	60	0.000
129	00835	Brown Road/Primeway Drive @ Woodlawn Road	1.693	2.347	1.998	2.769	2.769	2.471	26	0.000
130	00836	River Road @ Woodlawn Road	1.791	1.931	1.931	2.792	2.769	2.356	33	0.000
131	00837	Seaway Drive @ Woodlawn Road	2.161	1.698		3.030	3.030	2.586	35	0.000
132	00838	Niagara Street @ Quaker Road	2.226	2.768	2.781	2.002	2.002	2.388	55	0.000
133	00841	First Avenue @ Woodlawn Road	2.914	2.005	1.997	2.686	2.691	2.345	37	1.200
134	00842	Champlain Avenue @ Woodlawn Road	1.862	1.996	1.996	2.686	2.686	2.341	33	0.656
135	00848	Clare Avenue @ Woodlawn Road	1.782	1.979	1.977	1.987	1.987	1.983	49	0.000
136	00850	South Pelham Road @ Thorold Road	2.069	2.243	2.226	2.271	2.276	2.254	60	0.000
137	00853	South Pelham Road @ Woodlawn Road	2.109	2.018	2.005		1.652	1.891	42	0.000
138	00855	Humberstone Road/Townline Tunnel Road @ Prince Charles Drive South/Highway 58	2.040	2.081	2.222	2.166	2.188	2.164	51	0.000
139	00859	Lincoln Street @ Prince Charles Drive North/Prince Charles Drive South	2.053	2.949	2.945	2.235	2.932	2.765	43	0.000
140	00867	South Pelham Road @ Webber Road	1.806	1.988	1.986	2.188	2.058	2.055	38	0.000
141	00871	East Main St/Schisler Rd @ Moyer Road/Doans Ridge Road	1.610	2.191	2.015	2.232	2.200	2.160	39	0.000
142	00873	East Main Street @ Farr Road/Highway 140	1.557	1.986	2.571	2.940	2.902	2.600	39	0.000
143	00875	East Main Street @ Wellington Street/Wellington Street North	1.960	2.247	2.168	2.926	2.953	2.573	18	0.042
144	00876	East Main Street @ St Andrews Avenue	2.451		2.230	2.591	2.591	2.471	56	0.000
145	00881	Highway 406 West Ramp @ Westchester Avenue	1.632	1.569	2.239	2.958	2.958	2.431	50	0.000

Appendix C: Pedestrian Safety Risk Prioritization Scores for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	APT (S2)	North Ped ISI	South Ped ISI	West Ped ISI	East Ped ISI	Average Ped ISI	ODOT Risk Score	PSI
146	00882	Bond Street/Race Street/Ramp @ Geneva Street	2.283	2.979	2.898	1.912	1.912	2.425	56	0.000
147	00883	Geneva Street @ Westchester Avenue/Westchester Crescent	1.956	2.563	2.234	2.939	2.958	2.673	22	0.000
148	00885	Glenridge Avenue @ Westchester Crescent	1.815		1.670	2.706	2.366	2.248	31	0.036
149	00887	Glen Morris Drive @ Glenridge Avenue	2.005	2.340	1.991		1.655	1.995	23	0.664
150	00899	Glendale Avenue @ Niagara-on-the-Green Boulevard	1.372		1.318	2.673	2.673	2.222	7	0.164
151	00900	Glendale Avenue @ Taylor Avenue	1.745	2.618	2.295	2.911	2.948	2.693	27	0.000
152	00906	Glendale Avenue @ QEW North Ramp	1.859	2.710	2.375	2.020	1.669	2.193	37	0.000
153	00917	Airport Road @ York Road	1.027	2.379	1.961	2.192	2.042	2.143	34	0.000
154	00919	Glendale Avenue @ York Road	1.666	2.003	2.375	2.377	2.732	2.372	21	0.000
155	00929	Caroline Street @ Glendale Avenue	1.945	1.992		2.021	2.021	2.011	55	0.105
156	00937	Glenridge Avenue @ Norman Road/University Road East	1.583	2.896	2.896	2.002	2.216	2.502	45	0.204
157	00938	Bunting Road @ Queenston Street	2.213	2.004	1.987	2.011	1.979	1.995	48	0.000
158	00943	Court Street @ Welland Avenue	2.797		1.901	2.241	2.241	2.128	53	0.153
159	00945	Niagara Street @ Welland Avenue	4.323	2.939	2.914	2.249	2.254	2.589	66	0.080
160	00952	Glenridge Avenue @ Rockcliffe Road	2.393	2.005	2.005	1.988	1.988	1.997	49	0.000
161	00959	Erion Road @ Martindale Road	2.091	2.267	2.267	2.242	2.235	2.253	52	0.000
162	00962	Grapeview Drive @ Martindale Road	2.248	2.252	2.252	2.228	2.228	2.240	46	0.131
163	00970	Elderwood Drive @ Martindale Road	2.095	2.014	2.014	1.994		2.008	41	0.000
164	00972	Fourth Avenue @ Highway 406 Ramps	2.444	2.748	2.793	1.703	2.038	2.320	39	0.341
165	01001	Lake Street @ Ontario Street	1.998	1.989		1.996	1.990	1.991	54	0.000
166	01004	King Street @ Ontario Street	1.882	1.903		2.231	2.244	2.126	34	0.000
167	01006	Ontario Street/Westchester Crescent @ St. Paul Street/St. Paul Street West	2.614	2.228	2.240	2.244	2.609	2.330	48	0.649
168	01008	King Street @ William Street	2.275	2.239	2.585	2.213	2.213	2.312	56	0.175
169	01012	Church Street @ Geneva Street	6.413	2.955	2.599	2.230	2.223	2.502	84	5.774
170	01013	Church Street @ Niagara Street	3.468	2.579	2.244	2.558	2.556	2.484	81	0.162
171	01014	Geneva Street @ Niagara Street/Queenston Street/St. Paul Street	3.232	2.599	2.644	2.254	2.244	2.435	77	0.000
172	01019	Vine Street South @ Welland Avenue	2.480	2.236	2.236	2.254	2.258	2.246	59	0.000
173	01024	Dunlop Drive/Dunkirk Road @ Niagara Street	3.664	3.036	2.701	1.678	1.655	2.267	45	0.629
174	01025	Dieppe Road/North Service Road/Ramp @ Niagara Street	2.964	2.754	2.701	1.686	1.668	2.202	32	1.175
175	01027	Queenston Street @ Welland Canals Parkway	1.728	2.215	2.221	2.557	2.222	2.304	52	0.000
176	01029	Cushman Road @ Queenston Street	1.904	1.644		2.314	2.654	2.204	31	0.000
177	01061	Four Mile Creek Road @ Niagara Stone Road	2.465	2.217	2.208	2.241	2.255	2.230	54	0.000
178	01064	Line 1 Road/Penner Street @ Niagara Stone Road	2.443	2.404	2.404	2.227	2.227	2.316	26	0.000
179	01072	Glendale Avenue @ Welland Canals Parkway	1.588	1.993		2.344	1.997	2.112	40	0.000
180	01082	Hyundai Dealership Entrance @ Ontario Street	2.815	2.955	2.955	2.028	2.028	2.491	52	0.000
181	01085	Fourth Avenue @ Ridley Square Plaza Entrance	2.120	2.061	2.061	3.701	3.701	2.881	46	0.000

Appendix C: Pedestrian Safety Risk Prioritization Scores for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	APT (S2)	North Ped ISI	South Ped ISI	West Ped ISI	East Ped ISI	Average Ped ISI	ODOT Risk Score	PSI
182	01100	Main Street East @ Wentworth Drive	1.865	2.235	2.235	2.250	2.250	2.242	43	0.000
183	01101	Main Street East @ Nelles Road North/Nelles Road South	1.843	1.997	1.996	2.012	2.012	2.004	43	0.000
184	01105	Main Street East @ Maple Avenue	1.878	1.992		2.014	2.012	2.006	43	0.000
185	01110	Elm Street @ Main Street East	2.864		1.904	2.236	2.252	2.131	28	1.183
186	01112	Elm Street @ Mountain Street	1.855	1.979	1.987	1.984	1.982	1.983	41	0.000
187	01115	Christie Street/Mountain Street @ Main Street	2.450	2.256	2.217	2.247	2.236	2.239	43	0.664
188	01117	Livingston Avenue @ Murray Street	1.740	2.230	2.230	2.235	2.235	2.233	43	0.000
189	01122	Kidd Avenue @ Livingston Avenue	1.102	2.009	2.221	2.235	2.235	2.175	25	0.000
190	01129	Kerman Avenue @ Livingston Avenue	1.770	1.986	1.981	1.987	1.997	1.988	43	0.000
191	01137	Highland Avenue @ Lundy's Lane	2.671	2.253	2.040	2.979	2.979	2.563	47	0.489
192	01139	Drummond Road @ Lundy's Lane	4.444	2.590	2.587	2.979	2.939	2.774	35	2.423
193	01142	Ferry Street/Lundy's Lane @ Main Street	4.366	2.239	2.247	2.604	2.246	2.334	81	2.313
194	01148	Ferry Street @ Stanley Avenue	2.785	2.949	2.938	2.230	2.250	2.592	48	0.020
195	01155	Montrose Road @ Rysdale Street	1.927	2.675	2.675	1.986		2.445	52	0.000
196	01157	Highway 420 @ Montrose Road/Ramp/Watson Street	2.504	2.679	2.675	1.995	2.354	2.425	35	0.000
197	01161	Bertie Street/Ramp @ Thompson Road	1.478	2.699	2.808	2.749	2.752	2.752	34	0.000
198	01162	Bertie Street @ Central Avenue	2.306	1.966	2.300	1.967	1.967	2.050	57	0.000
199	01168	Gilmore Road @ Thompson Road	1.681	2.027	2.029	2.177	2.106	2.085	40	0.000
200	01178	Central Avenue @ Gilmore Road	2.092	1.881	1.966	1.955	1.943	1.937	44	0.204
201	01179	Livingston Avenue @ Roberts Road	1.532	1.905	1.978	1.987	1.987	1.964	38	0.000
202	01191	Casablanca Boulevard @ Ramp/South Service Road	2.225	2.322	2.317	2.195	2.210	2.261	33	0.189
203	01200	Greenlane @ Ontario Street	1.099	2.630	2.593	2.242	2.242	2.427	25	0.000
204	01279	Frederick Avenue @ Victoria Avenue	1.620	2.008	2.008	1.988		2.001	40	0.000
205	01280	May Street/Serena Drive @ Ontario Street	2.284	2.020	2.020	1.997	1.997	2.009	56	0.000
206	01286	Christie Street @ QEW Off Ramp	1.338	2.634	3.023	1.980	1.980	2.404	25	0.000
207	01287	Christie Street/Lakeview Avunue @ Olive Street	2.254	1.972	1.964	1.955	1.955	1.961	41	0.539
208	01307	John Street & Alyssa Drive @ Ontario Street	2.478	2.258	2.258	2.244	2.173	2.233	56	0.000
209	01317	Ontario Street @ South Service Road	1.764	2.696	2.727	2.293	1.940	2.414	25	0.164
210	01319	Friesen Boulevard @ Ontario Street	2.501	2.258	2.258	2.230		2.249	56	0.000
211	01330	South Service Road @ Victoria Avenue	1.825	2.398	2.083	2.165	2.164	2.202	28	0.000
212	01375	Grimsby Road @ Highway 20	1.636	2.036		2.197	2.215	2.149	41	0.000
213	01396	Canborough Road @ Regional Road 27/Wellandport Road	1.158	2.032	2.022	1.941	1.949	1.986	28	0.000
214	01408	Bridge Street @ Fourth Avenue	3.151	1.645	1.978	1.979	1.979	1.895	45	0.000
215	01412	Bridge Street @ Victoria Avenue	1.810	2.221	2.227	2.217	2.186	2.213	54	0.000
216	01417	Chorozy Street @ Montrose Road	2.449	2.695	2.360	1.990	2.680	2.431	54	0.000
217	01421	Montrose Road @ Thorold Stone Road	3.125	2.858	2.933	2.973	2.702	2.867	51	1.139
218	01422	QEW West Ramp @ Thorold Stone Road	1.784	1.598	1.915	3.037	2.979	2.382	56	0.000

Appendix C: Pedestrian Safety Risk Prioritization Scores for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	APT (S2)	North Ped ISI	South Ped ISI	West Ped ISI	East Ped ISI	Average Ped ISI	ODOT Risk Score	PSI
219	01423	QEW East Ramp @ Thorold Stone Road	1.988	1.907	1.587	2.979	2.979	2.363	51	0.000
220	01426	Dorchester Road @ Thorold Stone Road	4.727	2.934	2.943	2.979	2.948	2.951	74	1.800
221	01428	St James Avenue @ Thorold Stone Road	2.614	2.002	2.002	2.710	2.710	2.356	54	0.000
222	01432	Drummond Road / Portage Road @ Thorold Stone Road	2.297	2.932	2.579	2.948	2.932	2.848	79	0.025
223	01435	Stanley Avenue @ Thorold Stone Road	1.510		2.024	2.694	2.694	2.471	24	0.000
224	01437	Montrose Road @ South Wood Drive	2.040	2.188	2.188	1.964	1.853	2.048	41	0.000
225	01449	Mountain Road @ St Paul Avenue	1.743	2.303	2.311	2.225	2.261	2.275	43	0.000
226	01451	Dorchester Road @ Mountain Road	1.403	2.053	1.986	2.082	1.987	2.027	35	0.000
227	01462	Farr Avenue @ Gorham Road/Ridgeway Road	1.708	2.058	2.049	2.030	2.030	2.042	32	0.000
228	01467	Dominion Road @ Gorham Road	1.774	2.224	2.233	1.988	2.198	2.161	41	0.000
229	01473	Dominion Road @ Ridge Road North	2.171	2.203	2.201	2.198	2.198	2.200	44	0.000
230	01501	Garner Road @ Lundy's Lane	1.694	2.293	2.301	2.988	2.988	2.643	41	0.000
231	01502	Kalar Road @ Lundy's Lane	3.018	2.915	2.939	2.913	2.980	2.937	42	0.000
232	01504	Garner Road @ Thorold Stone Road	1.380	2.143	2.070	2.870	2.870	2.488	33	0.000
233	01505	Kalar Road @ Thorold Stone Road	2.425	2.303	2.261	3.033	3.048	2.661	53	0.000
234	01507	Brookdale Drive / Cardinal Drive @ Thorold Stone Road	2.847	2.015	2.012	2.735	2.735	2.374	74	0.000
235	01542	Biggar Road & Lyons Creek Road @ Montrose Road	1.693	2.194	2.219	2.187	2.205	2.201	41	0.000
236	01561	Marineland Parkway @ Stanley Avenue	2.195		1.960	2.692	2.694	2.448	30	0.000
237	01562	Marineland Parkway @ Stanley Avenue/Thundering Waters Boulevard	1.787	2.317	1.984	2.690	2.692	2.421	47	0.000
238	01563	McLeod Road @ Montrose Road	2.502	2.223	2.531	2.963	3.336	2.763	46	0.591
239	01564	McLeod Road @ Oakwood Drive/Ramp	2.312	2.259	2.613	3.001	2.986	2.715	51	0.000
240	01566	Dorchester Road @ McLeod Road	4.046	2.254	2.260	2.986	2.952	2.613	79	0.000
241	01573	Drummond Road @ McLeod Road	3.380	2.248	2.238	2.952	2.928	2.591	71	0.044
242	01579	Livingstone Street @ Stanley Avenue	1.263	2.890	2.890	2.557	2.213	2.638	33	0.000
243	01581	Dunn Street @ Stanley Avenue	1.255	2.907	2.890	2.221	2.227	2.561	35	0.000
244	01584	Dixon Street & Main Street @ Stanley Avenue	1.802	2.907	2.907	2.220	2.230	2.566	24	0.000
245	01587	Murray Street @ Stanley Avenue	3.017	2.914	2.907	2.228	2.588	2.659	65	1.177
246	01591	Robinson Street @ Stanley Avenue	2.865	2.938	2.914	2.234	2.228	2.579	48	1.196
247	01594	Lundy's Lane @ Montrose Road	3.944	2.578	2.223	2.980	2.975	2.689	54	1.802
248	01595	Belmont Avenue @ Lundy's Lane	2.057	2.249	1.719	2.975	2.975	2.480	27	0.000
249	01596	Lundy's Lane @ Royal Manor Drive	2.182	2.249	2.249	3.310	2.975	2.696	42	0.000
250	01599	Dorchester Road @ Lundy's Lane	3.986	2.940	2.917	2.975	2.979	2.953	48	1.145
251	01606	Central Avenue @ Wintemute Street	1.928	1.956	1.956	1.887	1.887	1.921	41	0.000
252	01613	Central Avenue @ Jarvis Street	2.324	2.192	2.194	2.196	2.196	2.195	40	0.460
253	01629	Falls Avenue & Highway 420 @ Stanley Avenue	2.910	2.919	2.949	3.506	3.306	3.170	31	0.000
254	01633	Stanley Avenue @ Valley Way	1.682	2.681	2.681	1.996	1.993	2.338	38	0.000
255	01634	Montrose Road @ Preakness Street	2.921	2.917	2.917	2.233	2.233	2.575	55	0.141

Appendix C: Pedestrian Safety Risk Prioritization Scores for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	APT (S2)	North Ped ISI	South Ped ISI	West Ped ISI	East Ped ISI	Average Ped ISI	ODOT Risk Score	PSI
256	01640	Morrison Street @ Stanley Avenue	1.782	2.011	2.011	1.995	2.002	2.005	51	0.000
257	01648	Bridge Street @ Stanley Avenue	1.257	2.024	2.011		1.979	2.005	43	0.000
258	01673	Gorham Road @ Highway 3	1.506	2.057	2.061	2.876	3.223	2.554	11	0.000
259	01676	Garrison Road @ Municipal Centre Drive	1.400	2.121	1.844	2.762	2.762	2.372	47	0.000
260	01681	Garrison Road @ Pettit Road / Daytona Drive	2.249	1.993	1.993	2.762	2.782	2.382	50	0.000
261	01725	Garrison Road @ Helena Street/Thompson Road	2.224	3.046	2.998	3.355	2.993	3.098	18	0.155
262	01728	Concession Road @ Garrison Road	1.830	2.573	2.229	2.993	2.904	2.675	35	0.157
263	01730	Garrison Road @ King Street	2.174	2.219	2.219	2.904	2.904	2.562	48	0.000
264	01745	East Main Street/West Main Street @ Stevensville Road	1.838	2.229	2.227	2.215	2.215	2.222	39	0.652
265	01826	Central Avenue @ Garrison Road/Veterans Way	1.236	2.883	2.856	2.569	2.219	2.632	33	0.000
266	01827	Sims Avenue @ Thompson Road	1.400	3.381	3.381	2.219	2.219	2.800	40	0.000
267	01828	Central Avenue @ QEW East Off-Ramp	1.230	3.208	3.208	1.534		2.650	10	0.000
268	020SBY	Highway 20 @ Sobey Entrance	1.735	2.017	1.690	2.605	2.605	2.229	34	0.000
269	03000	Clairmont Street @ Ormond Street South	3.010	2.243	2.233	2.204	2.211	2.223	47	0.195
270	03127	Burleigh Hill Dr/Collier Rd N @ St David's Rd	3.642	1.977	1.958	1.969	1.969	1.969	58	0.572
271	03131	Ormond Street North @ Regent Street	2.505	2.236	2.237	2.201	2.201	2.219	54	0.205
272	03707	Clare Avenue @ Thorold Road	1.830	1.888	1.961	1.991	1.991	1.958	47	0.000
273	040SSR	South Service Road @ Superstore/Rona	1.465		1.876	2.210	2.210	2.099	23	0.000
274	04220	Burbank Drive @ First Street Louth	1.360	2.244	2.231	2.550	2.202	2.307	36	0.000
275	042ANC	Anchor Pointe @ Ontario Street	1.815	2.032	2.032		1.767	1.944	57	0.000
276	05097	First Street Louth @ Third Avenue Louth	2.413	1.909	1.916	1.890	1.555	1.818	37	0.000
277	050PLZ	Glenridge Avenue @ Glenridge Plaza Entrance	1.914	2.243	2.243	1.681	2.016	2.046	23	0.000
278	05178	Erion Road @ First Street Louth	2.573		1.640	1.983	1.994	1.872	37	0.000
279	05650	Davis Road @ Highway 58	1.917	1.559	2.553	3.282	3.316	2.677	33	0.000
280	05691	Collier Road South @ Richmond Street	3.080	1.958	1.960	1.972	1.977	1.967	53	0.217
281	05705	Pine Street South @ Richmond Street	2.340	2.233	1.864	2.204	2.215	2.129	74	0.222
282	05817	Clarence Street @ Steele Street	1.852	1.991	1.981	1.958	1.967	1.974	52	0.000
283	05820	Clarence Street @ Elm Street	2.085	2.211	2.200	2.216	2.223	2.213	49	0.221
284	05823	Clarence Street @ King Street	2.965	2.211	2.200	2.216	2.228	2.214	47	0.219
285	05830	Clarence Street @ Welland Street	1.489		1.866	2.210	2.218	2.098	32	0.000
286	05939	Killaly Street West @ Steele Street	2.817	2.215	2.219	2.140	2.132	2.177	54	0.610
287	05943	Elm Street @ Killaly Street West	2.620	2.201	2.199	2.132	2.132	2.166	54	0.223
288	05947	Killaly Street West @ King Street	2.117	2.210	2.213	2.207	2.207	2.209	46	0.224
289	06011	Mellanby Avenue @ Welland Street	1.970	1.964	1.977	1.954		1.965	46	0.221
290	06140	Northland Avenue @ West Side Road	1.234	3.045	3.056	2.222	2.222	2.636	30	0.000
291	06163	Highway 140 @ Second Concession Road	1.740	2.203	2.203	1.972	1.970	2.087	41	0.000
292	06256	Colborne Street @ Forks Road	1.043	1.992		1.965	1.969	1.975	33	0.000

Appendix C: Pedestrian Safety Risk Prioritization Scores for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	APT (S2)	North Ped ISI	South Ped ISI	West Ped ISI	East Ped ISI	Average Ped ISI	ODOT Risk Score	PSI
293	06280	Canal Bank Street @ Highway 58A/Townline Tunnel Road	2.519	2.049	2.045	2.188	2.538	2.205	32	0.000
294	06333	Broadway & Ontario Road @ Canal Bank Street	1.837	1.957	2.049	1.971	1.995	1.993	50	0.000
295	06336	King Street @ Ontario Road	1.600	2.210		2.223	2.575	2.336	60	0.000
296	06340	Dain Avenue/Plymouth Road @ Ontario Road	1.554	1.971	1.962	1.979	1.988	1.975	44	0.000
297	06346	Ontario Road @ Wright Street	3.420	1.985	2.203	2.231	2.241	2.165	54	1.568
298	06348	Ontario Road @ Southworth Street	2.319	2.214	2.205	2.225	2.225	2.217	29	0.214
299	06454	King Street @ Third Street	1.685	2.230	2.218		2.230	2.226	53	0.000
300	06517	King Street @ Lincoln Street	3.865	2.217	2.218	2.611	2.243	2.322	76	2.788
301	06522	Denistoun Street @ Lincoln Street	1.799	1.964		2.002	2.665	2.210	46	0.204
302	06527	Hellems Avenue/Plymouth Road @ Lincoln Street	4.826	1.631	1.638	1.987	1.923	1.795	49	3.306
303	06534	Lincoln Street @ Wavell Court	1.882	2.202	2.202	2.239	2.240	2.221	54	0.000
304	06535	Crowland Avenue/Southworth Street @ Lincoln Street	3.198	2.220	2.218	2.239	2.233	2.227	39	1.139
305	06541	Classic Avenue @ Lincoln Street/Scholfield Avenue	2.221	1.992	1.992	1.987	1.987	1.989	54	0.000
306	06606	King Street @ Regent Street	2.648	2.227	2.238	2.230	2.230	2.231	68	0.000
307	06615	Crowland Avenue @ Hagar Street	2.014	1.985	1.995	1.961	1.961	1.976	52	0.000
308	06745	Fitch Street @ Willson Road	2.013	2.209	2.209	2.231	2.239	2.222	56	0.000
309	06949	First Avenue @ Thorold Road	2.920	1.981	1.971	1.986	2.002	1.985	39	0.198
310	070NIA	Niagara College @ Taylor Road	0.913	2.392	2.392		1.643	2.143	13	0.000
311	070WHT	South Service Road @ Taylor Road	1.060	2.953	2.953	2.329	1.990	2.556	17	0.000
312	07126	Eastwood Drive @ Rice Road/Talbot Trail	1.342	1.903	1.903	1.973	1.977	1.939	44	0.000
313	07129	First Avenue @ Woodgate Dr./Niagara College	1.047	1.975	1.990	2.303	1.957	2.056	35	0.000
314	077HSP	Fourth Avenue @ Hospital Entrance	1.137		1.753	2.711	2.636	2.367	11	0.000
315	07917	King Street @ Queen Street	2.179	2.246	2.214	2.207	2.207	2.219	54	0.000
316	07930	Church Street @ Queen Street	2.146	2.238	2.228	2.207	2.215	2.222	54	0.000
317	07951	Carlisle Street @ St. Paul Street	2.592	2.230	2.228	2.240	2.240	2.234	73	0.665
318	07952	James Street @ King Street	3.462	2.247	2.246	2.215	2.215	2.231	56	1.661
319	07972	Church Street @ James Street	2.820	2.239	2.239	2.215	2.225	2.230	60	0.000
320	07976	Carlisle Street @ King Street	3.941	2.242	2.250	2.217	2.227	2.234	73	1.679
321	07990	Carlisle Street/Lyman Street @ Church Street	2.469	2.219	2.219	1.883	1.912	2.058	81	0.000
322	08012	James Street @ Lake Street	3.859	2.605	2.240		1.899	2.248	53	0.113
323	08036	Prince Street @ Queenston Street	2.481	1.968		1.988	1.993	1.983	62	0.000
324	08059	Oakdale Avenue/Tasker Street @ Queenston Street	4.007	2.211	2.211	2.234	2.244	2.225	68	1.135
325	08110	Beech Street @ Lake Street	3.118	2.240	2.254	2.214	2.214	2.230	62	0.000
326	08170	Lake Street @ Russell Avenue	3.730	2.002	1.995	1.970	1.976	1.986	68	0.660
327	08186	Geneva Street @ Russell Avenue	3.220	2.017	2.017	1.971	1.977	1.996	81	0.000
328	08222	Dieppe Rd @ Welland Avenue	2.212	2.330	2.351	1.961	1.963	2.151	37	0.195
329	08266	Grantham Avenue @ Welland Avenue	4.183	2.554	2.222	2.937	2.925	2.660	48	1.195

Appendix C: Pedestrian Safety Risk Prioritization Scores for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	APT (S2)	North Ped ISI	South Ped ISI	West Ped ISI	East Ped ISI	Average Ped ISI	ODOT Risk Score	PSI
330	08325	Dunlop Drive @ Geneva Street	2.186	2.659	2.654	1.967	1.620	2.225	71	0.000
331	08333	Lake Street @ Springdale Avenue/Dunlop Drive	2.348	2.698	2.681	1.962	1.977	2.330	50	0.152
332	08397	Facer Street @ Grantham Avenue	2.140	1.995	1.995	1.967	1.967	1.981	64	0.000
333	08416	North Service Road @ YMCA Drive	2.511	1.993	2.237	2.611	2.593	2.359	92	0.000
334	08421	Lake Street @ Meadowvale Drive/North Service Road	3.685	2.962	2.974	2.237	2.585	2.689	72	0.553
335	08466	Lake Street @ Scott Street	3.639	2.947	2.973	2.216	2.226	2.591	51	0.000
336	08475	Hill Park Lane @ Vine Street	3.193	2.004	2.007	1.992		2.001	64	0.186
337	08507	Scott Street @ Secord Drive	2.431	2.225		2.242	2.247	2.238	54	0.000
338	08540	Geneva Street @ Scott Street	3.416	2.344	2.027	1.974	1.982	2.082	72	0.000
339	08549	Lake Street @ Secord Drive	2.940	2.926	2.944	2.215	2.219	2.576	57	0.000
340	08598	Lake Street @ Lakeport Road	2.706	2.262	2.955		1.875	2.364	60	0.000
341	08613	Scott Street @ Tabor Drive	2.481	1.992		1.998	2.006	1.999	62	0.000
342	08637	Scott Street @ Vine Street	4.167	2.229	2.230	2.251	2.256	2.242	76	0.000
343	08671	Lakeport Road @ Linwell Road	3.299	2.228	2.238	2.250	2.257	2.243	62	0.119
344	08696	Lake Street @ Linwell Road	3.796	2.585	2.255	2.221	2.228	2.323	64	0.000
345	08740	Grantham Avenue @ Scott Street	3.428	1.996	2.000	1.974	1.982	1.988	68	0.661
346	08777	Geneva Street @ Linwell Road	3.833	1.656	2.005	1.972	1.980	1.903	56	0.661
347	08871	Linwell Road @ Vine Street	2.656	2.234	2.243	2.215	2.219	2.228	56	0.000
348	08931	Linwell Road @ Maplewood Drive	1.891		1.992	1.983	1.994	1.990	52	0.000
349	089PND	Glendale Avenue @ Pen Centre Entrance	1.763	2.020	2.020	2.929	2.929	2.474	39	0.000
350	09740	Kalar Road @ McLeod Road	2.290	2.908	2.547	2.917	2.947	2.830	45	0.000
351	09775	Coventry Road @ Kalar Road	2.845	2.700	2.683		1.963	2.449	56	0.000
352	09807	Forestview Boulevard & Rideau Street @ Kalar Road	2.700	2.702	2.692	1.969	1.958	2.330	59	0.147
353	10020	Highway 58 @ Niagara Falls Road/Beaverdams Road	1.519	2.888	2.860	2.192	2.198	2.534	34	0.000
354	10172	Glendale Avenue @ Merritt Street	2.791	2.267	2.250	2.667	2.247	2.358	38	0.000
355	10209	Chestnut Street East @ Merritt Street	2.131	2.237	2.245	2.207	2.207	2.224	51	0.189
356	10250	Merritt Street @ Oakdale Avenue	2.775	2.235	2.242	2.207		2.228	55	0.195
357	10299	Hartzel Road/Merritt Street @ Rockwood Avenue	2.491	2.251	2.243	1.988	2.213	2.174	36	0.000
358	10330	Admiral Road @ Hartzel Road	2.529	2.252	2.588	1.981	2.206	2.257	57	0.665
359	10380	Dunvegan Road @ Hartzel Road	1.660	2.235	2.251	1.981	2.206	2.168	49	0.000
360	10455	Hartzel Road @ Keswick Street/Lincoln Avenue	2.916	2.238	2.246	2.216	2.208	2.227	54	0.181
361	10571	Eastchester Avenue @ Grantham Avenue South	2.318	1.961	1.961	2.000	1.985	1.977	46	0.640
362	10634	Bunting Road @ Eastchester Avenue	2.385	2.345	1.992	1.967		2.101	41	0.000
363	10648	Bunting Road @ Dunkirk Road	1.754	2.688	2.672	1.966	1.961	2.322	48	0.000
364	10651	Bunting Road @ Dieppe Road	2.240	2.940	2.935	2.202	2.202	2.570	51	0.000
365	10673	Neilson Avenue @ Welland Avenue	1.766	2.211	2.211	2.246	2.240	2.227	41	0.181
366	10681	Bunting Road @ Welland Avenue	4.764	2.928	2.943	2.210	2.210	2.573	53	2.786

Appendix C: Pedestrian Safety Risk Prioritization Scores for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	APT (S2)	North Ped ISI	South Ped ISI	West Ped ISI	East Ped ISI	Average Ped ISI	ODOT Risk Score	PSI
367	10703	Bunting Road @ Roehampton Avenue	2.091	2.232	2.258	2.205	1.980	2.169	51	0.185
368	10917	Bunting Road @ Scott Street	3.459	2.006	1.993	1.638	1.973	1.903	41	0.191
369	11754	Montrose Road @ Niagara Square Drive	0.605	2.866	2.866	1.305	1.533	2.143	8	0.000
370	11809	McLeod Road @ Pin Oak Drive	1.546	2.322	2.212	2.929	2.973	2.609	35	0.000
371	11816	McLeod Road @ Niagara Square Drive/Ramp	1.772	1.688	2.009	2.763	3.098	2.390	51	0.000
372	11818	McLeod Road @ QEW Ramp East	1.580		1.353	2.763	2.763	2.293	43	0.000
373	11910	Fraser Hill @ Niagara River Parkway	1.066	2.667	2.651	1.959		2.426	31	0.000
374	11976	Dorchester Road @ Dunn Street	2.253	1.984	1.986	1.961	1.970	1.975	66	0.219
375	11994	Drummond Road @ Dunn Street	3.305	2.256	2.235	2.213	2.226	2.232	60	0.163
376	12006	Dunn Street @ Fallsview Boulevard	1.977	2.235	2.241	1.871		2.116	31	0.000
377	12016	Fallsview Boulevard @ Main Street/Portage Road	2.660	2.226	2.216	2.225	2.225	2.223	49	0.651
378	12089	Allendale Avenue @ Main Street/Murray Street	2.852	2.203	2.896	2.236	2.248	2.396	40	0.000
379	12099	Fallsview Boulevard @ Murray Street	2.985	2.918	2.584	2.882	2.556	2.735	28	0.159
380	12211	Ellen Avenue/Clark Avenue @ Ferry Street	1.885	2.200	2.200	2.244	2.233	2.219	43	0.204
381	12215	Clifton Hill @ Niagara River Parkway/River Road	1.386	2.556		2.918	2.905	2.793	34	0.171
382	12248	Clifton Hill @ Falls Avenue	1.696	2.557	2.910	2.205	2.221	2.473	28	0.000
383	12299	Clifton Hill & Centre Street @ Victoria Avenue	2.162	2.206	2.215	2.235	2.234	2.223	53	0.658
384	12324	Main Street/Portage Road @ North Street	2.042	2.231	2.231	2.209	2.214	2.221	68	0.203
385	12329	Hiram Street @ River Road	1.462	2.227	2.225	1.870		2.107	32	0.000
386	12332	Bender Street & Blondin Avenue & Rainbow Bridge @ Falls Avenue	1.013	2.802	2.802	2.132	2.473	2.552	11	0.000
387	12346	Victoria Avenue @ Walnut Street	2.473	2.200	1.865	2.216	2.242	2.131	71	0.000
388	12348	Dorchester Road @ Frederica Street/Royal Manor Drive	3.192	2.697	2.679	1.961	2.651	2.497	38	1.687
389	12350	Blondin Avenue @ Hiram Street	0.944	2.200	2.212	2.235	2.551	2.299	18	0.000
390	12355	Bender Street @ Ontario Avenue	1.239	1.975	2.892	2.235	2.576	2.420	34	0.000
391	12368	Bender Street @ Victoria Avenue	1.679	2.236	2.230		2.223	2.230	28	0.000
392	12378	Drummond Road @ Frederica Street	2.583	1.990	2.345	1.633		1.989	41	0.658
393	12440	Falls Avenue @ MacDonald Avenue	1.839	2.218	2.219	2.971	2.971	2.595	18	0.000
394	12475	Dorchester Road @ Ramp	1.733	2.705	3.041	1.637		2.461	35	0.000
395	12493	Drummond Road @ Valley Way	2.132	1.997	2.015	1.963	1.975	1.988	53	0.000
396	12504	Portage Road @ Valley Way	2.491	1.988	1.989	1.961	1.973	1.978	66	0.000
397	12533	McRae Street/Kincald Place @ Victoria Avenue	3.100	2.233	2.239	2.207	2.207	2.222	62	0.657
398	12561	Dawson Street @ Dorchester Road	2.367	3.290	3.304	2.216	2.208	2.755	33	0.000
399	12607	Jepson Street @ Victoria Avenue	2.940	2.235	2.235	2.230	2.230	2.232	68	0.199
400	12674	Simcoe Street @ Victoria Avenue	2.643	2.237	2.238	2.211	2.211	2.224	68	0.000
401	12713	Dorchester Road @ Morrison Street	2.062	2.922	2.953	2.559	2.898	2.833	40	0.086
402	12716	Drummond Road @ Morrison Street	3.175	1.985	1.981	1.986	1.995	1.987	66	0.199
403	12727	Morrison Street @ Portage Road	2.587	2.201	2.217	2.240	2.236	2.223	54	0.194

Appendix C: Pedestrian Safety Risk Prioritization Scores for Signalized Intersections in Niagara Region, continued

#	GeoID	Intersection	APT (S2)	North Ped ISI	South Ped ISI	West Ped ISI	East Ped ISI	Average Ped ISI	ODOT Risk Score	PSI
404	12737	Fourth Avenue @ Morrison Street	2.901	1.977	1.970	2.002	2.010	1.990	62	0.000
405	12744	Morrison Street @ Valley Way	2.888	2.006	2.001	1.974	1.986	1.992	62	0.000
406	12745	Morrison Street @ Victoria Avenue	3.550	2.199	2.242	2.209	2.209	2.215	66	0.631
407	12764	Valley Way @ Victoria Avenue	1.925	2.217	2.217	2.247	2.234	2.229	51	0.000
408	12954	Dorchester Road @ Freeman Street	2.507	2.011	2.010	1.962	1.962	1.986	73	0.000
409	13144	Portage Road @ St John Street	3.132	2.701	2.691	1.974		2.455	84	0.000
410	13179	Colborne Street @ Portage Road	2.750	2.958	2.946	2.207	1.989	2.525	71	0.077
411	13194	Niagara River Parkway @ Victoria Avenue	0.962		1.636	1.953	1.984	1.858	32	0.000
412	13196	Keith Street @ Portage Road	2.462	2.933	2.955	1.996	2.212	2.524	48	0.000
413	13256	Dorchester Road @ O'Neil Street	2.010	1.980	2.000		1.637	1.872	43	0.000
414	13267	O'Neil Street/Portage Road @ Saint Paul Street	2.732	2.568	2.606	2.211	2.195	2.395	58	0.175
415	14194	Rebstock Road @ Ridgeway Road	1.730	2.145	2.140	2.124	2.124	2.133	47	0.000
416	14736	Highway 3 @ Ridge Road North	1.155	1.985	1.980	2.888	2.894	2.437	22	0.000
417	14869	Central Avenue @ QEW East Off-Ramp	0.863	2.873	2.883	1.867		2.541	25	0.000
418	14959	Bertie Street @ Concession Road/Ramp	1.562	2.323	2.329	2.303	1.964	2.230	29	0.000
419	15673	Cummington square west/Willoughby Drive @ Main Street	2.328	2.230	2.213	2.209	2.202	2.213	57	0.219
420	15720	Portage Road @ Upper Rapids Road	1.126	2.303	2.079	2.085	2.061	2.132	40	0.000
421	17208	Killaly Street West @ Mellanby Avenue	1.657	1.954	1.969	1.743	1.968	1.909	26	0.000
422	17281	Crossroads Drive @ Prince of Wales Avenue/Ramp	1.675	2.313	2.313	1.957	1.957	2.135	38	0.000
423	17282	Bertie Street @ Prince of Wales Avenue	1.837		1.639	2.732	2.660	2.343	31	0.000
424	17884	Louth Street & Pelham Road @ MacTurnbull Drive/Pelham Road	2.554	1.973	1.964	1.972	1.997	1.977	42	0.000
425	17985	Louth Street @ St. Paul Street West	3.044	2.259	2.211	2.215	2.225	2.228	20	0.663
426	18202	Cabernet Street @ Main Street East	1.409	2.010	2.227	2.240	2.240	2.179	40	0.000
427	18219	Bunting Road/Welland Canals Parkway @ Lakeshore Road	1.716	1.978	1.989	1.984	1.990	1.985	41	0.000
428	18807	Rockwood Avenue @ Welland Canals Parkway	1.354	1.982	1.992	1.961		1.978	38	0.000
429	20275	Louth Street @ Walmart Plaza	1.586	2.929	2.929	1.992		2.617	28	0.000
430	20277	Fairview Mall @ Geneva Street	2.188	2.945	2.961	2.336	1.985	2.557	44	0.000
431	20278	Glendale Avenue @ Plaza Keg Sobeys	1.871	2.401	2.045	3.002	3.002	2.612	49	0.000
432	20279	Garrison Road @ Sobeys Entrance	1.874	1.681	1.681	2.918	2.918	2.300	20	0.000
433	20280	General Motors Plant 2 @ Glendale Avenue	1.652		1.775	2.667	2.667	2.370	28	0.000
434	20423	Stanley Avenue @ Thorold Stone Road	1.906	2.196	2.244	2.262	2.262	2.241	41	0.000
435	420VCT	Falls Avenue Ramp @ Victoria Avenue	1.953	2.240	2.246	1.556	1.872	1.978	41	0.000
436	900038	Fourth Avenue @ Walmart Plaze	1.947	2.370	2.370	2.944	2.944	2.657	46	0.000
437	int10073	Thorold Townline Road @ Walker Brothers Quarries Ltd.	0.870	2.121	2.121	1.748		1.997	41	0.000
438	MCKPRT	Macklem Street @ Portage Road	1.574	2.212	1.975	2.224	2.228	2.160	53	0.000

Appendix D: Correlation of Prioritization Method Variables

		APT									FHWA				ODOT						PSI		
		Total pedestrian crashes	AADT (Average of all legs)	Traffic speed (85th percentile)	Total crossing distance	Number of right-turn lanes	Average number of through lanes on leg, both directions	Presence of raised median	Population density	Number of bus stops	Average number of through lanes, both directions	Average traffic speed (85th Percentile)	Average AADT	Presence of commercial area	Population density	Number of transit lines	Major AADT	Presence of median, major street	Presence of right-turn lane, minor direction	Presence of right-turn lane, major direction	Major AADT	Minor AADT	Total pedestrian crashes
APT	Total pedestrian crashes	1.00																					
	AADT (Average of all legs)	0.17	1.00																				
	Traffic speed (85th percentile)	-0.10	-0.19	1.00																			
	Total crossing distance	0.00	0.36	0.21	1.00																		
	Number of right-turn lanes	0.01	0.15	0.14	0.44	1.00																	
	Number of vehicle through lanes, both directions	0.08	0.48	-0.01	0.63	0.01	1.00																
	Presence of raised median	-0.05	0.37	-0.02	0.58	0.28	0.57	1.00															
	Population density	0.26	0.05	-0.27	-0.30	-0.19	-0.22	-0.31	1.00														
	Number of bus stops	0.25	0.16	-0.18	0.03	-0.08	0.15	-0.07	0.25	1.00													
FHWA	Average number of through lanes on leg, both directions	0.03	0.50	-0.03	0.61	0.06	0.93	0.61	-0.25	0.09	1.00												
	Average traffic speed (85th percentile)	-0.10	-0.19	1.00	0.20	0.14	-0.01	-0.02	-0.27	-0.18	-0.03	1.00											
	Average AADT	0.16	1.00	-0.19	0.34	0.14	0.46	0.36	0.07	0.16	0.49	-0.19	1.00										
	Presence of commercial area	0.21	0.23	-0.33	0.03	0.04	0.15	0.06	0.10	0.21	0.08	-0.33	0.23	1.00									
ODOT	Population density	0.26	0.05	-0.27	-0.30	-0.19	-0.22	-0.31	1.00	0.25	-0.25	-0.27	0.07	0.10	1.00								
	Number of transit lines	0.27	0.23	-0.12	0.14	0.04	0.27	0.13	0.17	0.25	0.23	-0.12	0.23	0.25	0.17	1.00							
	Major AADT	0.17	0.96	-0.13	0.38	0.14	0.52	0.38	0.03	0.16	0.53	-0.13	0.95	0.22	0.03	0.24	1.00						
	Presence of median, major street	-0.06	0.42	0.00	0.56	0.22	0.58	0.90	-0.30	-0.04	0.63	0.00	0.41	0.06	-0.30	0.13	0.43	1.00					
	Presence of right-turn lane, minor direction	0.03	0.15	0.00	0.26	0.74	0.03	0.28	-0.10	-0.06	0.08	0.00	0.14	0.03	-0.10	0.08	0.13	0.22	1.00				
	Presence of right-turn lane, major direction	-0.03	0.08	0.19	0.39	0.72	0.03	0.20	-0.23	-0.11	0.04	0.19	0.07	0.03	-0.23	0.04	0.08	0.14	0.22	1.00			
PSI	Major AADT	0.17	0.96	-0.13	0.38	0.14	0.52	0.38	0.03	0.16	0.53	-0.13	0.95	0.22	0.03	0.24	1.00	0.43	0.13	0.08	1.00		
	Minor AADT	0.14	0.87	-0.25	0.27	0.12	0.37	0.29	0.07	0.17	0.37	-0.25	0.87	0.25	0.07	0.18	0.70	0.33	0.14	0.05	0.70	1.00	
	Total pedestrian crashes	1.00	0.17	-0.10	0.00	0.01	0.08	-0.05	0.26	0.25	0.03	-0.10	0.16	0.21	0.26	0.27	0.17	-0.06	0.03	-0.03	0.17	0.14	1.00