Appendix G

Road Safety Performance Study

May 2017

Road Safety Performance Assessment

Lakeshore Road West
from Mississaga Street to Dorval Drive
Town of Oakville, Ontario

Client: **Town of Oakville and**
Amec Foster Wheeler Environment and Infrastructure

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1. Introduction

1.1 This report documents a Road Safety Performance Assessment of Lakeshore Road West from Mississaga Street to Dorval Drive in the Town of Oakville, Ontario. The assessment was conducted for the Engineering and Construction Department of the Town of Oakville, through a subconsulting assignment from Amec Foster Wheeler Environment and Infrastructure. The study location is shown in Figure 1.

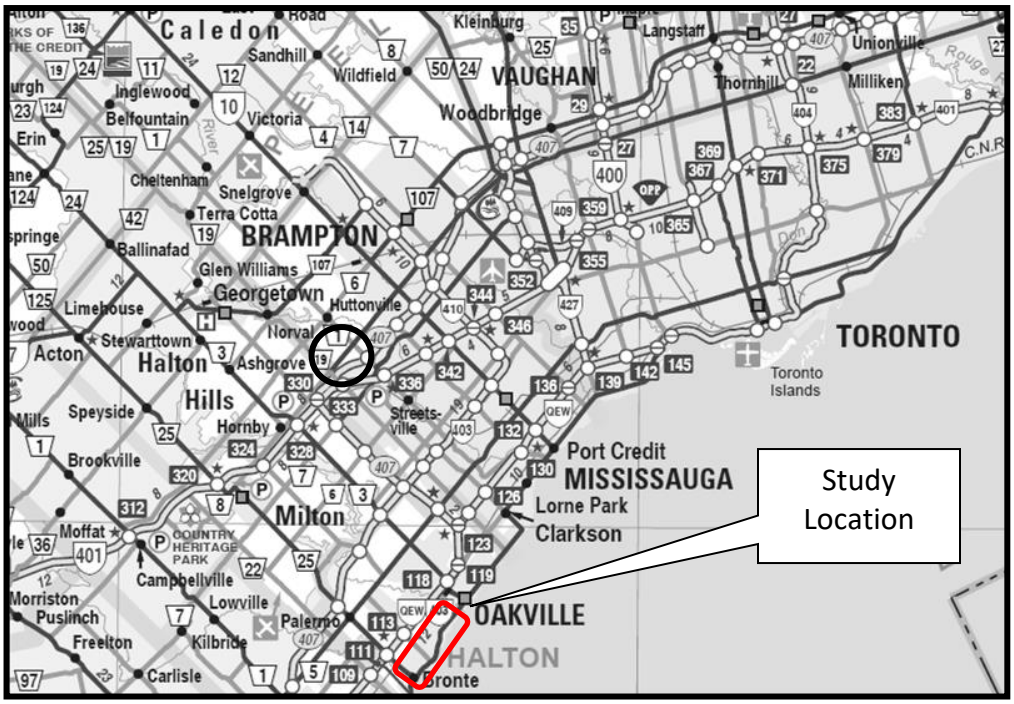


FIGURE 1: Study Location

1.2 The safety assessment was conducted as part of a Class Environmental Assessment (EA) being undertaken by Amec Foster Wheeler Environment and Infrastructure (Amec) for the Town. The terms of reference for the Class EA process call for a road safety performance assessment of the existing conditions in the study area.

1.3 The safety assessment was carried out by Gerry Forbes, M.Eng, P.Eng, PTOE, at the office of ***Intus Road Safety Engineering Incorporated*** in Burlington, Ontario. A site visit was undertaken on February 21, 2017.

1.4 The goal of this safety assessment was to examine the facility's safety performance, to identify areas or factors that are producing undue collision risk (if any), and to recommend infrastructure-based solutions to any identified problems.

1.5 This road safety performance assessment has been carried out in general accordance with the ***Canadian Guide to In-service Road Safety Reviews*** (Transportation Association of Canada, 2003).

1.6 The material provided to Intus to conduct the safety review is listed in Appendix A.

1.7 It is acknowledged that safety is one of many considerations that Amec and the Town of Oakville need to balance in undertaking the Class EA, including, but not necessarily limited to, cost, environmental protection, congestion management, and community impacts. This report is focused on safety, with the anticipation that in general, the issues identified will be considered in the planning and design process.

1.8 The scope of this assignment was limited to assessing the road safety performance of the existing conditions in the Lakeshore Road West study area. It does not include an assessment of traffic operations, unless delay/congestion is affecting safety performance. Nor does the assessment include an evaluation of the personal security of road users or structural safety of the roadway elements. Proposed designs, recommended plans, or future conditions have not been analyzed, but are to be assessed through a road safety audit of the preferred design at a later stage in the Class EA process.

2. Description of the Existing Facilities

2.1 The section of Lakeshore Road West under study is shown in Figure 2. For the purposes of this study Lakeshore Road West is described as an east-west facility with crossing roads referred to as north-south streets.

2.2 Lakeshore Road West is a minor arterial road with two basic lanes (i.e., one lane in each direction) throughout the study area[1]. With respect to basic roadway geometry, the study area can be subdivided into two distinct sections. The roadway east of East Street is a semi-rural cross-section with roadside ditches and inconsistent boulevard treatments (i.e., sidewalks, paths, and roadside trials). The roadway west of East Street is an urban cross-section and serves the Bronte Village Main Street District.

2.3 There is a posted speed limit of 50 km/h throughout the study area, except from Birch Hill Avenue to Whittington Place where the speed limit is 40 km/h. This latter speed limit is near Appleby College.

2.4 Ancillary turn lanes are added at some of the intersections in the study area.

[1] The short section of Lakeshore Road West, west of Bronte Road has a basic four-lane cross-section.

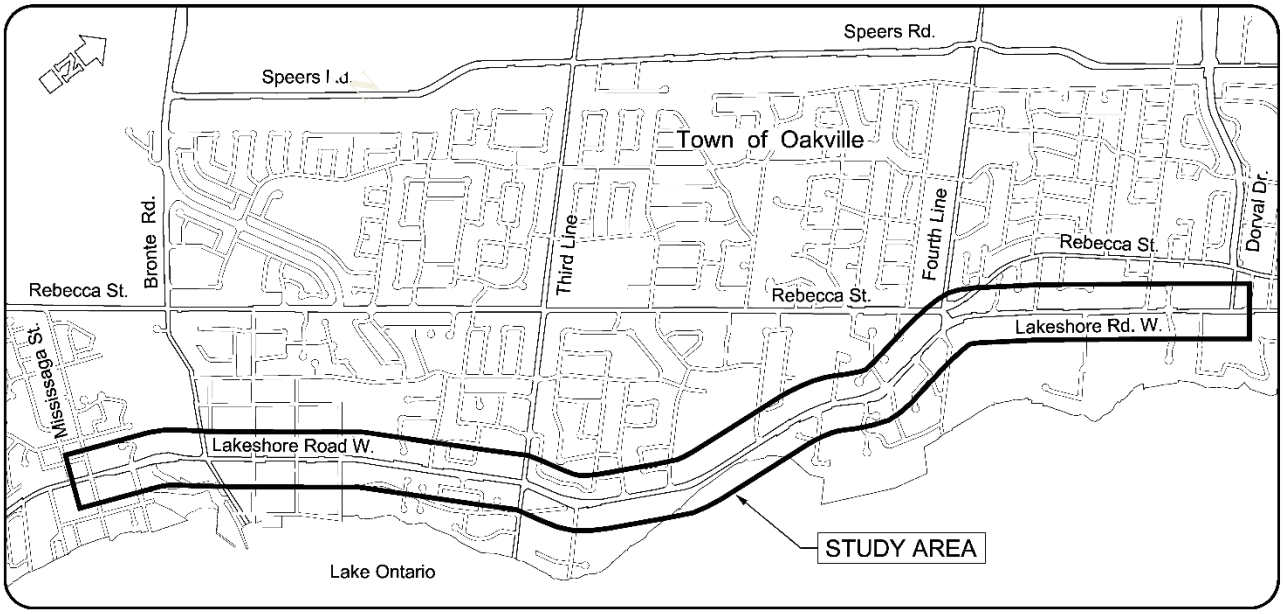


FIGURE 2: The Study Area

2.5 The study area has 10 signalized intersections, as shown in Table 1. The remainder of the intersections in the study area are unsignalized intersections with STOP signs facing the intersecting roads.

2.6 Lakeshore Road West is a curvilinear roadway that is mainly flat throughout the study area. None of the horizontal curves have been outfitted with roadway alignment signs with advisory speed tabs.

2.7 The land uses contiguous to Lakeshore Road West are mainly residential and park land, with commercial uses from the Bronte Creek to east of East Street within Bronte Village. The Sir John Colborne Centre for Seniors is located at the southeast corner of Lakeshore Road West and Third Line. Appleby College is a prominent land use near the intersection with Suffolk Avenue with a small neighbourhood commercial use on the north side of Lakeshore Road. Near the intersection of Dorval Drive, St. Thomas Aquinas High School is located on the north side of Lakeshore Road, and St. Jude's Cemetery, a designated property under the Ontario Heritage Act, is located on the south side of Lakeshore Road.

2.8 Transit service is provided along Lakeshore Road West from Mississaga Street to Third Line. Heavy vehicles (greater than 5 tonnes registered gross vehicle weight) are prohibited from using Lakeshore Road West between Third Line and Dorval Drive, except for local deliveries.

TABLE 1: Signalized Intersections in the Study Area

Intersecting Street	Type of Signal	No. of Approaches	Auxiliary Lanes			
			EBND Left	EBND Right	WBND Left	WBND Right
Mississaga Street	Full signal	4	X		X	X
Bronte Road	Full signal	4	X		X	X
Jones Street	Full signal	4	X		X	X
Nelson Street	Full signal	4	X		X	X
East Street	Full signal	4	X		X	X
Third Line	Full signal	4	X		X	X
Westminister Drive	PXO	3				
Fourth Line	Full signal	4*		X+	X	X
Morden Road	PS	3				
Dorval Drive	Full signal	3	X			

* One approach is a private driveway
+ Right turn taper

2.9 The study area is a "peak use" cycling and pedestrian route based on available data (see Figure 3). These cycling and pedestrian heat maps show the heaviest travelled cycling and walking routes throughout Oakville based on 5,624 and 2,002 Strava[2] users registered in Oakville, respectively. Lakeshore Road West through the study area is the most heavily-used east-west cycling and walking facility south of the Queen Elizabeth Way.

2.10 In addition to the traffic signals located at the intersections shown in Table 1, school-aged pedestrians are assisted in crossing Lakeshore Road West by a school crossing guard at the intersection of Lakeshore Road West and Bronte Road.

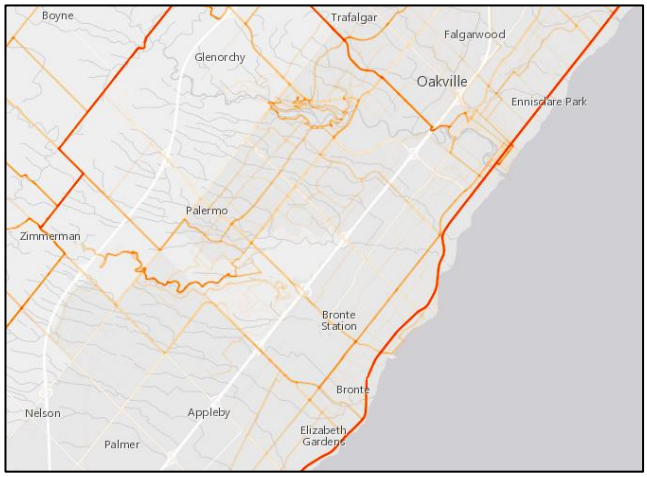
2.11 Cycling facilities in the study area are inconsistent. From Bronte Road to Third Line on-road bicycles lanes have been constructed and signed. From Woodhaven Park to Fourth Line there is a trail on the north side of the road, and from Fourth Line to Dorval Drive there is a trail on the south side of the road. There is a gap in the cycling facilities from Third Line to Woodhaven Park Drive.

3. Collision Record

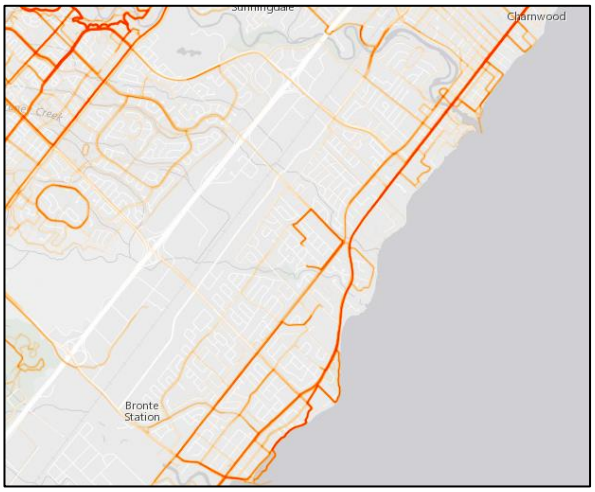
3.1 Collision data from January 1, 2006 to December 31, 2016 were supplied by the Town of Oakville as a "Collision Details Report" in PDF and MS-Excel™ format outputted from the Traffic Engineering Software maintained by the Town's Public Works Department. This

[2] Strava is a digital platform that permits registered users to upload their rides and walking/running trips to a centralized repository every week via their smartphone or GPS device. The data is made anonymous and aggregated before it is distributed to road authority partners who use the information to assist with infrastructure planning and improvements for bicyclists and pedestrians.

information was complemented with the results from the most recent (2010) Network Screening, and sanitized motor vehicle accident report (MVAR) forms for the fatal collisions, and pedestrian/cyclist collisions in the study area.



Cycling Heat Map



Pedestrian Heat Map

FIGURE 3: Cycling and Pedestrian Heat Maps[3]

[3] http://exploreoakville.maps.arcgis.com/apps/MapSeries/index.html?appid=c7467485a681458e876324b2f0c13795, and http://exploreoakville.maps.arcgis.com/apps/MapSeries/index.html?appid=c7467485a681458e876324b2f0c13795, accessed on February 20, 2017.

3.2 According to municipal records, there were 494 collisions in the Lakeshore Road West study area during this period (see Figure 4), or an average of 44.9 collisions/year [40.1 : 49.7][4]. There is a slight downward trend in the year-to-year collision data.

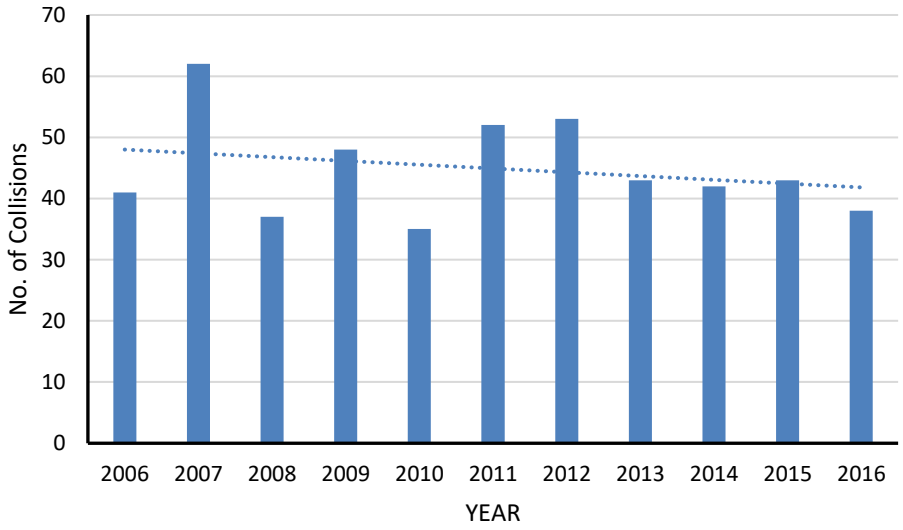


FIGURE 4: Annual Collision Frequency

3.3 Because the study area for Lakeshore Road West is comprised of two distinct road sections (the urbanized section from Mississaga Street to East Street, and the semi-urban section from East Street to Dorval Drive), much of the ensuing collision analysis will assess each section independently.

3.4 More than half (54%) of the collisions in the study area occurred in the Bronte Village area. More importantly, Lakeshore Road West through Bronte Village experiences an average of 18.8 collisions per kilometre per year [16.3 : 21.3], whereas the remainder of the study area (to the east) experiences an average of 4.2 collisions per kilometre per year [3.3 : 5.1]. The collision risk in the Bronte Village area is more than four times higher than the collision risk in the eastern study area. This is to be expected, given the greater access density and higher traffic volumes in the Bronte Village area.

3.5 There were two fatal collisions in the Lakeshore Road West study area during the analysis period. According to the motor vehicle accident report, the first fatal collision was a westbound rear-end collision where a passenger vehicle struck a cyclist from behind. There

[4] [X:Y] - These are the 95% Confidence Limits associated with the average collision frequency using all of the available collision data.

were no adverse environmental or road surface conditions. This fatal collision occurred at the intersection of Lakeshore Road West at Third Line[5]. The motorist was not impaired and was ultimately recorded as being "inattentive". The second fatal collision involved an elderly male driver suffering a medical emergency while driving, running off the road, and striking a utility pole. The fatality was due to "natural causes". This fatal collision occurred at the intersection of Lakeshore Road West at Fourth Line.

3.6 Overall about 18% of the collisions in the study areas resulted in a fatal or injury collision. This severity distribution is slightly elevated, given that 13% of collisions on Oakville roads typically result in a fatality or personal injury[6].

3.7 A review of the available collision characteristics for the study area also reveals the following:

- ***Location of the collisions:*** The east and west sections of the study area had 56% and 61% of the collisions recorded as occurring at intersections, respectively. General collision statistics indicate that about 43% of all collisions in Ontario occur at an intersection or are intersection-related[7].

- ***Seasonal variations:*** Within the study area, collisions in the summer (June to August) are over-represented, and collisions in the winter (December to February) are under-represented. Only 19% of the collisions in the study area occur during the winter months whereas 29% of all collisions on Ontario roads occur during this time.

- ***Time of day:*** There are more collisions than expected in the afternoon (PM) peak travel period (1500h to 1759h). The Provincial statistics indicate that about 24% of all collisions occur during this period, whereas 30% of the collisions in east section of the study area, and 37% of the collisions in west section of the study area occurred during this same period.

- ***Road surface condition:*** Collisions in both sections of the study area are over-represented on dry road surfaces. Sixty-five percent of collisions in Ontario occur on dry roads, whereas 76 to 78% of the collisions in the study area also occur when the road surface is dry.

3.8 Further analysis of the collision data was undertaken to identify specific locations in the study area that are performing worse than expected from a safety perspective. To determine if the number of collisions in the study area is a safety concern, it must be tempered by the

[5] A "ghost bicycle" currently marks the location of this fatal collision.
[6] See Appendix A of the Town of Oakville 2015 Road System Report, Table 2.
[7] All Ontario road safety statistics are from the 2013 Ontario Road Safety Annual Report.

exposure (i.e., the length of the facility and/or the volume of traffic using the facility), since roads and intersections accommodating higher volumes experience higher collision frequencies.

3.9 The Town of Oakville's method of calculating the safety performance of a facility is to separate the facility into intersections and road segments, and to calculate the excess expected average EPDO[8] collision frequency with an empirical Bayes adjustment. In this process, the observed average collision frequency and the predicted collision frequency (as calculate from a suitable collision prediction equation) are combined using an empirical Bayes methodology to calculate a stable long-term average collision frequency. The excess expected EPDO collision frequency (referred to as the potential for safety improvement or PSI) is the difference between the long-term average EPDO collision frequency, and the average EPDO collision frequency from the collision prediction equation. The higher the PSI, the worse a site is performing from a safety perspective, and the greater the potential for safety improvements to be effective.

3.10 When the above procedure is applied to all facilities within a road authority's purview, it is termed "network screening". The last network screening of the Town's road network was in 2010. The process involved a review and analysis of a database of motor vehicle collisions reports for a 5-year period, as provided by Halton Regional Police Service.

3.11 The PSIs and the rankings for all of the study area intersections from the 2010 Network Screening are shown in Table 2. Seven hundred and twenty-seven (727) intersections were examined. The highest PSI calculated was 49.13.

3.12 The PSIs and the rankings for all of the road sections in the study area from the 2010 Network Screening are shown in Table 3. Nine hundred and six (906) road sections were examined. The highest PSI calculated was 94.03.

3.13 The primary metric for evaluating the safety performance of an element of the Oakville road system is the PSI that is output during the network screening exercise. Therefore, the results included in Tables 2 and 3 are the key indicators for identifying specific locations (if any) that require further safety assessment. Technically, any location that has a PSI of greater than one is a location that is performing worse than expected from a safety perspective, and could benefit from countermeasures.

[8] EPDO = equivalent property damage only

TABLE 2: Safety Performance Rankings for the Study Area Intersections

Intersection	PSI	Ranking
EAST STREET	10.36	15
JONES STREET	6.36	24
BRONTE ROAD	2.90	40
NELSON STREET	2.12	59
MISSISSAGA STREET	2.05	63
HOLYROOD AVENUE	1.35	83
SOLINGATE DRIVE	0.99	95
WESTDALE ROAD	0.84	114
FOURTH LINE	0.50	157
WEST RIVER STREET	0.45	163
WINDSOR GATE	0.41	170
SANDWELL DRIVE	0.07	245
STRATHCONA AVENUE	0	261
THIRD LINE	0	262
BELVEDERE DRIVE	0	263
WOODHAVEN PARK DRIVE	0	264
WOLFDALE AVENUE	0	265
WILLOWRIDGE COURT	0	266
WESTDALE ROAD	0	267
WILDER DRIVE	0	268
WEST LYNN ROAD	0	269
WHITTINGTON PLACE	0	270
SUFFOLK AVENUE	0	271
BIRCH HILL LANE	0	272
TAVISTOCK SQUARE	0	273
WILSON STREET	0	276

TABLE 3: Safety Performance Rankings for the Study Area Road Sections

Road Section	PSI	Ranking
BRONTE ROAD & JONES STREET	8.20	20
NELSON STREET & EAST STREET	6.78	26
WEST RIVER STREET & BRONTE ROAD	5.33	28
EAST STREET & SOLINGATE DRIVE	1.96	63
HOLYROOD AVENUE & DORVAL DRIVE	1.75	68
FOURTH LINE & WHITTINGTON PLACE	0.85	103
SHOREWOOD PLACE & HOLYROOD AVENUE	0.79	125
WESTDALE ROAD & FOURTH LINE	0.72	139
JONES STREET & NELSON STREET	0.68	144
WESTMINSTER DRIVE & WOODHAVEN PARK DRIVE	0.49	175
MISSISSAGA STREET & TRILLER PLACE	0.42	186
BIRCH HILL LANE & MORDEN ROAD	0.41	188
WINDSOR GATE & THIRD LINE	0.35	194
THIRD LINE & BELVEDERE DRIVE	0.16	277
SOLINGATE DRIVE & WINDSOR GATE	0	703
BELVEDERE DRIVE & WESTMINSTER DRIVE	0	704
WOODHAVEN PARK DRIVE & SANDWELL DRIVE	0	705
SANDWELL DRIVE & WOLFDALE AVENUE	0	706
WOLFDALE AVENUE & WILLOWRIDGE COURT	0	707
WILLOWRIDGE COURT & WESTDALE ROAD	0	708
WESTDALE ROAD & WILDER DRIVE	0	709
WILDER DRIVE & WEST LYNN ROAD	0	710
WEST LYNN ROAD & WESTDALE ROAD	0	711
WHITTINGTON PLACE & SUFFOLK AVENUE	0	712
SUFFOLK AVENUE & BIRCH HILL LANE	0	713
MORDEN ROAD & SHOREWOOD PLACE	0	714

3.14 It is generally not practical to investigate every location that has a PSI greater than one. Resource limitations restrict the investigation of sites with promise of safety improvement to only those that are the highest ranked. Also, when the PSI is based on EPDO collisions, locations with a high collision severity may actually have a comparatively low collision frequency. In this instance, there may not be enough collision data to identify the patterns and trends that are indicative of an infrastructure-based safety deficiency.

3.15 There is no industry-accepted guidance that recommends a PSI threshold, above which a site is flagged for a road safety investigation. The number of sites to be investigated is ordinarily based on available resources, and road authorities start investigating the highest ranked site and continue down the list until resources are exhausted.

3.16 For the purposes of this road safety assessment, additional analysis is undertaken at all sites with a PSI of 2.5 or higher. This includes three signalized intersections and three road sections. All of these facilities are located in the west section of the study area.

3.17 Lakeshore Road West at East Street

3.17.1 The collision diagram for the intersection of Lakeshore Road West at East Street is shown in Figure 4. There is a total of 14 collisions at this location. All of the collisions occurred during clear weather conditions and all but one collision occurred on dry roads.

3.17.2 Three of the 14 collisions (21%) involved a cyclist. None of the collisions involved a pedestrian. The only injury collisions (three collisions) were those involving the cyclists.

3.17.3 It is noteworthy that 10 of the 14 collisions (71%) involved eastbound road users. Of those 10 collisions, four of the collisions were rear-end collisions, and three of the collisions were sideswipe collisions. None of the eastbound rear-end and sideswipe collisions were precipitated by poor weather or road conditions. There is also no particular day or time of the day that these eastbound collisions occur. Rear-end and sideswipe collisions in this type of setting are usually due to inter-user speed differentials that are precipitated from traffic congestion, poor signal timing, lack of exclusive turn lanes, accesses proximate to the intersection, and/or driver distraction.

3.18 Lakeshore Road West at Jones Street

3.18.1 The collision diagram for the intersection of Lakeshore Road West at Jones Street is shown in Figure 5. There is a total of 14 collisions at this location[9]. All but one of the collisions occurred during clear weather conditions and all but two collisions occurred on dry roads.

3.18.2 Two of the 14 collisions (14%) involved a cyclist. One of the collisions involved a pedestrian. Five of the 14 collisions (36%) were inury collisions.

[9] The Collision Details Report for this intersection listed 15 total collisions for this site. However, one of the collisions was a duplicate, based on the Collision Identification number.

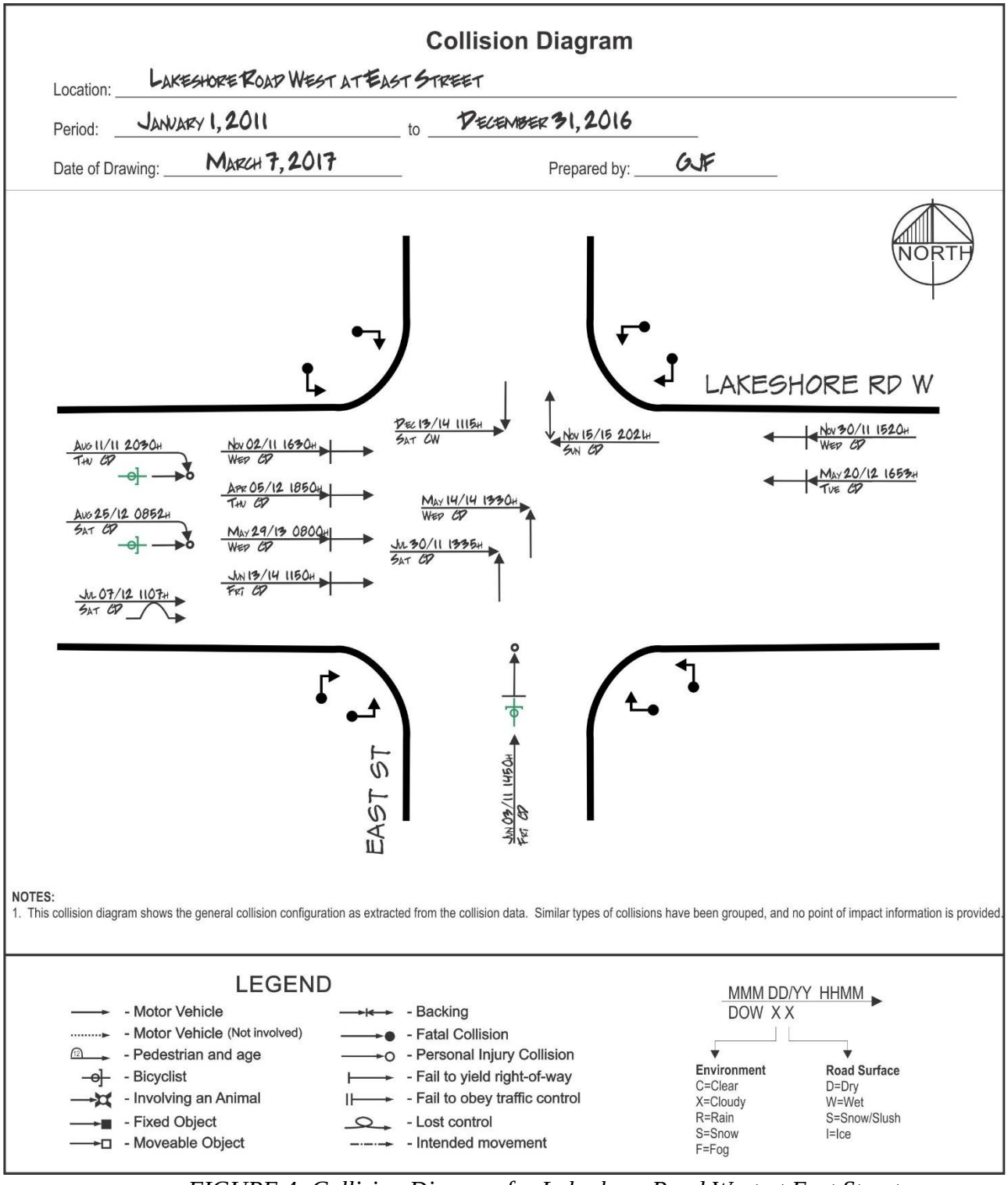


FIGURE 4: Collision Diagram for Lakeshore Road West at East Street

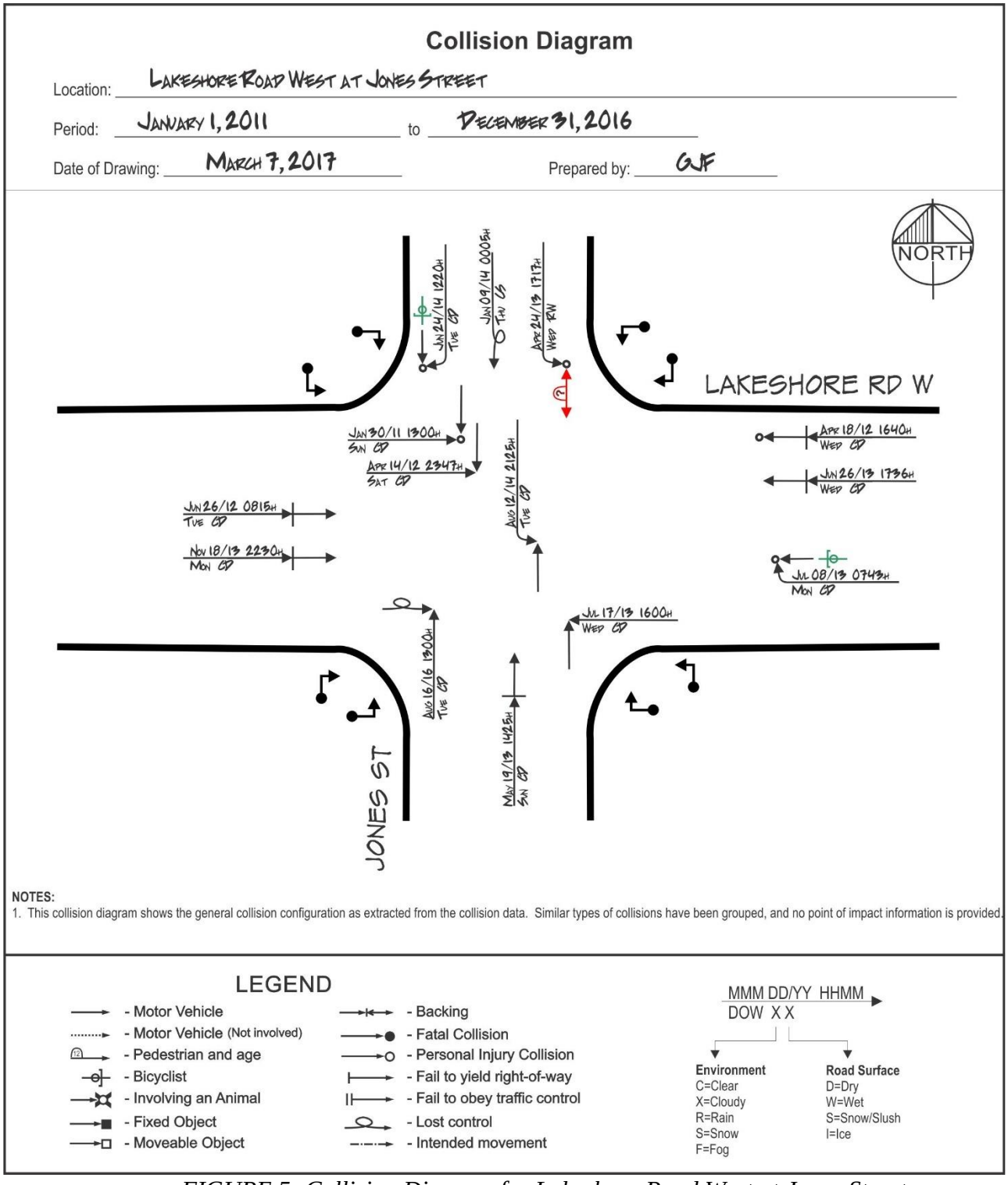


FIGURE 5: Collision Diagram for Lakeshore Road West at Jones Street

3.18.3 There were 27 road users involved in the 14 collisions. The initial direction of travel of the involved users, compared to the percentage of vehicles entering the intersection are shown in Table 4. North and south traffic is disproportionately involved in the collisions at this intersection, based on traffic volume entering.

TABLE 4: Distribution of Road Users

Direction of Travel	Collisions		8-hour Volume		Relative Risk
	Number	Percentage	Number	Percentage	
Northbound	5	19%	649	7%	2.64
Southbound	8	30%	1027	11%	2.67
Eastbound	7	26%	3643	39%	0.66
Westbound	7	26%	3938	43%	0.61
All	27	100%	9257	100%	

3.18.4 Eighty percent of the collisions at the intersection of Lakeshore Road West at Jones Street occurred on a weekday. Four of the 11 (36%) weekday collisions occurred in the PM peak travel period. In comparison, it is typically for 10 to 15% of weekday traffic to pass over a facility during the PM peak travel period.

3.19 Lakeshore Road West at Bronte Road

3.19.1 The collision diagram for the intersection of Lakeshore Road West at Bronte Road is shown in Figure 6. There is a total of 35 collisions at this location. The majority of the collisions occurred during clear weather (86%) and on dry roads (77%).

3.19.2 Two of the 35 collisions (6%) involved a cyclist, and two of the collisions (6%) involved a pedestrian. Three of the four above-referenced collisions resulted in an injury, the severity of the remaining collision was reported as “other”.

3.19.3 Rear-end collisions is the most prevalent collision type, comprising 13 of the 35 (37%) collisions. All but one of the rear-end collisions occurred on Lakeshore Road West, with only three rear-end collisions occurring during wet road conditions. The next most prevalent collision types are sideswipe collisions (17%) and collisions involving a left-turning motorist (17%). The sideswipe collisions are primarily occurring on the north approach; the left-turning collisions exhibit no trend or pattern. Rear-end and sideswipe collisions in this type of setting are usually due to inter-user speed differentials that are precipitated from traffic congestion, poor signal timing, lack of exclusive turn lanes, accesses proximate to the intersection, and/or driver distraction.

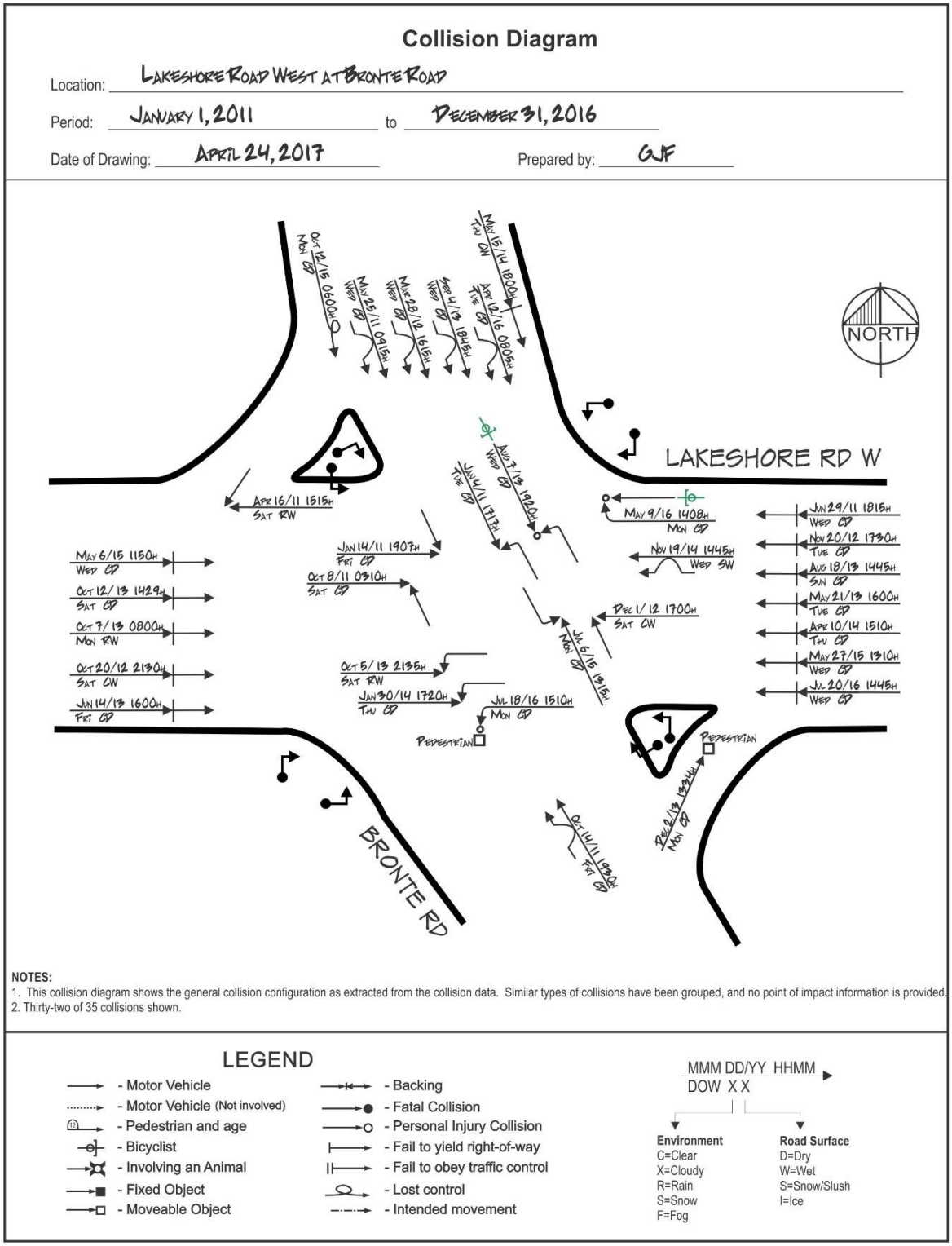


FIGURE 6: Collision Diagram for Lakeshore Road West at Bronte Road

3.20 Lakeshore Road West from Bronte Road to Jones Street

3.20.1 The collision diagram for Lakeshore Road West from Bronte Road to Jones Street is shown in Figure 7. There is a total of 14 collisions at this location. Eighty-six percent of the collisions occurred during clear weather conditions and on dry roads.

3.20.2 One of the collisions involved a cyclist, and there were no pedestrian-involved collisions during the study period. Three of the 14 collisions (21%) were injury collisions.

3.20.3 Eight of the 14 collisions (57%) were rear-end collisions. Five of the rear-end collisions involved westbound vehicles; three of the rear-end collisions involved eastbound vehicles. Only two of the rear-end collision occurred on wet roads – indicating that road surface conditions were not a causative factor.

3.20.4 Half of the 14 collisions occurred on a weekday during the PM peak travel period.

3.20.5 Without specific information on the location of the collisions within this section of road it is impossible to determine the causes of the rear-end collisions. It is likely that these collisions are due to increase traffic congestion during the PM peak periods of travel.

3.21 Lakeshore Road West from Nelson Street to East Street

3.21.1 The collision diagram for Lakeshore Road West from Nelson Street to East Street is shown in Figure 8. There is a total of 17 collisions at this location. Seventy-six percent of the collisions occurred during clear weather conditions, and 82% of the collisions happened on dry roads.

3.21.2 Five of the collisions (29%) involved a cyclist. All of the cyclist collisions resulted from a turning vehicle colliding with a cyclist who was travelling straight. Three of the collisions involved motorists turning left, and two of the collisions involved a motorist turning right. Four of the five (80%) of the cyclist collisions involved a westbound cyclist.

3.21.3 There was one pedestrian-involved collision during the study period. Half of the 14 collisions (50%) were injury collisions.

3.21.4 Seven of the 17 collisions (41%) were rear-end collisions. Four of the rear-end collisions involved westbound vehicles; three of the rear-end collisions involved eastbound vehicles. Only two of the rear-end collision occurred on wet or snowy roads – indicating that road surface conditions were not a causative factor. All of the rear-end collisions occurred on weekdays in either the mid-day or PM peak travel period.

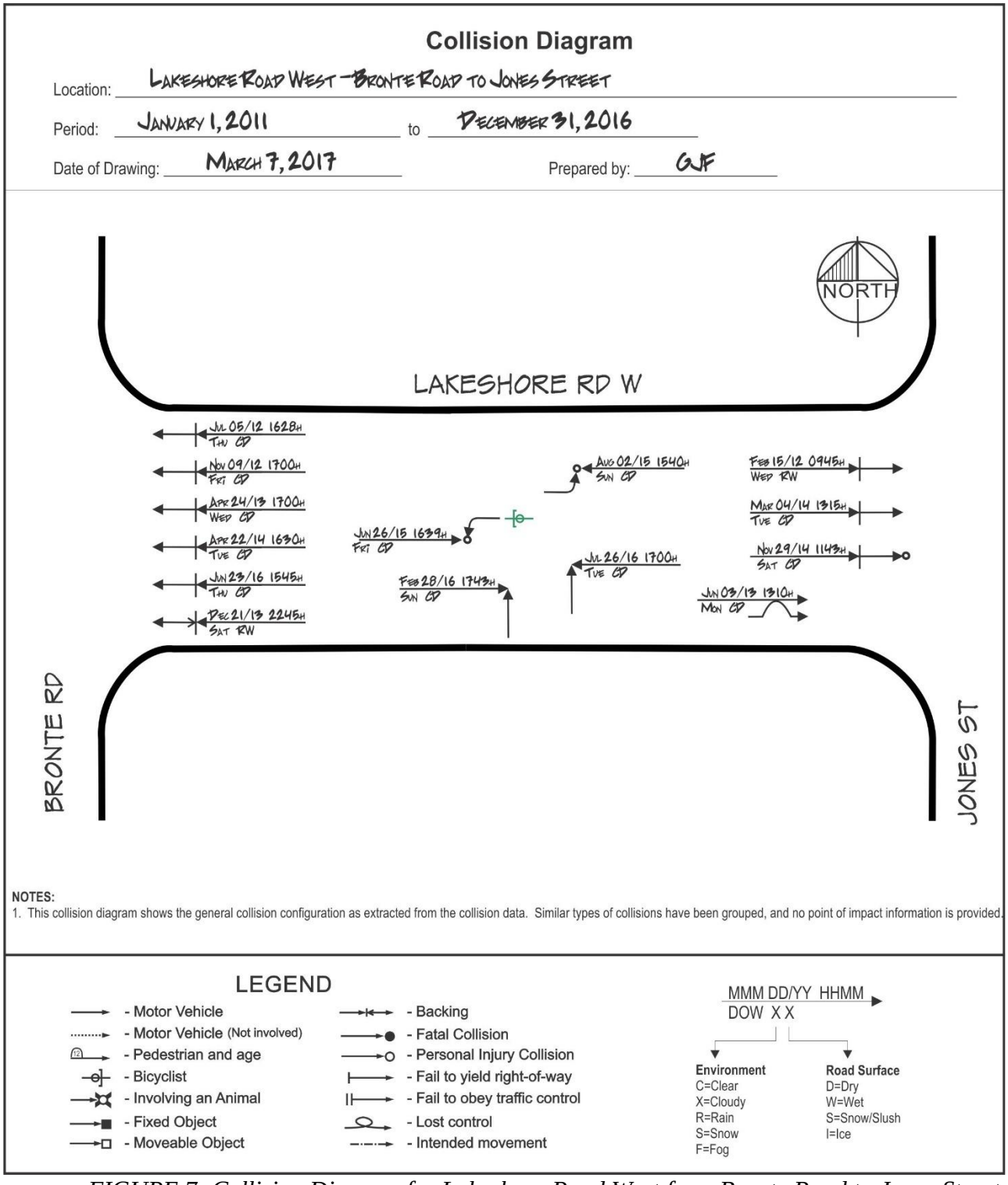


FIGURE 7: Collision Diagram for Lakeshore Road West from Bronte Road to Jones Street

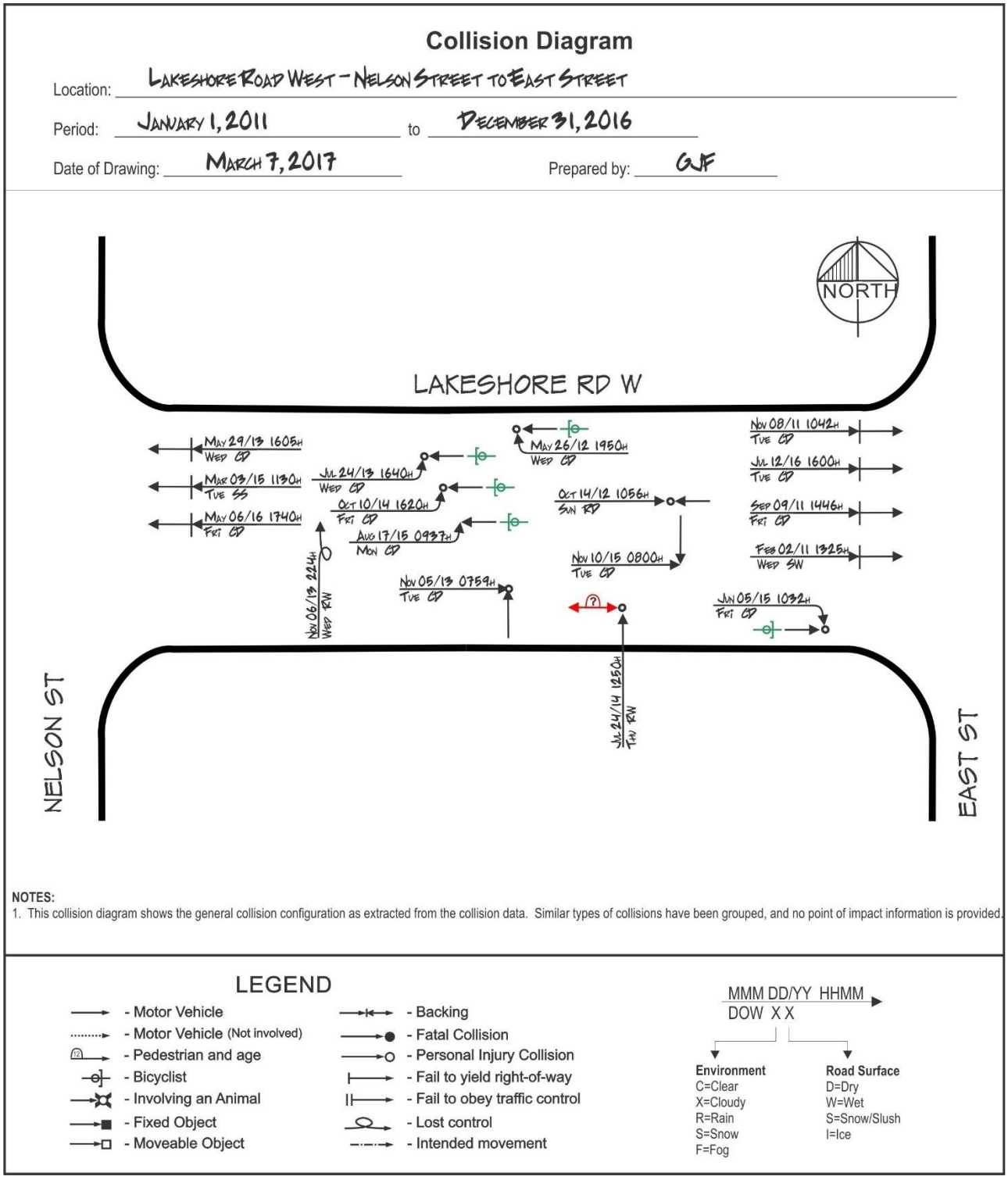


FIGURE 8: Collision Diagram for Lakeshore Road West from Nelson Street to East Street

3.21.5 Only one of the collisions occurred on a weekend. Seven of the 16 weekday collisions (44%) occurred mid-day (0900h to 1459h).

3.22 Lakeshore Road West from West River Street to Bronte Road

3.22.1 The collision diagram for Lakeshore Road West from West River Street to Bronte Road is shown in Figure 9. There is a total of 16 collisions at this location. Eighty-one percent of the collisions occurred during clear weather, and 69% of the collisions happened on dry roads.

3.22.2 There were no collisions involving cyclists or pedestrians during the study period. Two of the 16 collisions (13%) were injury collisions.

3.22.3 Thirteen of the 16 collisions (81%) were collisions between vehicles moving in the same direction (i.e., rear-end collisions, sideswipe collisions, and turning collisions). Ten of the 13 same direction collisions (77%) involved westbound vehicles. This is disproportionate to the traffic volume on this section of Lakeshore Road West which indicates that eastbound and westbound traffic is roughly equal over a typical day. The same direction collisions typically occur on a weekday during the mid-day or PM peak travel period. Sixty-nine percent of the same direction collisions occurred on dry roads – indicating that road surface conditions are not a primary causative factor.

4. Site Visit

4.1 A site visit was conducted on February 21, 2017 with a purpose of reviewing road user operations and interactions, and identifying site-specific deficiencies that may be leading to any increased collision risk in the study area.

4.2 A positive guidance review was undertaken on Lakeshore Road West from a passenger vehicle throughout the study area. This road safety assessment technique assists in understanding the road users' mindset and workload issues while moving through the study area. Lakeshore Road West from Bronte Road to East Street was also traveled on foot, to assess the safety aspects of the pedestrian environment.

4.3 The following items were noted during the site visit:

- The sidewalks and longitudinal cycling facilities are not continuous through the study area. In sections where there is no exclusive cycling facility (i.e., on-road bicycle lane) there are no signs or markings indicating that road is to be shared with cyclists.

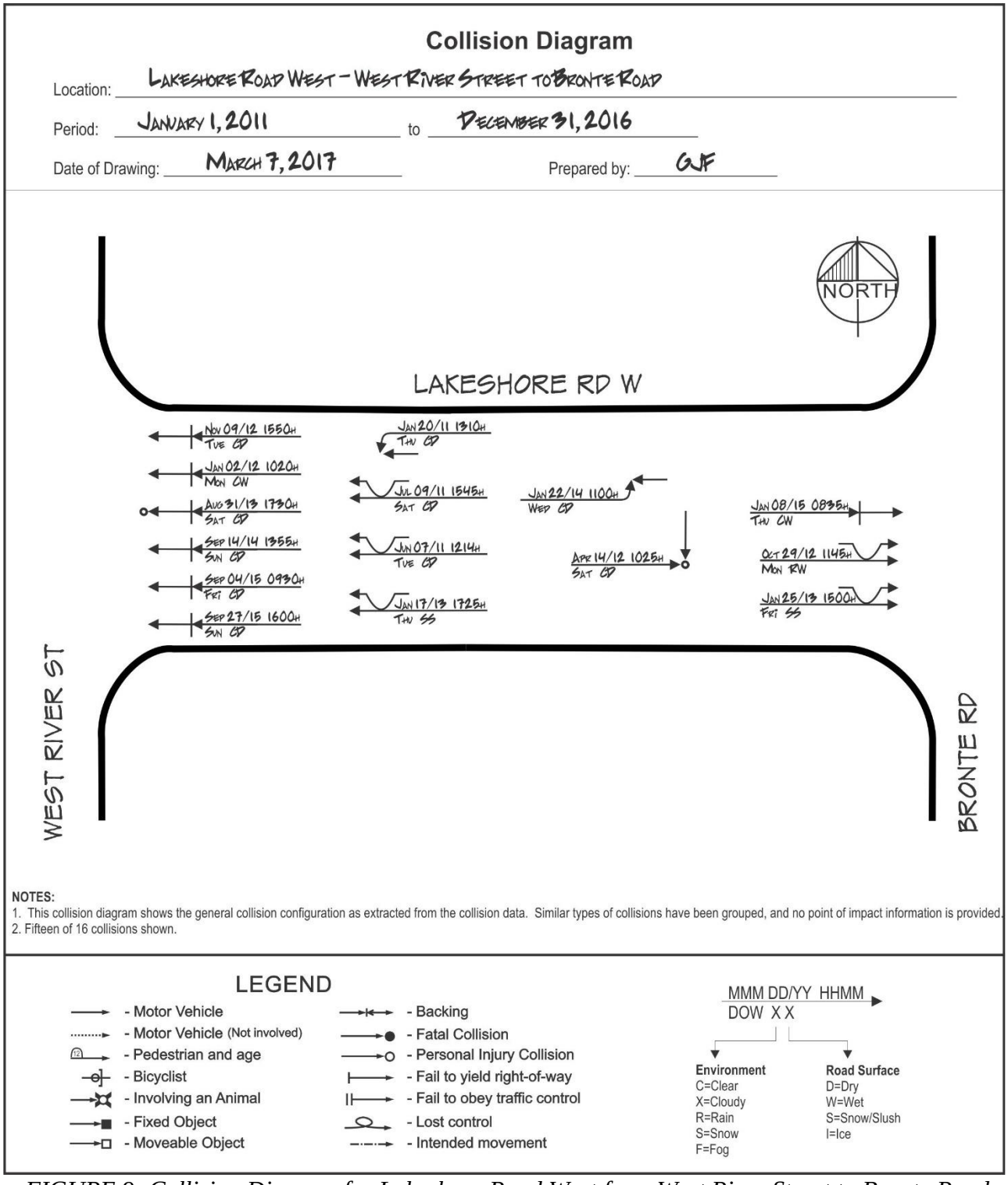


FIGURE 9: Collision Diagram for Lakeshore Road West from West River Street to Bronte Road

- The operating speeds in the study area are consistent with the geometry of the road and the surrounding land uses. Operating speeds appear to be at or above the speed limit.

- Forward visibility is general very good.

- There are relatively narrow medians on Lakeshore Road West at Birch Hill Lane and west of Whittington Place that are inconspicuous. The ends of the islands have been marked with flexible delineators to increase conspicuity. During the site visit, one or more of these delineators was broken/missing.

- The traffic barrier (steel beam guiderail) on the north side of Lakeshore Road West between Whittington Place and Fourth Line has no end treatments.

- West of Fourth Line there is a horizontal curve that is delineated with three westbound CHEVRON ALIGNMENT sign (Wa-9). There is no corresponding roadway alignment sign or advisory speed tab posted in advance of this curve. Similarly, there are no eastbound signs present for this same curve, despite the radius of the curve being smaller for the eastbound lanes.

- Westbound on Third Line at or near Belvedere Drive, Old Lakeshore Road is more-or-less longitudinally aligned with Lakeshore Road West creating a perceptual trap-style hazard. In other words, in times of darkness and/or diminished visibility, it may appear to the westbound motorist that Lakeshore Road West continues straight instead of curving to the right.

- The raised median island on Fourth Line at Lakeshore Road West extends into the north crosswalk, creating a trip hazard for visually-challenged pedestrians (Figure 10).

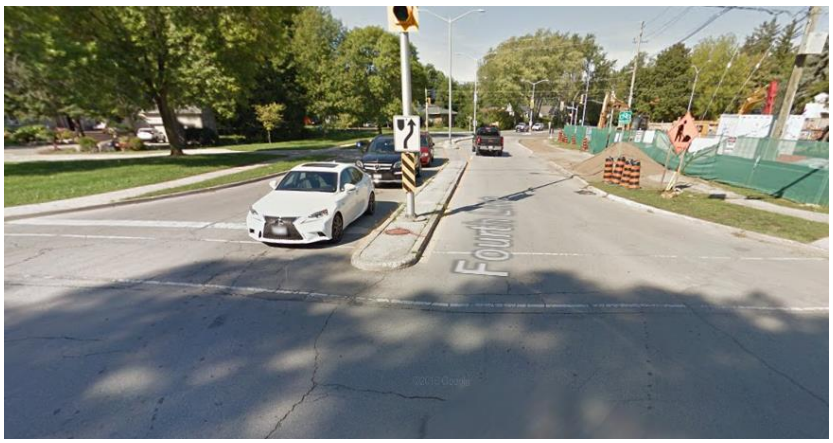


FIGURE 10: Raised Island Protruding in to the North Crosswalk at Fourth Line

- One or more of the traffic signal poles at the intersection of Lakeshore Road West and Mississaga Street are located in the middle of the sidewalk, reducing the available sidewalk width to a dimension that will not accommodate a wheelchair (Figure 11).

FIGURE 11: Sidewalk Too Narrow for a Wheelchair at Mississaga Street

- The sidewalk through Bronte Village is continuous on both sides of the road, and the buildings fronting on Lakeshore Road West are set back to afford minimum visibility triangles at the interstitial driveways. The exception to the above is at 2347 Lakeshore Road West (Zara's By The Lake) where the fence surrounding the outside dining area directly abuts the sidewalk and the driveway (see Figure 12). At this location, the combination of the fence and the planters may create a visibility obstruction between pedestrians and motorists exiting the driveway.

- The right-turn channelization on the north and south approaches to Lakeshore Road West from Bronte Road are generally considered incongruous with a pedestrianized environment. These features promote higher turning speeds and create conflicts between vehicular and pedestrian traffic.

- The east crosswalk at the intersection of Bronte Road and Lakeshore Road West is not straight, creating a hazard for visually-challenged pedestrians who cannot detect the change in direction of the crosswalk (see Figure 13).

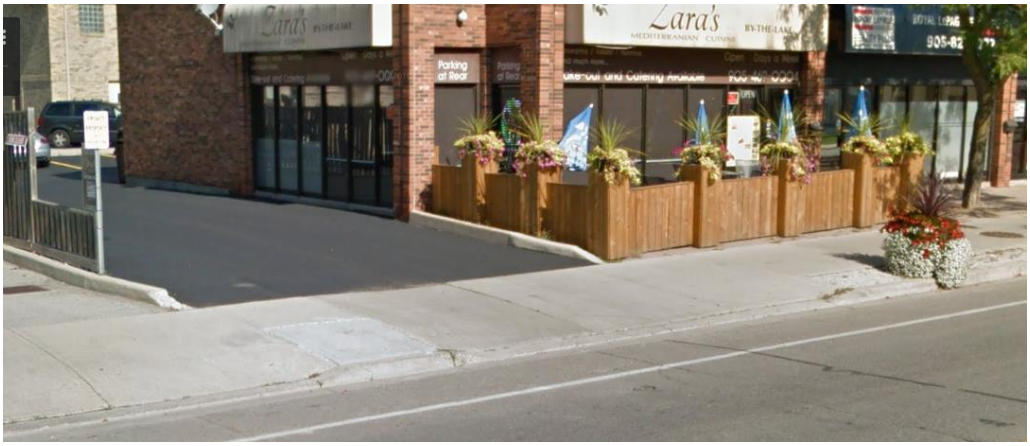


FIGURE 12: Driveway Visibility Obstruction for Pedestrians

FIGURE 13: Bent Crosswalk at the Intersection of Lakeshore Road West and Bronte Road

- By virtue of their placement, it is not clear which pedestrian pushbuttons activate which pedestrian signal heads at the southwest corner of Lakeshore Road West and Bronte Road (Figure 14). Both pushbuttons appear to activate the WALK signal for the west

crosswalk, despite one of these pushbuttons activating the WALK signal for the south crosswalk.

FIGURE 14: Confusing Placement of Pedestrian Pushbuttons

- The treatment of the transition from two lanes to one lane westbound on Lakeshore Road West between Mississaga Street and Triller Place is unusual, and may be creating a hazard for motorists. The two westbound lanes on Lakeshore Road West over the Bronte Creek bridge are abruptly converted to one wide westbound lane by terminating the lane line marking at Triller Place.

- The section of Lakeshore Road West from Mississaga Street to Bronte Road is generally inconsistent with the remainder of the road in that, this is a short section of four-lane roadway on a two-lane road.

- There is a recreation centre for seniors located at or near the intersection of Lakeshore Road West with Third Line.

5. Areas of Focus

5.1 The collision record of the study area has suggested a number of issues that should be considered and addressed in the Class EA process. Specifically:

- Collision severity in the study area is elevated when compared to general statistics for Oakville roads. This suggests that either operating speeds are too high, the roadway infrastructure is unforgiving, or both of the aforementioned.

- When compared to general collision statistics, the study area is experiencing more collisions at intersections than expected. The cause or causes of this are difficult to pinpoint. Based on the available data and observations made during the site visit, there does not appear to be any pervasive and noticeable safety deficiencies with the area intersections.

- Collisions are more prevalent in the PM peak travel period than expected. This may be an indication that traffic operations during this time are degraded and it is impacting safety performance.

- The majority of the collision risk in the study area is in the section of Lakeshore Road West from Mississaga Street to East Street. The sites with the greatest opportunity for safety improvements are located in this section: the intersections of Lakeshore Road West with East Street, Jones Street and Bronte Road, and the sections of Lakeshore Road West from West River Street to Jones Street, and from Nelson Street to East Street. The prevalent collisions at these locations are rear-end and sideswipe collisions in the mid-day and PM peak travel periods. This is typically indicative of traffic congestion causing safety performance issues.

5.2 The site visit to the study area has also revealed the following potential safety issues that should be considered and addressed in the Class EA process:

- Inconsistent pedestrians and cycling facilities throughout the study area, and no signs or markings warning motorists to share the road in areas without dedicated on-road cycling facilities.

- The section of Lakeshore Road West from Mississaga Street to Bronte Road is incongruous with the remainder of the road. The majority of Lakeshore Road, through all of Halton, has one basic lane for each direction of travel, with ancillary lanes as required. The aforementioned section is a four-lane facility and presents the appearance of a higher-order facility which promotes higher operating speeds. The collision risk on Lakeshore Road West from West River Street to Bronte Road is higher than expected, and worthy of investigation. During the Class EA process, consideration should be given to making this section of Lakeshore Road West consistent with the remainder of the road.

- Various isolated issues as detailed in Section 4.0 of this report (i.e., bent crosswalks, raised curbs protruding into crosswalks, etc.).

6. Opportunities for Safety Improvement

6.1 General

6.1.1 In discussing opportunities for safety improvement, the report will focus on geometric design options and other roadway features that are associated with larger capital expenditures and longer time frames that are consistent with the Class Environmental Assessment process. However, interim measures to improve safety in the study area will also be provided, if appropriate. Education and enforcement options are not discussed as these measures are typically the responsibility of other agencies or departments, and are not generally consistent with the infrastructure focus of this study.

6.1.2 It is understood that the purpose of the Lakeshore Road West Class Environmental Assessment Study is to identify long-term improvements for the study area to 2031. Expected geometric design modifications, based on pre-study materials, include[10]:

Alignment

- Sundry improvements to the horizontal and vertical alignment;

Cross-section

- Widening of Lakeshore Road West to three through lanes;

[10] These recommendations come from the Request for Proposals issued by the Town of Oakville.

- Provision of pedestrian and cycle facilities (including physically separated bike lanes and sidewalks);
- Bridge structure improvements for pedestrian safety;
- Changes necessary to accommodate transit;
- The addition of on-street parking in commercial districts, where possible;
- Review of the current four-lane configuration west of Bronte Road;

Access

- Intersection improvements or changes along Lakeshore Road (e.g., realignments, changes to intersections with lower order cross streets including signalization);
- Modifications to pedestrian crossing controls;
- Access improvement at Bronte Harbour Park from Lakeshore Road; and
- Streetscaping and public realm improvements in the Bronte Village area that would increase pedestrian and cyclist regard e.g. provision of bike racks and other furnishing, wider pedestrian space, on-street and lay by parking options.

6.1.3 Each of these study considerations are discussed below from a safety perspective.

6.2 Alignment

6.2.1 Lakeshore Road West currently has a curvilinear alignment that follows, more-or-less, the shoreline of Lake Ontario. None of the curves in the study area are signed with an advisory speed, and based on the collision record of the study area, none of the horizontal curves are contributing to an elevated collision risk. Given the current road allowance and development along the study area, significant changes to the horizontal alignment of Lakeshore Road West will be limited.

6.2.2 The conventional wisdom concerning alignment is that straight roads are safer than curved roads. Horizontal curves can limit forward sight distance, increase the probability of skidding and lane departures, and therefore increase collision risk. Horizontal curves typically produce single vehicle, run-off-road collisions and head-on collisions. This lends to an argument that Lakeshore Road West should be straightened, and curve radii should be increased wherever practical.

6.2.3 Research concerning the impact of curve radius also demonstrates that larger radii increases operating speeds. All things being equal, a straighter road will have a higher operating speed than a curved road. This is particularly important for the Lakeshore Road West study area, where speed management is critically important because of the frequent use of the road by cyclists.

6.2.4 The general relationships between curve radius, operating speed, and collisions is shown in Figure 15.

6.2.5 It behooves the design team to carefully consider the selection of each horizontal curve radius. The selected radius in each instance should provide the proper balance between collision risk reduction and speed management.

6.2.6 Having stated the above, a far more important consideration in selecting a revised horizontal alignment for Lakeshore Road West is that of alignment consistency. The actual "design speed" for each individual element is less important, from a safety perspective, than the relationship of the individual design speed to the design speed of the elements upstream and downstream of that element. The operating speeds that are expected to result from each horizontal alignment element should reduce operating speed variations along a route. For example, a low radius curve should not be placed at the end of a long tangent. The maximum difference between the design speeds and expected operating speeds of successive elements, should be ideally no more than 10 km/h different.

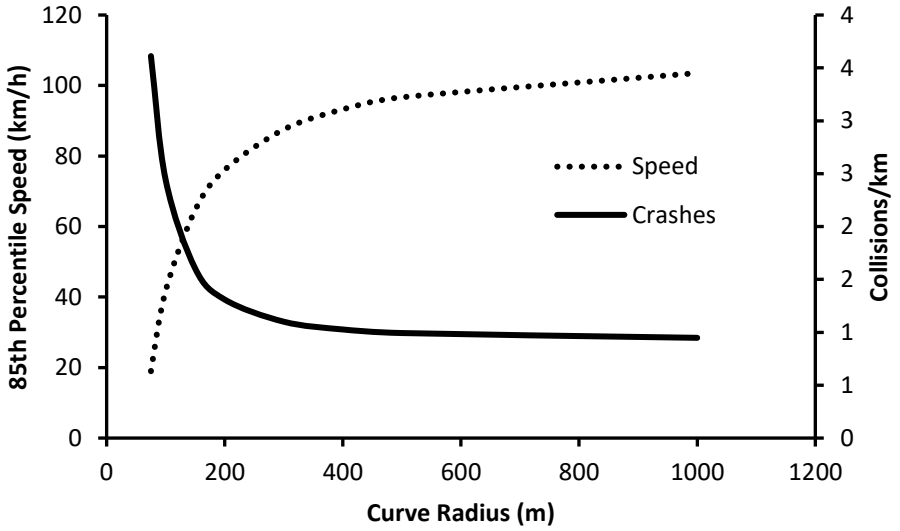


FIGURE 15: Relationship of Collision Risk to Horizontal Curve Radius

6.2.7 The operating speed of Lakeshore Road West west of East Street is 56 to 65 km/h under the current alignment. The revised alignment of Lakeshore Road West should be developed to be consistent with a proposed cross-section that will generally manage speeds to around 50 km/h through the entire study area. If a suitable speed prediction model can be found, then it is suggested that the preferred design of Lakeshore Road West be modelled to ensure that operating speeds and operating speed differentials are acceptably safe.

6.2.8 With respect to vertical alignment, there are no extreme vertical alignment conditions in the study area. Improvements to the vertical alignment will likely focus on improving roadway drainage, and enhance visibility at cross streets and driveways. Alignment improvements implemented for these reasons are expected to be a safety benefit.

6.3 Cross-section

6.3.1 Although road widening in the form of adding through lanes is generally undertaken as a solution to a capacity or level of service issue for traffic movement, this action also impacts on safety performance.

6.3.2 One of the primary considerations during the Class EA will undoubtedly be selecting the number of travel lanes for motorized traffic. The pre-study materials indicate that a three-lane cross-section is likely (one through lane in each direction and a centre turn lane). Converting Lakeshore Road West from a two-lane facility to a three lane-facility as suggested will be a safety improvement. The addition of centre turn lanes to two-lane roads is typically associated with a 15 to 30% reduction in collisions[11]. The magnitude of the reduction is dependent on the access density of the facility and the types of accesses.

6.3.3 Widening to four lanes (two lanes in each direction) is not recommended from a safety perspective. Available research indicates that a three-lane cross-section is safer than a four-lane undivided road for traffic volumes typically associated with Lakeshore Road West. Also, the four-lane road can be expected to result in higher operating speeds, which is incompatible with cyclists using this road.

6.3.4 As mentioned early in this report, the section of Lakeshore Road West from Mississaga Street to Bronte Road is incongruous with the reminder of the road, and presents the appearance of a higher-order road that promotes higher operating speeds. The collision risk in this section is also higher than expected. During the Class EA process, consideration should be given to making this section of Lakeshore Road West consistent with the remainder of the road.

6.3.5 In the interim, consideration should be given to remarking Lakeshore Road West from Mississaga Street to Bronte Road as a facility with one lane for motorized traffic and one bicycle lane for each direction. The remainder of the road space can be used for a centre-turn lane or painted median, as required. Alternatively, some of the road space may be used to create a separated bicycle lane as opposed to a standard bicycle lane.

[11] The effectiveness of any measure that is mentioned in this report is based on the best available evidence at the time of writing this report. It is important to note that the reduction factors are estimates and the actual effectiveness of the countermeasures are likely to vary from site-to-site depending on the specifics of the situation.

6.3.6 It is desirable from a safety perspective to provide sidewalks on both sides of the road throughout the entire study area. Whether this is possible will depend largely on the available road allowance and the competition for road space between the various user groups. Although pedestrian collisions are comparatively rare in the study area, these collisions tend to result in injury collisions. Sidewalks should be prioritized over boulevards and outer separations, and if necessary the absolute minimum vehicular lane widths should be used in order to provide enough road space for a sidewalk.

6.3.7 With respect to cycling facilities, Ontario Traffic Manual (OTM) Book 18 offers a cycling facility selection guide that is appropriate for the current study. A reasonable level of safety for cyclists will be achieved if the design team conforms to the guidance provided by this document.

6.3.8 On some structures pedestrians are (and will be) required to walk adjacent to motorized traffic on curb-faced sidewalks but will be shielded from moving traffic by a handrail or barrier (e.g., the structure over the Bronte Creek). When this occurs, the device separating pedestrian and motorized traffic should also offer a splash and spray protection.

6.4 Access and Intersection Control

6.4.1 Intersections are by design points of conflict within the street system, and therefore have a measurable impact on the safety performance of a corridor. Collisions at intersections are over-represented in the study area.

6.4.2 Two-way stop control (TWSC), traffic signals, and roundabouts are the three principle forms of intersection control that are suitable for an arterial road. All-way stop control (AWSC) is also an available option, but due to the delay associated with this form of control, AWSC is generally reserved for special circumstances, and is not typically a desired intersection control choice for an arterial roadway.

6.4.3 While there are no specific safety problems associated with most of the intersections in the study area, this does not suggest that there is not an opportunity to improve the safety of the system by considering other forms of traffic control.

6.4.4 For the most part, the intersection control selected for an individual intersection/driveway will be selected based on the control warrants adopted by the Town of Oakville (e.g., the OTM Book 12 warrants for traffic signal control). In the vast majority of instances, the application of these warrants will result in a form of intersection control that is reasonably safe, and will achieve a balance between intersection safety and efficiency.

6.4.5 Having stated the above, it is noted that roundabouts have been demonstrated to provide a superior safety performance to both TWSC and traffic signal control. The conventional wisdom concerning the safety performance of roundabouts is that conversion of a traffic signal to a roundabout in a suburban setting reduces all collisions by 67%. If used in an urban setting roundabouts do not appear to change total collisions, but they reduce injury collisions by 60%. The safety effects of converting a TWSC intersection to a roundabout include reducing total collisions by 39% and 78% in urban and suburban settings, respectively.

6.4.6 Roundabouts could be considered as a form of control for intersections and major driveways in the study area. If the roundabout option is pursued at any location, it would be required for the designers to assess the appropriate sight distances to determine feasibility. Moreover, any recommendations concerning roundabouts that are presented herein have not been checked against available property or the capacity to process expected traffic volumes. It is expected that this would be done as part of the Class EA process.

6.4.7 The roundabout is an opportunity to improve safety but is not a required measure. As such it is prudent for the Town to consider whether the application of this measure is consistent with their current operating practices in order to achieve consistency and uniformity in design and operation of their facilities. This is important because consistency is a cornerstone in traffic engineering practice that allows roadway designs to meet driver expectations and reduce overall collision risk.

6.4.8 Having stated the above, key intersections that should be considered for roundabouts are the intersections of Lakeshore Road West with East Street, Mississaga Street, and Suffolk Avenue. The former two intersections essentially mark the east and west limits of the Bronte Village area and roundabouts at these locations can serve as a prominent visual and physical cue to motorists that the land use and road conditions are markedly different in Bronte Village. This “disruption” in the visual scene can assist motorists in changing behaviours when traversing through the village (e.g., operating more slowly, being more vigilant for non-motorized road users, etc.). Moreover, the roundabouts can be expected to assist in managing motor vehicle operating speed in the village.

6.4.9 The intersection of Lakeshore Road West with Suffolk Avenue is another likely candidate for a roundabout. This intersection is also the entrance to Appleby College, and a location with increased pedestrian activity. The Town has already implemented some traffic calming measures in this area, suggesting that speed management is a relevant issue. A roundabout would facilitate safer motor vehicle movements to/from the college grounds, and lower speeds vicinal to the college entrance along Lakeshore Road West.

6.4.10 As the study area is heavily-used by pedestrians and cyclists, the impact of roundabouts on these user groups is an important consideration. With respect to pedestrians, the research is

sparse but consistent in that roundabouts reduce pedestrian-vehicle collisions and conflicts. The impact of roundabouts on cyclist safety is still somewhat uncertain. However, the most recent research concludes that the details of design are critical factors in delivering a safer roundabout environment for cyclists. Roundabouts with one lane and mixed traffic or a separated cycling facility offer cycling safety benefits, while multilane roundabouts and roundabouts with a bicycle lane carried through the circulatory roadway appear to increase collision risk for cyclists.

6.5 Speed Management

6.5.1 Travel speeds are a critical variable within a safe road system. Allowable speeds on any part of the network should be dependent on the vehicle types (and their protective features), the forgiving and protective nature of the infrastructure and roadsides, the restrictions upon roadside access to the roadway, and the presence of vulnerable road users. All of these factors need to be factored into selecting the maximum vehicular speed that will be permitted on each section of the network.

6.5.2 The most effective way to minimize (or eliminate) fatal or serious injury collisions is through active management of collision energy[12], so that no individual road user is exposed to collision forces that are not survivable. A key strategy is in this regard is to establish design criteria and set posted speed limits that are commensurate with the road infrastructure, the vehicles, and the traffic mix, so that users are afforded the necessary level of protection. Under a safe system approach to road design and operation, safety trumps mobility and speeds are set for reasons of safety first and mobility second.

6.5.3 The result of the above discussion, is that pedestrians/cyclists and motorized traffic are generally-speaking a poor mix. The mass and speed differences between these user groups can result in kinetic energies that produce serious injuries and fatalities to the former group, when a collision occurs. In areas where the interaction between motorized traffic and pedestrians is inevitable, then the speed of motorised traffic should be kept as low as possible to increase the probability of pedestrian survival in the event of a collision.

6.5.4 The probability of a pedestrian being fatally injured in a collision with a motor vehicle has been determined from field investigations of collisions, and is shown in Figure 16. Around 80% of pedestrians survive a car strike at a speed of 50 km/h, whereas only 25% survive at a strike at a speed of 80 km/h. Several studies have been conducted in this area, and many have found slightly different figures, but the trend is clear – lower impact speeds result in less severe collisions.

[12] Collision energy is directly related to the mass of the vehicles/users involved in the collision, and the square of the speed of the users/vehicles at the time of impact. Increased vehicular speed results in a disproportionate increase in kinetic energy, and a similarly pronounced increase in collision risk.

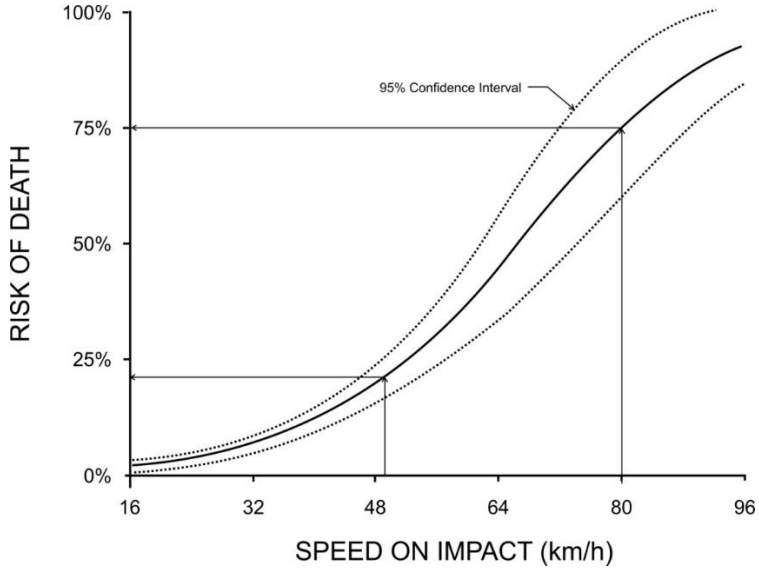


FIGURE 16: Pedestrian Survivability in a Collision

6.5.5 Two interrelated road safety concerns on roads that have multiple user types are the "design speed" of the road, and the selection of a suitable speed limit. In general, arterial roads, such as Lakeshore Road West, warrant a higher speed to satisfy the road's express purpose of providing mobility. On the other hand, cyclists and pedestrians typically warrant slower speeds in the name of safety. In a safe system approach to road design, the design and operating speeds in a mixed use environment should be the slower speed.

6.5.6 The Lakeshore Road West study area is a peak use pedestrian and cycling route, and these road users must share road space with motorized traffic. While the ultimate design of Lakeshore Road West will most likely include continuous facilities for pedestrians and cyclists that are laterally-separated from the motor vehicle lanes, the fact is that motor traffic and vulnerable road users are sharing the road allowance. While the 50 km/h speed limit is suitable for the section of Lakeshore Road West east of East Street, the more intense pedestrian and cycling activity in the Bronte Village community may warrant a speed limit of 40 km/h.

6.5.7 A 40 km/h speed limit from Bronte Road to East Street is consistent with the current look and feel of Lakeshore Road West, appropriate for the mix of different road users and the proximate land uses, and should be a pro-safety measure.

6.5.8 The effect of reducing the speed limit to promote increased safety has been debated in the engineering literature. It is well known that a reduction in the speed limit without a

corresponding change in the physical features of the road, or an increased threat of enforcement, has a marginal impact on actual travel speeds. A 10 km/h change in speed limit yields about a 3 to 4 km/h (statistically significant) change in the mean speed. This finding, while it appears trivial, is quite significant from a safety perspective.

6.5.9 The design team and the Town should consider speed management measures in Class EA process including but not limited to, roundabouts, narrow lanes, cycling lanes, roadside landscaping, and a reduced speed limit of 40 km/h in the Bronte Village area.

6.6 Other Safety Considerations

6.6.1 The entire Lakeshore Road West study area is a commonly used cycling route. While the section of road from Bronte Road to Third Line is well signed and marked with an on-road bicycle lane, there are no signs or markings to indicate the presence of cyclists along the reminder of the study area. Given the current condition and layout of Lakeshore Road West east of Third Line, it is recommended that this section of Lakeshore Road West be provided with BICYCLE ROUTE MARKER signs (M511) and SHARE THE ROAD sign (Wc-19) until such time as the road can be reconstructed.

6.6.2 Pavement marking sharrows would not typically be used given the availability of a paved shoulder in many sections of the road, and the relatively narrow width of the travel lane. Nonetheless, the Town may consider also marking “enhanced sharrows” on some sections of Lakeshore Road West, similar to those used on Lakeshore Road through the City of Burlington.

7. Summary

7.1 The Town of Oakville is undertaking a Class EA for Lakeshore Road West from Mississaga Street to Dorval Drive, which includes this road safety performance assessment.

7.2 The collision data made available for this assessment indicate:

- The severity of the collisions in the Lakeshore Road West study area are higher than expected;
- There are more collisions occurring at intersections in the study area than expected;
- Collisions are over-represented in the PM peak travel period;
- Adverse environmental or road conditions do not appear to be contributing to an elevated collision risk; and

- The collision risk is elevated in the Bronte Village community (from Mississaga Street to East Street) where three intersections and three road sections have safety performance that have good potential for improvement.

7.3 Items that should be considered during the Class EA process are:

- The revised alignment of Lakeshore Road West should be developed to be consistent with a proposed cross-section that will generally manage speeds to around 50 km/h through the entire study area;

- If a suitable speed prediction model can be found, it is suggested that the preferred design of Lakeshore Road West be modelled to ensure that operating speeds and operating speed differentials are acceptably safe;

- Converting Lakeshore Road West east of Bronte Road from a two-lane facility to a three-lane facility will be a safety improvement;

- Widening to four lanes (two lanes in each direction) is not recommended from a safety perspective;

- The section of Lakeshore Road West from Mississaga Street to Bronte Road should be made congruous with the reminder of the road (i.e., with respect to number of lanes and cross-section design);

- It is desirable from a safety perspective to provide sidewalks on both sides of the road throughout the entire study area, if possible;

- Sidewalks should be prioritized over boulevards and outer separations, and if necessary the absolute minimum vehicular lane widths should be used in order to provide enough road space for a sidewalk;

- A reasonable level of safety for cyclists will be achieved if the design team conforms to the guidance provided in OTM Book 18 with respect to cycling facility type selection;

- On structures where pedestrians will be required to walk adjacent to motorized traffic on curb-faced sidewalks (e.g., the structure over the Bronte Creek), the device separating pedestrian and motorized traffic should also offer a splash and spray protection;

- Selecting intersection control for individual intersections based on the control warrants adopted by the Town of Oakville (e.g., the OTM Book 12 warrants for traffic signal control) will result in a form of intersection control that is reasonably safe;

- Due to their safety benefits, roundabouts could be considered as a form of control for intersections and major driveways in the study area. Primary candidate locations for roundabouts are East Street, Mississaga Street, and Suffolk Avenue.

- The design team and the Town should consider speed management measures during the Class EA process including but not limited to, roundabouts, narrow lanes, cycling lanes, roadside landscaping, and a reduced speed limit of 40 km/h in the Bronte Village area; and

- Various isolated issues as detailed in Section 4.0 of this report (i.e., bent crosswalks, raised curbs protruding into crosswalks, etc.).

7.4 Items that should be considered as interim improvements until such time that Lakeshore Road West can be reconstructed include:

- A 40 km/h speed limit for the section of Lakeshore Road West in the Bronte Village area where there is intense pedestrian and cycling activity;

- Lakeshore Road West east of Third Line, should be provided with BICYCLE ROUTE MARKER signs (M511) and SHARE THE ROAD sign (Wc-19);

- "Enhanced sharrow" markings on some sections of Lakeshore Road West, similar to those used on Lakeshore Road through the City of Burlington, may be used until such time as the road can be reconstructed to provide dedicated cycling facilities; and

- Consideration should be given to remarking Lakeshore Road West from Mississaga Street to Bronte Road as a facility with one lane for motorized traffic and one bicycle lane for each direction.

Appendix A: Material Available for the Road Safety Performance Assessment

The following material was supplied by AMEC and the Town of Oakville for the conduct of this road safety performance assessment:

- Network Screening results for Oakville Intersections and Midblocks (2010) as an MS-Excel file with 2 tabs.

- Collision Details Reports produced by TES for all road sections and intersections in the study area from 2006 to 2016, printed in November 2016.

- Sanitized copies of Motor Vehicle Accident Reports for all (2) fatal collisions in the study area during the analysis period mentioned in the body of this report.

- Sanitized copies of Motor Vehicle Accident Reports for all cyclist and pedestrian-involved collisions in the study area during the analysis period mentioned in the body of this report.

- Town of Oakville Staff Report to the Community Services Committee, from D. Crkvenjas, of the Engineering and Construction Department, Subject: Speed Limit Review, dated April 4, 2016, 11 pages plus Appendices A, B and C.

- Town of Oakville Staff Report to the Community Services Committee, from D. Crkvenjas, of the Engineering and Construction Department, Subject: Traffic Calming Process Update, dated April 4, 2016, 14 pages plus Appendices A to F.

- Available turning movement counts and ATR Volume Summary Details report in PDF format for the intersections and road sections in the study area, respectively.

- AADT Intersection Report produced by TES printed on November 3, 2016 for the study area, including data from 1970 to 2016.

- AADT Midblocks Report produced by TES printed on November 3, 2016 for the study area, including data from 2002 to 2016.

Appendix B: Statistical Tests of Significance for the Difference Between Two Proportions

Chi-square Test

The chi-square test is a measure of the differences between measured and expected frequencies. If the number of collisions at a subject location is greater than the expected number of collisions for a particular characteristic (i.e., "wet pavement" collisions), then use of the chi-square test will assist the analyst in determining if the difference is statistically significant or likely a random variation in the data. The expected number of collisions is determined by using collisions statistics from a number of years, or a number of similar locations.

The chi-square test for a 2 x 2 table can be calculated using the following equation:

$$X^2 = \frac{(x - pn)^2}{pn} + \frac{[(n - x) - n(1 - p)]^2}{n(1 - p)}$$

where: X^2 = chi-square test value
p = the average ratio for the collision type being investigated
x = the number of collision types being investigated, and
n = the total number of collisions at the site.

If a 95 percent level of confidence is used the chi-square test value is 3.84 (i.e., this is the value for a 2 x 2 collision table). Therefore, if the calculated X^2 is greater than or equal to 3.84, then the difference between the measured collision frequency is statistically different from the expected collision frequency to a 95 percent level of confidence.

The chi-square test is not reliable when the *expected* frequency is less than five. The expected frequency is determined by multiplying p and n. If p*n is less than five, then the Fisher Exact Test should be used.

Fisher Exact Test

The Fisher exact test calculates an exact probability value for the relationship between two variables, as found in a 2 x 2 table. It works in exactly the same way as the chi-square test for independence; however, the chi-square gives only an *estimate* of the true probability value, an estimate that might not be very accurate if there is a small value (less than five) in one of the cells. In such cases the Fisher exact test is a better choice than the chi-square test.

To explain the Fisher exact test, consider the notation in the following table, and note that the table should be arranged so that "a" is the smallest value in the table.

Collision Characteristic	**GROUP**		**Sum**
	SITE	**COMPARISON**	
X	a	b	a+b
Not X	c	d	c+d
Sum	a+c	b+d	N

The probability of obtaining this set of values is calculated by:

$$p = \frac{(a + b)!\,(c+d)!\,(a+c)!\,(b+d)!}{N!a!b!c!d!}$$

where: p = probability of obtaining the values in the 2 x 2 table
a,b,c,d = the cell values in the 2 x 2 table
N = a+b+c+d
! indicates the factorial, for example if N=5,
then N! = 5*4*3*2*1. (Note: 0!=1)

In order to calculate the probability that the proportions are different between the site and the comparison groups, one must also consider all results that are equal to or "more extreme" than the one observed (i.e., the table provided). Therefore, the probabilities for all tables that have 1) an "a" that is less than or equal to the observed "a", and 2) row and column sums that are the same as in the "observed" table, are calculated and summed.

The summed "p" values provide the probability that the observed values are different than the expected/comparison values.