Innisfil Design Guide for Traffic Calming Measures

Final Report

February 1, 2023

Introduction

In 2022, the Town of Innisfil developed this Design Guide for Traffic Calming Measures (TCM) providing guidelines for the review and decision-making process of traffic calming requests. TCM, if chosen and implemented properly, can help reduce travel speeds on Town streets, while, in parallel, improving safety for vehicle occupants as well as vulnerable users such as pedestrians and cyclists.

This Guide provides a step-by-step process by which Town officials can determine if TCM are warranted at particular locations, taking into consideration public input, engineering principles, and the Town's own priorities. The Guide then presents multiple TCM options, including a detailed discussion of their potential effectiveness, guidance on their design and implementation, as well as the positive and negative aspects and costs associated with each potential TCM. This information, based on similar applications in other jurisdictions, as well as other national and regional TCM guidelines, will help the town make educated decisions on this important topic.

Traffic Calming Design – Decision Process Flow Chart

The following TCM adoption and design process includes three tasks, subdivided into 9 subtasks, as shown in **Figure 1**. This flow chart is set up to be followed from top to bottom, left to right, in sequence. Specific considerations for each step in the TCM decision process is presented in subsequent sections.

The Town's new policy involves two paths for calming traffic: a forward-thinking approach for implementation, and a responsive method for dealing with citizens' grievances.

The reactive process starts when a request for traffic calming is received. After that, the TCM Pre-study phase is launched, followed by the TCM study, and then the TCM implementation.

Conversely, the proactive process involves cutting out the TCM pre-study step and proactively screening all of the Town's roads in accordance with the TCM study step in order to determine and rank the locations that qualify for traffic calming. The TCM implementation would then take place after the selection as the last step of the process.

As big data advances to the level of providing dependable and precise data for use in programs, it can be effortlessly integrated into the proactive process to cover more streets and achieve satisfying results promptly.

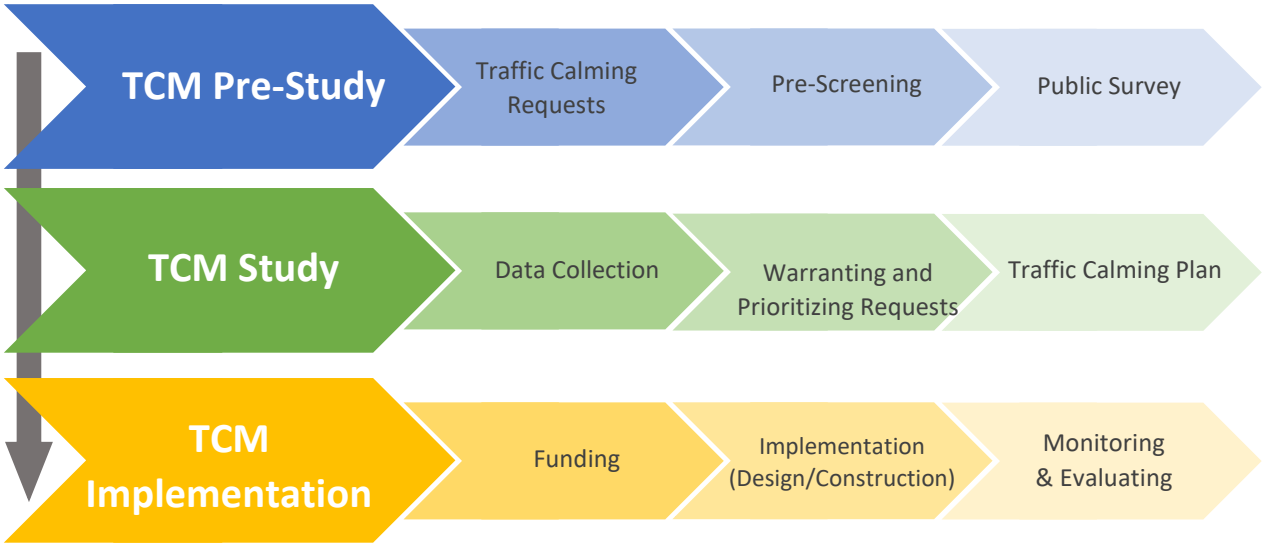


Figure 1: Traffic Calming Measures – Decision Process Flow Chart

1. TCM Pre-Study

The first step of the TCM process is to undertake a Pre-Study of existing conditions at the location(s) of concern. This would include a review of traffic calming requests from the public, as well as a review of the Town's relevant policies, standards, and plans for its roadway network. All these inputs must be considered to confirm that there is a need for traffic calming at the requested location(s). The purpose of this Pre-Study is to choose locations where TCM are warranted and should be applied. This can streamline Town efforts as this preliminary process may eliminate locations that are not good candidates for TCM. The Pre-Study includes receiving traffic calming requests, pre-screening, and, potentially, a public survey on the subject. The following section presents the prescribed sequence for completing a TCM Pre-Study.

1.1 Receive Traffic Calming Request

The Town must have a TCM request process which includes complete and easy-to-follow instructions for the public on how such requests can be made, how they will be received, and the timeframe for review by the Town. The instructions must be provided online, as well in hard copy at the Town Hall.

1.2 Pre-Screening

Once a traffic calming request is received, the next step is to pre-screen the request using the criteria shown in **Table 1**. This process will help determine if a location is eligible for the implementation of TCM. The pre-screening criteria presented in **Table 1** should be considered as the minimum eligibility requirements for TCM. The location specified in the request is only to be

considered as a potential candidate for traffic calming applications if all pre-screening criteria are met.

Table 1: Pre-Screening Criteria

Criteria	Requirement
Location Area	Primarily residential area
Road Classification	Local or Collector
Road Grade	Road grade ≤ 8% (depends on mitigative measure)
Street Length	Street segment length with uninterrupted traffic flow (no traffic control) ≥ 150 m
Traffic Volumes	Traffic volumes ≥ 250 vpd (vehicles per day) (data no older than five years)
Posted Speed Limit	Posted speed limit of 50 km/h or less
Vehicle Speeds	85^{th} percentile speed is 10 km/h or more over posted speed limit (using available data, not older than 3 years)

1.3 Public Survey (Community Support/Concerns)

The final step in the TCM Pre-Study process is to conduct a public survey to confirm community support from residents within the study area and to identify any concerns/complaints with regards to traffic conditions. In order to achieve that, a compilation of all the people and businesses in the area ought to be created and contacted for their feedback on the request.

2. TCM Study

Once a location is confirmed to be a good candidate for the implementation of TCM, based on the Pre-Study process, a formal study will be required. This Study will help the Town further understand the existing conditions at the complaint location and to prioritize this location considering all other outstanding requests for TMC within the Town. This process will allow the Town to develop an overall traffic calming plan for the region, with each specific complaint and potential resolution ranked in terms of immediacy, feasibility, cost, and implementation requirements. The TCM Study process includes speed data collection, a warrant analysis, and developing a TCM implementation strategy. The individual stages of the TCM Study process are described in detail below.

2.1 Data Collection

Prior to the traffic calming warrant process, a significant amount of data must be collected, including the following

Note: Some of these data may already have been collected during the Pre-Screening stage. Other data is collected/verified as part of the Roads Needs Study, the Transportation Master Plan, or through design.

- 85^{th} and 95^{th} percentile speeds
- Street length
- Road grade
- Traffic volumes and patterns (motor vehicles, pedestrians, cyclists)
- Traffic generators (e.g., residential, commercial, tourist establishments)
- Public complaints
- Collision history
- Road classification

The 85^{th} percentile speed should be determined soon after the time of the TCM request. Traffic volumes for the Study Area are to be based on Average Annual Daily Traffic (AADT) values and must have been counted within the last 5 years, otherwise updated traffic counts should be collected. Collision history data may be sourced from MTO's ARIS database and should include reported collisions within the last 5 years of the request, including those involving motorists, pedestrians, and cyclists.

2.2 Warrants and Prioritizing Requests

The next step in the TCM process includes utilizing the collected data to determine where TCM may be most effectively implemented. This process can also be used to prioritize multiple potential TCM candidate locations to determine which facility(s) requires immediate attention. The purpose of this warrant process is to enable the Town of Innisfil to systematically prioritize their traffic calming efforts when there are multiple candidate locations for new TCM.

The Innisfil traffic calming warrant criteria, as well as the prioritizing process, are presented in **Table 2**. This TCM warrant functions as a point-based system, with the maximum amount of points a location can receive being 100. Each criterion in the warrant was selected and weighted based on a review of traffic calming warrants used in other Ontario jurisdictions, and considers safety and operational concerns that may be addressed with TCM.

The number of points a location receives, based on the criteria presented in **Table 2**, can be used to determine if a TCM(s) is warranted at a particular facility. If the warrant process produces a value of **15** or more, TCM may be useful to reduce travelling speeds. Once additional traffic speed data is obtained for the roadway segments which pass the Traffic Calming Warrant process presented in **Table 2,** the additional data can be added to the warrant process based on the **Table 3** methodology. At this stage, if the warrant process produces a value of **25** or more, the segment should be included in the prioritization process.

In some cases (e.g., where a fatal collision occurred within the last 5 years) a facility may warrant the implementation of a TCM even if the warrant threshold score is not achieved.

This process may also be used to evaluate the relative priority of one potential location over one or more other locations, with higher points indicating which location has a greater need for TCM. Once the warrant values for all potential locations are calculated, these locations should be prioritized from highest to lowest total scores.

Table 2: Traffic Calming Warrant and Prioritization

Criteria	Point Criteria	Max Pts.	Score
Vehicle Volumes	Local: 5 pts for every 1,000 AADT (rounded down). (e.g., 1,400 AADT would get 5 pts) Collector: 5 pts for every 2,000 AADT (rounded down). (e.g., 1,700 AADT would get no points, 2,400 would get 5 pts)	**20**	
Collision History	1 pt. per collision of any type (other than involving pedestrians/cyclists) in the last 5 years. 5 pts. per collision involving pedestrians or cyclists in the last 5 years.	**30**	
Public Complaints	5 pts. per complaint regarding vehicle speeds in most recent year to a maximum of 20 points.	**20**	
Pedestrians and Cyclists	10 pts for no sidewalk or bike lanes. 5 pts for every nearby (within 500 m) pedestrian generator (e.g., park, places of worship, town hall, mall, theatre, library). 10 pts for every nearby school.	**30**	
Total (minimum 15 to continue data collection)		**100**	

Criteria	Point Criteria	Max Pts.	Score
Vehicle Speeds	1 pt. for every 1 km/h that the 85th percentile speed exceeds the posted speed limit. Additionally, 1 pt. for every 1 km/h 95th percentile speed exceeds 20 km/h over the speed limit.	**30**	
Total (minimum 25 for TCM consideration)		**130**	

2.3 Develop Traffic Calming Plan

The next step in the TCM process is to develop a Traffic Calming Plan for those locations determined to have the highest priority. The TCM Options Table (Table A in **Appendix A** of this report) describes each potential traffic calming application, including their estimated applicability, effectiveness, potential risks and constraints, as well as a preliminary estimation of

installation costs (i.e., Low: Up to $10,000, Moderate: $10,000 to $25,000, or High: More than $25,000).

Table A in **Appendix A** of this guide provides a large range of TCM options based on various speed reduction techniques, including:

- Vertical Deflections
- Horizontal Deflections
- Pavement Markings
- Roadway Narrowing
- Interactive Measures
- Enforcement
- Education
- Surface Treatments
- Access Restrictions
- Others

3. TCM Implementation

A Traffic Calming Plan should be developed based on the priority ranking process presented in this Guide as well as the Town's annual budget (both capital and maintenance) for traffic calming measures. Once a Traffic Calming Plan is developed, the chosen TCM must be implemented properly and effectively. The costs of the individual calming mechanisms must be ascertained to assure that the community has the current and future funding available to invest in the Plan. There are various suppliers who can provide the needed tools to install the calming measures where they have been prescribed. It would be useful to always know what the costs will be to implement the calming measures, especially those that require ongoing maintenance.

3.1 Confirm Funding

As the TCM plan moves from the planning stage to the implementation stage, the Town must determine its funding priorities and allocations. When several TCM options are being considered at locations throughout the Town, the costs associated with these measures must be compared to the available TCM budget in order to assure that the most necessary measures take precedence. If it is not possible to implement the entire TCM plan, the Town must invest in the applications that were determined to be of the highest priority. Once these measures are allocated funding, the Town should continue to plan the implementation of the remaining measures over the next few years. The Town must also be constantly aware of the ongoing maintenance costs associated with the implemented TCM.

3.2 Implementation (design/construction)

The budgeting of each potential TCM project will depend on the scope of the application, including the individual costs and timelines of the TCM measures employed. For projects not

requiring significant roadway modifications, it is advised that the budgeting for the design and construction be done within the same year. For larger traffic calming projects, the budget for the design phase should be prepared for the first year and the construction budget should be prepared for the following year.

Design

Most of the potential TCM presented in this Guide require some measure of design. Potential TCM may have several variations which must be explored, with the appropriate application being chosen based on local traffic patterns, roadway configurations, environmental conditions, and other factors. It is advised that, once TCM are chosen and prioritized, the Town engage a professional designer who is thoroughly familiar with TCM, including their specific design and implementation requirements. The Town may choose to undertake some of the design process, themselves, but it is essential that a Traffic Engineer (or equivalent) at least review the Town's design and implementation plan.

The design process for virtually all the TCM presented in this Guide is already carefully outlined in various TCM design guides. The Transportation Association of Canada (TAC) has a detailed design process for TCM, as does the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO) in the United States. These design guides are complete and well researched and provide the necessary instructions for designing the TCM presented in this Innisfil TCM Guide.

The Town has previously implemented a variety of TCM on various roadways, including temporary and permanent mounted radar speed displays, as well as temporary roadside radar speed display boards carried by mobile trailers. The results of these TCM applications are discussed further in the Innisfil Pilot Study Report.

Construction

Once a TCM has been chosen, and a full design is completed, the application must be installed correctly at the designated location. Ideally, these measures would be constructed when weather and roadway conditions are suitable (i.e., not during late fall or winter months). Several of the potential TCM may need to be removed in the fall and reapplied during the spring as they may interfere with winter snow removal, and possibly get damaged. If several TCM are chosen for a particular location, they should all be implemented within a short period of time to achieve the desired, combined traffic calming effect.

3.3 Monitor and Evaluate

Temporary and permanent TCM should be properly and diligently monitored once they are implemented. Traffic speed data should be regularly (e.g., after the first month and during the 3 months, at least one weekday and weekend day) collected at the subject roadway or intersection in order to verify that the installed TCM are having the desired effect. It is suggested that, 3 months after implementation, a study be conducted to determine if the TCM has been effective,

and to what degree. This information will aid in deciding whether to continue using that particular TCM at that location, or replace it with another traffic calming option. It also may be decided to focus on another potential location where a TCM application may be more effective. Monitoring the effectiveness of a TCM at the 6 months and one year implementation milestones will also help the Town better understand how TCM work, how effective they can be (or not be), and help in the choosing of future TCM applications.

Note: As part of the monitor and evaluate process, ensure the TCM used does not result in an adverse impact on another street(s) in the area. For example, a TCM to reduce traffic volumes on a local street may result in traffic diverting to an adjacent street in the immediate area.

4. Pedestrian Crossing Warrant

The presence of motor vehicles, pedestrians, and cyclists should be considered before implementing TCMs. Pedestrian crossings should be paired with the appropriate traffic calming measures at locations where there are high crossing desire lines (e.g., schools, parks, and beach accesses). TCMs that may be compatible with pedestrian crossings include: raised crosswalks, curb radius reductions, traffic circles, roundabouts, curb extensions, raised median islands, coloured/textured pavement, textured crosswalks, and LED pavement markings.

Pedestrian crossovers require a separate warrant system from standard TCM. The Pedestrian crossing warrant methodology is presented in OTM Book 15 – Pedestrian Crossing Treatment. The OTM Book 15 pedestrian crossing warrant flowchart is included in **Appendix B** of this Design Guide.

5. Higher Class Roadways

Local and low-volume collector roads are most often the locations considered for Traffic Calming programs undertaken in other Canadian jurisdictions. Applying TCM on higher volume collector and arterial roads, that are designed for higher speeds, emergency services routes, and truck routes is not normally desirable; however, there are particular TCM options, such as on-street parking, road diets (e.g., lane narrowing), and pavement markings, which may be appropriate for higher-class roadways within urban settings.

6. New Roadway Facilities

For greenfield developments involving the construction of new roadways and intersections, a traffic calming review should be conducted during the initial roadway network planning stage. During this planning process, a traffic calming plan should be required, with all potential TCM included on the site plans. All TCMs to be used for new developments should be selected and installed in accordance with the latest Innisfil Traffic Calming Design Guide.

Appendix A

Table A: Traffic Calming Measures Options

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Speed Cushion (Innisfil Pilot Study) Description: Raised areas on the roadway that cause a vertical deflection for vehicles, but do not cover the whole width of the road – allows larger vehicles to straddle the cushion[1].	 Source: National Association of City Transportation	• All sides of cushion must be ramped to allow for drainage • All edges of ramps should be formed and keyed into existing asphalt • One speed cushion per travel lane is typical • Optimal width of a speed cushion is 1.8 m (narrow enough to allow emergency vehicles to pass unaffected) • Space between the cushions and the curb approximately 0.6 m • Distance between cushions if only two are installed must be at least 1.5 m (prevents heavy vehicles from passing too closely to one another) • The cushion design is shown in Figure 4.5 of the TAC Traffic Calming Design Guide (for non-transit routes or for locations where transit can drive over centreline for short periods of time) • Signage: Speed Hump sign (WA-50) facing traffic and immediately adjacent to the speed cushion (may require Speed Hump warning signs if visibility is an issue), required on both sides of road for one-way streets • Recommended pavement markings are shown in Figure 4.4 and 4.5 of the TAC Traffic Calming Design Guide • Preliminary estimation of installation costs – Medium • **Reference: TAC Traffic Calming Design Guide**
Speed Hump/Table Description: Raised areas on the roadway that cause a vertical deflection for vehicles and cover the entire width of the roadway (speed tables are more elongated speed humps)[1] .	 Source: Transportation Association of Canada	• Use speed tables for roadways with higher design speeds • Similar configurations – speed tables have flat top section 3 m long by 80 mm high between the two halves of the local street hump • Vertical transition at end should be keyed into existing pavement • Use a series of speed humps/tables to retain slower vehicle speeds over longer distances – spacing of 80 m to 150 m is recommended to maintain an 85th percentile operating speed between 40 and 48 km/h • Install Speed Hump sign (WA-50) facing traffic and immediately adjacent to the speed hump • Configuration of design shown in Figure 4.6 and 4.7 of TAC Traffic Calming Design Guide • Preliminary estimation of installation costs – Medium • **Reference: TAC Traffic Calming Design Guide**

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Raised Crosswalk (Innisfil Pilot Study) Description: Marked crosswalks that are at a higher elevation than approaching roadways[1].	 Source: District of Squamish, BC	• Can be implemented at an intersection or mid-block • Typically, a crosswalk is 6.5 m wide with a minimum width of 2.5 m (in accordance with MUTCD) • Ramps (sloped section of crosswalk) on either side of crosswalk are typically 2 m in width each • Design shown in Figure 4.1 and 4.2 of the TAC Traffic Calming Guide • Location of raised crosswalks relative to curbs and sidewalks should be the same as for non-raised crosswalks • Vertical transition at end of retrofit raised crosswalk to be keyed into existing pavement • Signage: Speed Hump sign (WA-50) should be installed facing traffic and immediately adjacent to raised crosswalk (on both sides of the road for one-way streets); Pedestrian Crosswalk sign (RA-4) installed on both sides of road facing traffic (not required at traffic signal or stop-sign controlled intersections) • Preliminary estimation of installation costs – Medium • **Reference: TAC Traffic Calming Design Guide**
Raised Intersection Description: Intersections that are at a higher elevation than approaching roadways[1].	 Source: National Association of City Transportation	• Raised the same amount as any adjacent raised sidewalk (consistent throughout street system) • 80 mm recommended 15 mm curb face retained at all crosswalk locations • Sloping surfaces connecting adjacent sidewalks have tactile finish and slope of 6% or less • Vertical transition at end should be keyed into existing pavement • Minimum pavement slope of 1% for surface drainage • Install Speed Hump sign (WA-50) facing traffic and immediately adjacent to the speed hump unless intersection is stop controlled (no signage needed) • Configuration of raised intersection design illustrated in Figure 4.3 of TAC Traffic Calming Design Guide • Preliminary estimation of installation costs – High • **Reference: TAC Traffic Calming Design Guide**

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Actibump Description: A radar-controlled module that sinks into the roadway for vehicles with a detected speed over the posted limit.	 Source: Actibump	• To be installed as per manufacturer requirements • Preliminary estimation of installation costs – High
Chicane **(Innisfil Pilot Study)** Description: A series of curb extensions that alternate between sides of a roadway. Designed to narrow the roadway and require drivers to make a horizontal deflection to steer between them[2].	 Source: Traffic Calming Guide for Toronto	• Development of effective 2-lane chicanes is restricted to wider local or collector streets • Two-lane chicanes require a pavement width of at least 12 m • One-lane chicanes require a pavement width of at least 7 m • Chicane must disrupt any single lane alignment along the street – offset between the apexes of adjacent chicane islands must be 2 m or less • Parking and stopping prohibited within the limits of the chicane • Signage: Object Markers (WA-36) typically provided at its apex (note that Delineation Markers (WA-37) or bollards with reflective striping may be an alternative to Object Markers); Yield to Oncoming Traffic sign (TC-178) required for a two-way one-lane chicane in advance of the chicane; Stopping Prohibited sign (RB-55) required • Pavement Markings: solid yellow line or raised median may be used to separate opposing traffic on two-lane chicane • Preliminary estimation of installation costs – High • **Reference: TAC Traffic Calming Design Guide**

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Lateral Shift Description: A change in the alignment on the roadway causing drivers to make a horizontal deflection[2].	 Source: Institute of Transportation Engineers	• Applicable for one-lane one-way and two-lane two-way streets • Applicable for streets with or without bike lanes • Can be used on streets with bus transit routes/emergency vehicle routes (buses and emergency vehicles must be able to straddle centreline) • Opposing traffic through the lateral shift can be separated with raised median • Applicable in mid-block locations only • Should be located near streetlights if possible • Preliminary estimation of installation costs – Medium to High • **Reference: Institute of Transportation Engineers** (https://www.ite.org/pub/?id=2a582794%2Dfd92%2D4e12%2Defa0%2Ddc618963b268)
Curb Radius Reduction Description: Reconstruction of the corner of an intersection that uses a smaller radius[2].	 Source: National Association of City Transportation	• Introduce the smallest radius required to accommodate a passenger vehicle (3-5 m) and then check for larger vehicles • Evaluate risk of damage to sidewalks caused by larger vehicles as well as risk to pedestrians • In isolation do not require any additional signing or pavement markings • Relocation of existing utility poles, posts, and signing and pavement marking replacement may be required • Potential designs shown in Figure 4.9 of TAC Traffic Calming Design Guide • Preliminary estimation of installation costs – High • **Reference: TAC Traffic Calming Design Guide**

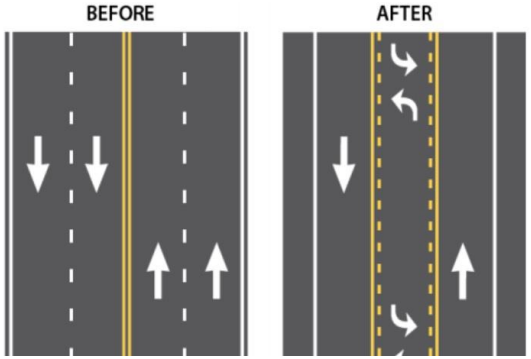
TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Speed Kidney Description: 3 Elongated speed humps arranged in a curvilinear shape positioned with the direction of traffic[1].	 Source: Mike on Traffic	• Minimum lane width of 3.7 m • Sidewalk curb or edge line may require modification if street is not wide enough for a pair of speed kidneys • Radius of central curve dependent on radius of speed kidney • Speed kidney should be painted in white • Speed hump warning sign required • Can use WA-50 Speed Hump signs • Design shown in Figure 4.10 of TAC Traffic Calming Design Guide • Preliminary estimation of installation costs – High • **Reference: TAC Traffic Calming Design Guide**
Traffic Circle Description: Raised island in the middle of an intersection that requires vehicles to drive in a circular, counterclockwise direction through the intersection[2] (Mini roundabout)	 Source: City of Vancouver, BC	• Yield signs (RA-2) recommended on all approach streets • Chevron alignment signs (WA-9) required • Central island includes small raised/landscaped portion with mountable outer portion for larger vehicles • Inscribed circle diameter of 30 m or less • When used, splitter islands can be raised, traversable, or flush • Specific geometric requirements provided in Section 4.3.1 A. of the TAC Traffic Calming Design Guide • Guidelines for pedestrian and bicycle requirements are also available in the TAC Traffic Calming Design Guide • Design shown in Figure 4.11 of TAC Traffic Calming Design Guide • Preliminary estimation of installation costs – High • **Reference: TAC Traffic Calming Design Guide**

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Roundabout	 Source: Canadian Institute of Transportation Engineers	• Preliminary estimation of installation costs – High • **Reference: TAC Geometric Design Guide**
Full Lane Transverse Bars Description: Series of parallel pavement markings that extend across the entire travel lane to create the illusion of increasing speed by decreasing the space between them[1].	 Source: Federal Highway Administration	• Recommended spacing is the same as what is provided for Peripheral Transverse Bars in the TAC Traffic Calming Design Guide • Spacing for roadways with a posted speed of 80 km/h down to 60 km/h: 4 m spacing between bars 1 to 6, 5 m spacing between bars 7 to 12 • Spacing for roadways with a posted speed of 60 km/h down to 40 km/h: 3 m spacing between bars 1 to 7, 4 m spacing between bars 8 to 12 • Spacing for roadways with a posted speed of 50 km/h down to 30 km/h: 2 m spacing between bars 1 to 4, 3 m spacing between bars 5 to 12 • Maximum width of 0.3 m, extended across most of the travelled lane width • Preliminary estimation of installation costs – Medium • **Reference: City of Kingston – TAC Traffic Calming Design Guide, Traffic Calming Guidelines** (https://www.cityofkingston.ca/documents/10180/15058/Traffic+Calming+Guidelines.pdf/804c309a-7195-ba08-e20e-dd17349f0a53?t=1629998980890)

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Peripheral Transverse Bars Description: Variation of full lane transverse bars but they are placed along the side of the travel lane.	 Source: Federal Highway Administration	• Series of white transverse lines on both sides of the lane perpendicular to the centerline, edge line, or lane line • Maximum width of 0.3 m, maximum length (extended into the lane) of 0.5 m • Spacing for roadways with a posted speed of 80 km/h down to 60 km/h: 4 m spacing between bars 1 to 6, 5 m spacing between bars 7 to 12 • Spacing for roadways with a posted speed of 60 km/h down to 40 km/h: 3 m spacing between bars 1 to 7, 4 m spacing between bars 8 to 12 • Spacing for roadways with a posted speed of 50 km/h down to 30 km/h: 2 m spacing between bars 1 to 4, 3 m spacing between bars 5 to 12 • Design shown in Figure 4.20 and Tables 4.1, 4.2, and 4.3 of TAC Traffic Calming Design Guide • Preliminary estimation of installation costs – Medium • **Reference: TAC Traffic Calming Design Guide**
Converging Chevrons Description: Variation of full lane transverse bars but arranged in a converging chevron pattern.	 Source: Ruidoso Traffic Calming Design Guides	• Size of converging chevrons varies depending on width of travel lane • Following equation can be used as a guideline for spacing: $L = v_1 * t_b + \frac{(v_1^2 - v_2^2)}{2a}$ FIGURE 148. EQUATION. DECREASING VELOCITY LINEAR EQUATION Where: L = distance between successive pair of transverse bar pairs $pair_1$ and $pair_2$ (ft) v_1 = speed at pair 1 (ft/s) (speed at the first pair is the transition zone speed, speed at the last pair is the entrance posted speed limit) v_2 = speed at pair 2 t_b = perception reaction time (0.5 s) a = deceleration rate (ft/s^2) • Requires regular maintenance/reapplication • Preliminary estimation of installation costs – Medium • Reference: **City of Kingston – Traffic Calming Guideline** (https://www.cityofkingston.ca/documents/10180/15058/Traffic+Calming+Guidelines.pdf/804c309a-7195-ba08-e20e-dd17349f0a53?t=1629998980890); **FHWA** (https://www.fhwa.dot.gov/publications/research/safety/15030/009.cfm)

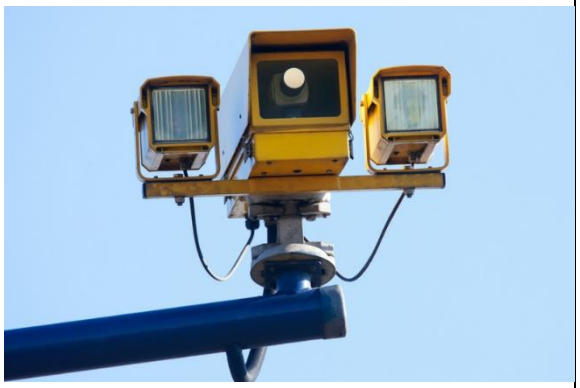
TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Dragon Teeth Pavement Markings Description: Variation of full lane transverse bars but use a series of triangular markings on the edge of the travel lane.	 Source: City of Ottawa	• Size and Spacing: Each triangular pavement marking is typically 2 ft wide, 2 ft tall, and spaced 5 ft apart from adjacent pair of teeth • No specific constraint to number of teeth (typically 9-17 pairs of teeth are used) • Requires regular maintenance/application • Preliminary estimation of installation costs – Medium • **Reference: City of Kingston – Traffic Calming Guideline** (https://www.cityofkingston.ca/documents/10180/15058/Traffic+Calming+Guidelines.pdf/804c309a-7195-ba08-e20e-dd17349f0a53?t=1629998980890)
On Road Sign (Innisfil Pilot Study) Description: Pavement markings that provide information to drivers.	 Source: Queen Street at Glenfern	• Examples of messaging: set speed limit, “SLOW”, school crossing/school ahead • Requires regular maintenance/reapplication • Preliminary estimation of installation costs – Medium • Reference: **City of Ottawa Traffic Calming Design Guidelines** (https://documents.ottawa.ca/sites/documents/files/traffic_calm_design_guide_en.pdf); **City of Kingston – Traffic Calming Guidelines** (https://www.cityofkingston.ca/documents/10180/15058/Traffic+Calming+Guidelines.pdf/804c309a-7195-ba08-e20e-dd17349f0a53?t=1629998980890)

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Lane Narrowing (Innisfil Pilot Study) Description: Reducing lane widths using pavement markings or features so that drivers perceive the roadway as less comfortable and reduce their speeds.	 Source: King Township Traffic Calming	• Lane widths can be reduced to a minimum width of 3.0 m • Use on roads with a grade of 8% or less • Preliminary estimation of installation costs – High • **Reference: Geometric Design Guide for Canadian Roads: Chapter 6 – Pedestrian Integrated Design; City of Kingston – Traffic Calming Guidelines** (https://www.cityofkingston.ca/documents/10180/15058/Traffic+Calming+Guidelines.pdf/804c309a-7195-ba08-e20e-dd17349f0a53?t=1629998980890)
Curb Extension Description: An extension of the curb to narrow the roadway.	 Source: National Association of City Transportation	• Lane width approaching intersection reduced to 3 m for maximum effectiveness (minimum of 2.5 m where permitted) • Departure lane width remain at 3 m for a minimum total width of 5.5 m • Minimum clear offset of 5 m required when used on diagonally opposite corners of intersection • Curb extension at intersection 5 to 7 m in length (or long enough to accommodate longest bus when used at bus stops) • At mid-block – 3 m lane widths (minimum of 2.75 m where permitted) for a total street width of 5.5 m • At mid-block – 7 m length minimum • Object Markers (WA-36) optional • Delineation Markers (WA-37) may be acceptable alternative to Object Markers • Design shown in Figure 4.13 of TAC Traffic Calming Design Guide • Preliminary estimation of installation costs – High • **Reference: TAC Traffic Calming Design Guide**

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Road Diet Change Description: Reconfiguration of roadway that reduces the number of lanes and allocates the reclaimed space for other uses.	 Source: The Kinder Institute for Urban Research	• Applicable for existing roadways with 4 or more lanes • Geometric and Operation Design available from the FHWA Road Diet Information Guide – Section 4 • Preliminary estimation of installation costs – High • **Reference: FHWA Road Diet Informational Guide** Road Diet Informational Guide - Safety | Federal Highway Administration (dot.gov)
Raised Median Island Description: Elevated median constructed along the centerline of a two-way road that reduces the lane widths.	 Source: Federal Highway Association	• Minimum width of 3.5 m for single lane adjacent to median island • Length of median section at intersection or mid-block crossing is 5 to 7 m • Minimum width of median is 1.5 m • Keep Right sign (RB-25) required at each end of median section • Object Marker (WB-36L) is optional • Stopping Prohibited signs (RB-55) required in the area of the median island • Crosswalk signs (RA-4) required for mid-block crosswalk applications • Geometric requirements available in Section 4.4.3 A. of TAC Traffic Calming Design Guide • Design shown in Figure 4.15 of TAC Traffic Calming Design Guide • Preliminary estimation of installation costs – High • **Reference: TAC Traffic Calming Design Guide**

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Vertical Centerline Treatment (Innisfil Pilot Study) Description: Use of vertical treatments on the centerline to create a center median (flexible post-mounted delineators or raised pavement markers).	 Source: Iowa State University Institute for Transportation Research	• Used on roads with a grade of 8% or less • Vertical treatments can be flexible post-mounted delineators or raised pavement markers • Installed on a temporary/seasonal basis • Preliminary estimation of installation costs – Medium • **Reference: Ottawa Traffic Calming Design Guidelines** (https://documents.ottawa.ca/sites/documents/files/traffic_calm_design_guide_en.pdf); **City of Kingston – Traffic Calming Guidelines** (https://www.cityofkingston.ca/documents/10180/15058/Traffic+Calming+Guidelines.pdf/804c309a-7195-ba08-e20e-dd17349f0a53?t=1629998980890)
On-Street Parking Description: Variation of lane narrowing using on-street parking.	 Source: City of Toronto	• Should only be used where cyclist volumes are low, and cyclists can use vehicular travel lanes • Site constraints include driveway locations, fire hydrant locations, etc. • Should not be used as form of curb extension at or near intersections • Parking Prohibited signs (RB-51) used in areas of minimum pavements width and adjacent to intersections • Minimum geometric requirements shown in Figure 4.14 of the TAC Traffic Calming Design Guide • Preliminary estimation of installation costs – Low • **Reference: TAC Traffic Calming Design Guide**

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Speed Display Devices Description: Interactive signs that display the speed of an oncoming vehicle by using radar speed detectors.	 Source: University of New Brunswick	• Post or trailer mounted • Use as a stand-alone system or part of a broader traffic calming strategy • Should not be used where other devices and roadway environments are already making intensive demands on driver attention (i.e., close to traffic control devices, pedestrian crossings, etc.) • Most beneficial over limited distances • TAC Application Guidelines for Speed Display Devices has guidelines for specific applications – school zones • TAC Application Guidelines for Speed Display Devices – Section 6 contains Design of Display guidelines, Section 7 contains Installation information • Active display text must be a minimum of 200 mm high and clearly visible from entire approach lane from a distance of 45 m to 200 m • For urban or residential areas: ideally placed between 300 mm to 2 m from curb lane • For rural areas: ideally placed 2 to 4 m from edge of outer travel lane • Preliminary estimation of installation costs – Low to Medim • **Reference: TAC Application Guidelines for Speed Display Devices; City of Kingston – Traffic Calming Guidelines** (https://www.cityofkingston.ca/documents/10180/15058/Traffic+Calming+Guidelines.pdf/804c309a-7195-ba08-e20e-dd17349f0a53?t=1629998980890)
Vehicle Activated Signs Description: Interactive signs that alert drivers of a hazard ahead when their speed is detected to be above a threshold.	 Source: Trafficlogix	• Post or trailer mounted • Use as a stand-alone system or part of a broader traffic calming strategy • Should not be used where other devices and roadway environments are already making intensive demands on driver attention (i.e., close to traffic control devices, pedestrian crossings, etc.) • Most beneficial over limited distances • TAC Application Guidelines for Speed Display Devices has guidelines for specific applications – school zones, narrow lanes and bridges, highway community entry, neighbourhood traffic calming, curves, work zones • TAC Application Guidelines for Speed Display Devices – Section 6 contains Design of Display guidelines, Section 7 contains Installation information • Active display text must be a minimum of 200 mm high and clearly visible from entire approach lane from a distance of 45 m to 200 m • For urban or residential areas: ideally placed between 300 mm to 2 m from curb lane • For rural areas: ideally placed 2 to 4 m from edge of outer travel lane • Preliminary estimation of installation costs – Low **Reference: TAC Application Guidelines for Speed Display Devices; City of Kingston – Traffic Calming Guidelines**

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
		(https://www.cityofkingston.ca/documents/10180/15058/Traffic+Calming+Guidelines.pdf/804c309a-7195-ba08-e20e-dd17349f0a53?t=1629998980890)
Fixed Speed Enforcement Description: Permanent cameras that photograph vehicles travelling at unsafe/high speeds without requiring a law enforcement officer present.	 Source: Trafficlogix	• To be installed as per manufacturer requirements • Preliminary estimation of installation costs – High
Aircraft/Drone Radar Enforcement Description: Aircrafts or drones that monitor the speeds of vehicles on highways/freeways using transverse pavement markings.	 Source: NNTC Innovative Technology Company	• To be installed as per manufacturer requirements • Preliminary estimation of installation costs – Medium

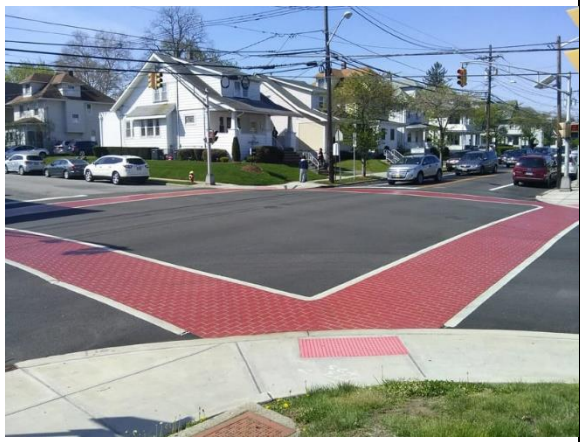
TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Mobile Speed Enforcement Description: Radar photography units mounted in mobile vehicles or trailers that are used in areas that require speed enforcement.	 Source: Trafficlogix	• To be installed as per manufacturer requirements • Preliminary estimation of installation costs – Medium
Speed Watch Programs Description: Volunteers/residents help monitor traffic and record license plates of vehicles that are speeding. Letters may be sent to vehicle owners alerting them of their excessive speeding.	 Source: SRTS Guide – Safe Routes Info	• To be implemented based on community requirements • Preliminary estimation of installation costs – Low

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Pace Car Program Description: Community awareness measure where local drivers sign a pledge to drive within the speed limit, effectively becoming mobile traffic calming devices. Bumper stickers are used to alert other drivers.	 Source: Cochrane Neighbourhood, CBC Calgary	• In Canada main concept is to encourage drivers to sign a pledge and display a sign on car rear window or bumper to show commitment to drive within the speed limit • Preliminary estimation of installation costs – Medium • Reference: **City of Kingston – Traffic Calming Guidelines** (https://www.cityofkingston.ca/documents/10180/15058/Traffic+Calming+Guidelines.pdf/804c309a-7195-ba08-e20e-dd17349f0a53?t=1629998980890)
Targeted Education Campaign Description: Community awareness measure where programs, event, or media campaigns are used to educate and raise awareness of road safety issues.	 Source: King Township Traffic Calming Strategy	• To be implemented based on community requirements • Preliminary estimation of installation costs – High

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Active and Safe Routes to School Program Description: A community-based program that promotes the use of active transportation for school trips and addresses traffic safety issues.	 Source: City of Toronto	• To be implemented based on community requirements • Preliminary estimation of installation costs – High • **Reference: The Canadian School Travel Planning Toolkit** (Guide-for-Facilitators-STP-Toolkit-May-2018-En-1.pdf (ontarioactiveschooltravel.ca))

Coloured/Textured Pavement
 	
Description: Pavement that incorporates texture, patterned, or coloured surfaces that contrasts with the surrounding roadway.
	
	Source: City of Vaughan
		• For textured crosswalks:
		  ○ Minimum crosswalk width is 2.5 m (3-4 m is typical in urban areas with high pedestrian activity)
		  ○ Parallel standard crosswalk lines that are 0.1-0.2 m wide are required to delineate outside edges of crosswalk if measure is implemented at a controlled crossing
		  ○ If zebra crosswalk markings are used, configuration typically consists of block markings 0.6 m and spaced at 0.6 m
		• Preliminary estimation of installation costs – Medium
		• **Reference: City of Kingston – Traffic Calming Guidelines** (https://www.cityofkingston.ca/documents/10180/15058/Traffic+Calming+Guidelines.pdf/804c309a-7195-ba08-e20e-dd17349f0a53?t=1629998980890)
		• For coloured pavement:
		  ○ Must be accompanied by appropriate regulatory signage
		  ○ Maintain minimum required friction characteristics of pavement
		  ○ Use the same colour for the same purpose to convey a message to roadway users
		• Preliminary estimation of installation costs – Medium
		• **Reference: MUTCD**

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Transverse Rumble Strips Description: Grooves in the pavement or raised bars closely spaced at regular intervals on a roadway that create noise and vibration for a vehicle travelling over them.	Source: Center for Transportation Research and  Education – Iowa State University	• Reference the **Transportation Association of Canada - Best Practice Guidelines for the Design and Application of Transverse Rumble Strips** • Preliminary estimation of installation costs – Medium • **Note: These rumble strips in neighbourhoods can result in noise complaints.**

Sidewalk Extension/Textured Crosswalk
 	
Description: Coloured/textured pavement applied to a crosswalk.
	
	Source: Endurablend Polymer Cement Surfacing
		• For sidewalks located at the curb line on approaches to intersection
		  ○ Sidewalk must be lowered to 15 mm above the intersecting street
		  ○ Slope of sidewalk transition approaching intersection must not exceed 6%
		• For sidewalk offset from the curb line on approaches to intersection
		  ○ Sidewalk can be lowered to match intersection street
		  ○ 40 mm curb face recommended
		• Design shown in Figure 4.19 of TAC Traffic Calming Design Guide
		• Preliminary estimation of installation costs – High
		• **Reference: TAC Traffic Calming Design Guide**

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA

Directional Closures
 	
Description: Barrier that extends to the centerline of the roadway that prohibits one direction of traffic.
	
	
	Source: U.S. Department of Transportation Federal Highway Administration
		• Exit-only directional closure
		  ○ Island width must be sufficient so traffic going straight through would conflict with opposing traffic
		  ○ Dimensional requirements shown in Figure 4.21(a) of TAC Traffic Calming Design Guide
		  ○ Signage – Right or Left Turn Only sign (RB-43) and Entry Prohibited signs (RB-23) required; Except Bicycles supplementary tab sign (RB-98) required for bicycle traffic; One-way signs (RB-21) must be used on the cross-street; Object Markers (WA-36) to be used
		• Entrance-only directional closure
		  ○ Best implemented with hammerhead or cul-de-sac area
		  ○ Dimensional requirements shown in Figure 4.21(b) of TAC Traffic Calming Design Guide
		  ○ Signage – RB-21, RB-43, and WA-36 signs are NOT required; Cul-de-sac sign (ID-21) and Checkerboard sign (WA-8) are required
		• Openings in the closures to accommodate bicycle traffic should be approximately 1.5 min width
		• Preliminary estimation of installation costs – Medium
		• **Reference: TAC Traffic Calming Design Guide**

Intersection Channelization Description: Raised islands at intersections used to obstruct certain movements and physically direct traffic through the intersection.	 Source: City of Campbell River Neighbourhood Traffic Management Procedures	• Minimum island size of 6-10 m^2 required for pedestrian refuge • Selected right-turn radius should create a divisional island large enough to discourage left-turn and through movements • Width of turning lane designed to only accommodate vehicles that use segment of road on a regular basis • Effectiveness improved with an island size of 10 m^2 or greater • Signage – Entry Prohibited sign (RB-23) required on island facing the straight-through movement no longer permitted; Right or Left Turn Only lane sign (RB-43) on that approach; Left Turn Prohibited Sign (RB-11L) should be used on the cross-street on the far side of the intersection as well as the end of the divisional island; Keep Right sign (RB-25) and Object Marker (WA-36) placed on end of divisional island; Object Marker (WA-36) required at the corner of island facing traffic turning right from collector • Design shown in Figure 4.24 of TAC Traffic Calming Design Guide • Preliminary estimation of installation costs – High • **Reference: TAC Traffic Calming Design Guide**

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA

Raised Median Through Intersection
 	
Description: An island constructed on the centreline of a two-way road through an intersection used to restrict left turns and through movements to/from the intersecting roadway.
	
	Source: National Association of City Transportation Officials
		• Geometric Requirements:
		  ○ Raised portion of median minimum width – 1.5 m
		  ○ Single lane width on both sides beyond intersection – 3.5 m
		  ○ Lane width adjacent to median – determined by turning vehicle requirements
		  ○ Median extends 5-7 m beyond crosswalk outer edges
		  ○ Reference Figure 4.25 in TAC Traffic Calming Design Guide
		• Signage – Keep Right sign (RB-25) and Object Markers (WA-36) for two ends of median; U-Turn Prohibited sign (RB-16) may be required; either Right Turn Required (RB-14R) or On-Way sign (RB-21) at center of protected cross-street on median facing both approaches; Stopping Prohibited signs (RB-55) may be required
		• Pavement markings – reference MUTCD
		• Preliminary estimation of installation costs – High
		• **Reference: TAC Traffic Calming Design Guide, MUTCD**

Right-In Right-Out Island Description: A raised triangular island at an intersection that restricts left turns and through movements to/from an intersection road.	 Source: National Association of City Transportation Officials	• Intersection radii should create divisional island large enough to discourage through and left turn movements • Minimum island for pedestrian refuge = 6-10 m^2 • Design shown in Figure 4.26 of TAC Traffic Calming Design Guide • Signage – Right Turn Only Lane sign (RB-41R) for protected intersection approach in advance of intersection and on divisional island; Keep Right sign (RB-25) and an Object Marker (WA-36) on end of divisional island facing approach; Entry Prohibited sign (RB-23) on divisional island facing prohibited through movement; Left Turn Prohibited sign (RB-11L) on the cross-street and divisional island facing prohibited left turning traffic; Right or Left Turn Only sign (RB-43) on intersection approach facing divisional island • Preliminary estimation of installation costs – High • **Reference: MUTCD for signage, TAC Traffic Calming Design Guide**

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Diverters Description: Raised barrier placed diagonally across an intersection that diverts traffic to turn rather than going straight through the intersection.	 Source: Global Designing Cities Initiative	• Diversion alignment must make adequate provision for the turning paths of all vehicles • Parking should not be permitted within limit of diversion • Typical diverter requirements shown in Figure 4.22 of TAC Traffic Calming Design Guide • Special requirements for landscaping and/or bollards for areas where cyclists or sidewalks are present • Options available to accommodate emergency vehicles (break-away or lockable bollards or lockable gates) • Signage – Single Curve signs (WA-2) to advice motorists of turning requirement; Parking Prohibited sign (RB-51) • Preliminary estimation of installation costs – High • **Reference: TAC Traffic Calming Design Guide**
Full Closure Description: Barrier that covers the entire width of a road restricting all vehicular traffic.	 Source: Roxborough and Province, City of Vancouver	• Geometric requirements shown in Figure 4.23 in TAC Traffic Calming Design Guide • Must include provision of some form of cul-de-sac at end of closed roadway • Bollards or trees placed to discourage continued off-road travel to/from severed street • Rolled or mountable curbs recommended adjacent to bicycle lanes • Signage – Cul-de-sac sign (ID-31) required at entrance to full closure block; Checkboard sign (WA-8) recommended at center of severed roadway; Parking Prohibited signs (RB-51) may be required • Preliminary estimation of installation costs – Medium to High • **Reference: TAC Traffic Calming Design Guide**

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Gateways Description: A combination of traffic calming measures that provides a visual cue to help road users identify a transitional zone.	 Source: Global Designing Cities Initiative	• Must be designed at appropriate scale and significance to attract drivers attention • Includes fixed roadside and/or overhead features • First determine physical space, utility, electrical, and other options before selecting most feasible gateway option • Preliminary estimation of installation costs – High • **Reference: City of Ottawa Traffic Calming Design Guidelines**
Shared Space Description: A design concept where the priority is shifted from vehicular traffic to active transportation users, who are free to cross anywhere.	 Source: Global Designing Cities Initiative	• Preliminary estimation of installation costs – High • To be implemented based on community requirements
LED Pavement Marking Description: LEDs placed in the pavement that display a variety of messages to drivers.	 Source: TAPCO Safe Travels	• Preliminary estimation of installation costs – Medium • To be installed as per manufacturer requirements

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA
Traffic Calmed Neighbourhood Sign Description: Signs placed in conjunction with traffic calming measures that raise awareness that it is a traffic calmed area.	 Source: CBC City of Ottawa	• Used to inform drivers that traffic calming measures are implemented within a neighbourhood • The ID-32 sign is always used in conjunction with the ID-32S supplementary tab sign • Installed at the entrance to the neighbourhood • Preliminary estimation of installation costs – Low • **Reference: MUTCD (A4.6.6 Traffic-Calmed Neighbourhood Sign (ID-32))**
Community Safety Zones	 Source: City of Toronto	• All zones require a sign with a BEGINS tab and an ENDS tab indicating the start and end of a designated community safe zone • Other signs can be used within the zone • Former sign is TC-46 from Ontario MUTCD • Preliminary estimation of installation costs – Low • Reference: Ontario MUTCD (Book 5 part 1.pmd (civicweb.net))
Stop Signs	 Source: The Centre for Active Transportation	• Preliminary estimation of installation costs – Low • **Reference MUTCD**

TRAFFIC CALMING MEASURE	EXAMPLE	DESIGN CRITERIA

Maintenance and Signage	
	Source: Minnesota's Best Practices for Traffic Sign Maintenance/Management Handbook
		• From MUTCD:
		  ○ Signs should be kept clean, legible, and in proper position
		  ○ Repair/replace damaged signs
		  ○ Establish schedule for inspection (day and night), cleaning, and replacement
		  ○ Remove weeds, shrubbery, construction materials, or piled snow that my obstruct sign
		• Preliminary estimation of installation costs – Medium
		• **Reference: MUTCD**

Temporary/ Flexible Median Description: A temporary/flexible structure installed in the centreline of a roadway to act as a removable median.	 Source: Maple Ridge, BC Traffic Calming Policy	• Used on roads with a grade of 8% or less • Vertical treatments are typically flexible post-mounted delineators • Installed on a temporary/seasonal basis • Preliminary estimation of installation costs – Medium **Reference: Ottawa Traffic Calming Design Guidelines** (https://documents.ottawa.ca/sites/documents/files/traffic_calm_design_guide_en.pdf); **City of Kingston – Traffic Calming Guidelines** (https://www.cityofkingston.ca/documents/10180/15058/Traffic+Calming+Guidelines.pdf/804c309a-7195-ba08-e20e-dd17349f0a53?t=1629998980890)

Note references:

[1] - Ottawa Traffic Calming Design Guidelines

[2] - Transportation Association of Canada (TAC) Canadian Guide to Traffic Calming

Appendix B

MTO Book 15:

- **Decision Support Tool – Preliminary Assessment**
- **Pedestrian Crossover Selection Matrix**

5. Treatment System Selection for Controlled Crossings

Section 4.2 provides the hierarchy of Pedestrian Crossing Treatment Systems for Controlled Pedestrian Crossings.

To support an efficient deployment of the previously described hierarchy of treatment systems, this manual provides a DST based on the seven guiding principles as explained in Section 4.3. In addition to these guiding principles, the DST is consistent with other relevant OTM Books, as well as the latest safety research involving pedestrian crossing control.

The DST includes two components: (1) Preliminary Assessment and (2) Pedestrian Crossing Selection. The preliminary assessment is used to check whether a pedestrian crossing control is a candidate site and then the pedestrian crossing selection assists practitioners to choose a pedestrian crossing treatment system for the site.

5.1 Preliminary Assessment

Even before the preliminary assessment is undertaken it must be confirmed that the identified location has adequate sight distance for both motorists and pedestrians. It is the practitioners' responsibility to review the identified locations for safety and provide adequate measures to enhance safety of pedestrians, if required. Motorists must be able to see pedestrians in the waiting area adjacent to the crossing in sufficient time to perceive their intent to cross, react and brake to a stop comfortably. Similarly, pedestrians must be able to see oncoming traffic in both directions of travel so that they do not begin to cross when motorists have insufficient time to stop. These minimum stopping sight distances can be determined through standard guidance, such as the Geometric Design Standards for Ontario Highways.[27] and Geometric Design Guide for Canadian Roads, Transportation Association of Canada (TAC), September 1999 [12]

The main purpose of the preliminary assessment component of the DST for pedestrian crossing control is to identify whether a pedestrian crossing treatment of any type is warranted at a location.

Figure 2 illustrates the flow chart for performing the preliminary assessment to identify whether a site is a candidate for pedestrian crossing control.

The preliminary assessment involves the following steps:

- Check whether a traffic signal is warranted for pedestrians based on Justification 6 of OTM Book 12. Justification 6 of OTM Book 12 is also presented in Section 5.1.1. The types of traffic signals implemented include full traffic signal, IPS, and MPS.
- If a traffic signal is not warranted, the flow chart assists in checking whether a PXO is warranted for the site.

The rest of this subsection includes the details of the above noted steps.

5.1.1 Traffic Signal Assessment

As shown in Figure 2, checking for traffic signals is the first step in the preliminary assessment process. The pedestrian crossing treatment systems under traffic signals include full traffic signals, IPS, and MPS.

According to OTM Book 12-Justification 6, the installation of a pedestrian treatment is warranted if the subject site exceeds both the minimum pedestrian volume and the minimum pedestrian delay criteria for a period of 8-hour.

The pedestrian volume criterion is defined as the total 8-hour pedestrian volume crossing the main road at an intersection or mid-block location during the highest 8-hour of pedestrian traffic. Similarly, the pedestrian delay criterion is defined as the total 8-hour volume of pedestrians experiencing delays of ten seconds or more in crossing the road during the highest 8-hour of pedestrian traffic.

For pedestrian volume to be used in the above criteria, an adjusted pedestrian volume is applied

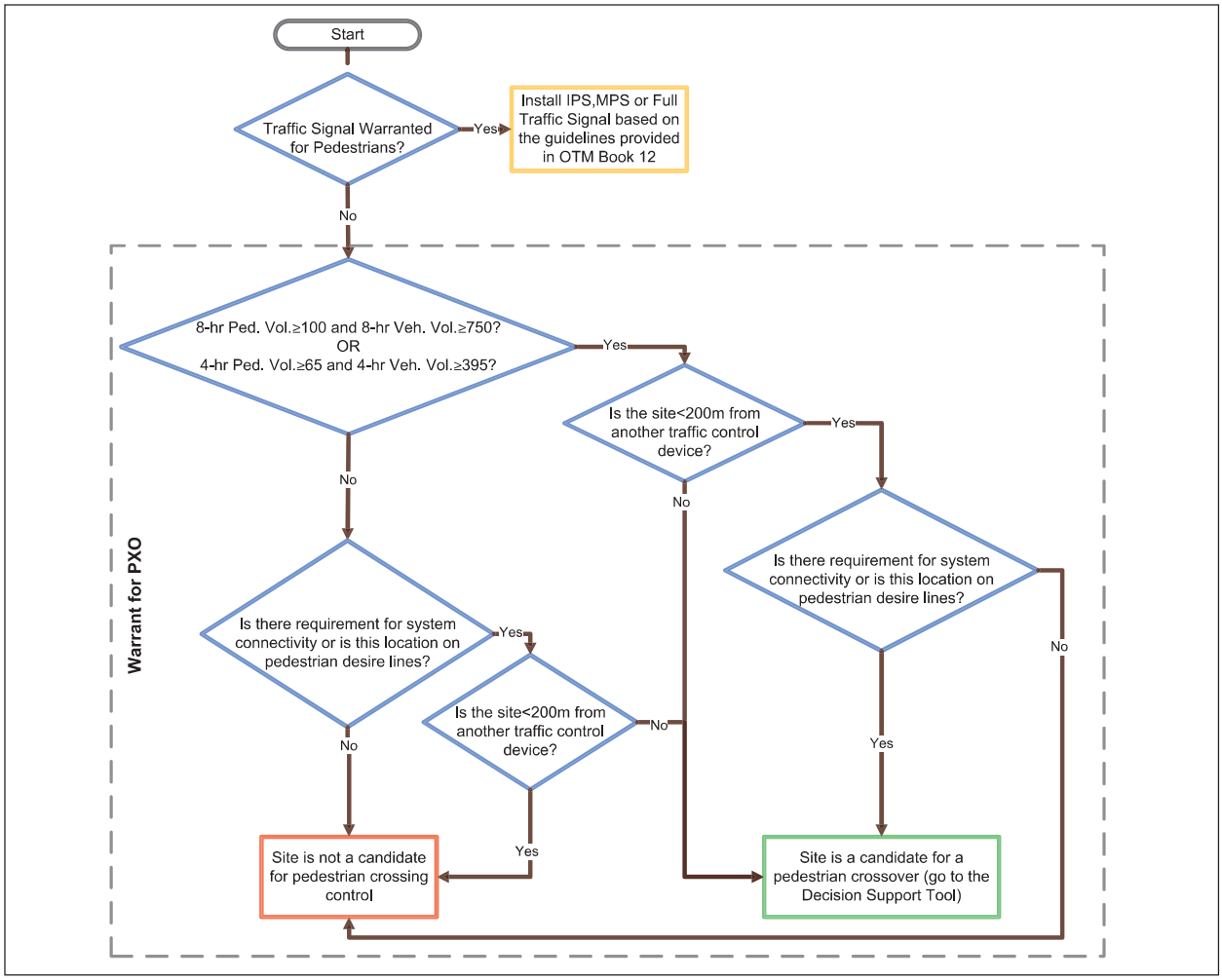


Figure 2: Decision Support Tool – Preliminary Assessment

to reflect a factored volume based on "equivalent adults" and the following definitions as described in OTM Book 12:

- Unassisted – Adults and adolescents at or above the age of 12 are considered "unassisted" pedestrians.
- Assisted – Children under the age of 12, senior citizens, disabled pedestrians and other pedestrians requiring special consideration or assistance are considered "assisted" pedestrians. In cases where an adult is accompanying a pedestrian included in the "assisted" category, both individuals should be counted as "assisted" pedestrians to reflect their higher vulnerability. It should be recognized that the exact age of the pedestrian is not critical, but the observers will need to use their judgment to place each pedestrian into one of the two categories.

The factored pedestrian volume is calculated as follows:

Adjusted volume = Unassisted Pedestrian Volume + 2 x Assisted Pedestrian Volume

Figure 3 and Figure 4 show the graphs used to determine whether a pedestrian control

treatment system is justified under the 8-hour criterion. In addition to 8-hour warrants, OTM Book 12-Justification 6 provides 4-hour warrants for installation of pedestrian treatment for smaller communities. Smaller communities are defined as communities with population of less than 10,000.

Figure 5 and Figure 6 show the 4-hour pedestrian volume and pedestrian delay criteria for communities with population less than 10,000.

For further details on Justification 6 – Pedestrian Volume and Delay, refer to OTM Book 12.

5.1.2 Pedestrian Crossover Assessment

If a traffic signal (i.e. IPS, MPS, or full traffic signal) is not warranted at a site, the next step as shown in Figure 2 is to check whether a PXO is warranted. The preliminary assessment for PXOs is based on the following three factors:

Traffic volume: The research conducted by Zegeer et al[18], which analyzed pedestrian collisions at 2000 marked and unmarked crosswalks, found that there is a statistically significant relationship between pedestrian collision rate and traffic volume. Specifically, at locations with marked crosswalks, collision rates increase significantly as a function of traffic volume, for ADTs greater than approximately 9000 vehicles per day. This suggests the need to enhance the marked crosswalks at these locations with additional treatments to improve pedestrian safety. In addition, there is also a relationship between traffic volume and crossing opportunities, which affects pedestrian delay. Therefore, by including traffic volume as a variable within the Pedestrian Crossover System preliminary assessment process, delay considerations are also integrated. This approach is consistent with the TAC's PCCG[14].

Crossing distance: The same research by Zegeer et al. (2005)[18] found that crossing distance has an impact on the likelihood of a pedestrian collision, particularly on roads with higher traffic volumes (i.e., the wider the crossing distance, the more difficult it is for pedestrians to safely cross the street). A particular concern with wider cross-sections is the multi-threat situations that are created by multilane roads. Collisions involving multiple threats typically occur when the driver and pedestrian fail to see each other because of the sight obstruction created by a vehicle that has already stopped for the pedestrian in another lane.

Pedestrian system connectivity: The provision of pedestrian system connectivity is important for proper pedestrian accommodation. As indicated in the guiding principles in Section 4.3, facilitating connectivity between crosswalks and sidewalks, and/or trail networks involves understanding and monitoring pedestrian desire lines, which evolve as a function of land use, the location of pedestrian generators and attractors, and proximity to existing crossing facilities. Providing proper connectivity between origins and destinations allow pedestrians for simple and convenient access to facilities with the shortest possible deviation.

Based on the above factors, the steps to check the requirement of a PXO are as follows:

1. Check minimum pedestrian and vehicular volume as the first step. If the total 8-hour pedestrian volume crossing the main road at an intersection or midblock location during the highest pedestrian traffic hours is greater than 100 "equivalent adult pedestrians" as defined in section 5.1.1 and the 8-hour vehicular volume during the same time period is greater than 750 vehicles, then check whether the distance of the site from the closest traffic control device is more than 200 m. If the distance is more than 200 m then the location is a candidate for a PXO. The 200 m minimum distance required from the site to the nearest traffic control device is consistent with Justification 6 of OTM Book 12 and the TAC's PCCG[14]. Otherwise, check for any justification based on connectivity requirements, such as existing sidewalks or walkways to confirm pedestrian desire lines. If the site cannot be justified for a pedestrian crossing control based on connectivity requirements or pedestrian desire lines, then the site is not a candidate for a pedestrian crossing control.

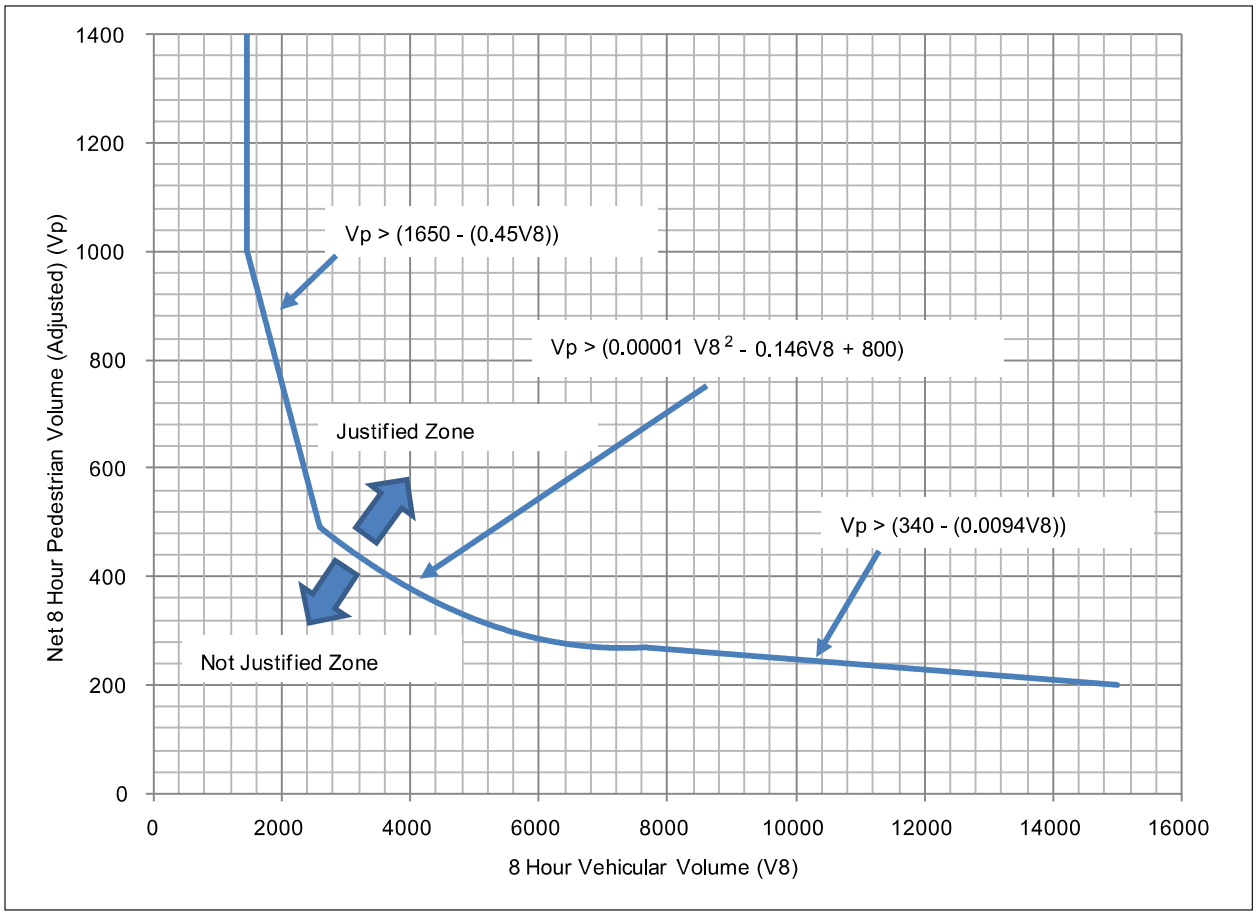


Figure 3: OTM Book 12 Justification 6 - Pedestrian Volume

As an alternative to the 8-hour pedestrian and vehicular volumes threshold, the flow chart shown in Figure 2 allows for the use of 4-hour pedestrian and vehicular volumes. If a road authority chooses to use 4-hour pedestrian and vehicular volumes, the minimum thresholds for the total 4-hour pedestrian volume crossing the main road at an intersection or a midblock location during the highest pedestrian traffic and the total vehicular volumes during the same periods are 65 equivalent adult and 395 vehicles respectively. It should be noted that equivalent adult pedestrian volume should be calculated based on Section 4 of OTM Book 12 – Traffic Signals.

2. If the minimum pedestrian and vehicular volume requirements are not met, assess whether this site provides system connectivity or is on a desired pedestrian line. The system connectivity or pedestrian desire lines should be assessed based on sound engineering judgment and should be appropriately documented. If the site does not satisfy the system connectivity requirement or it is not on a pedestrian desire line, the site is not a candidate for a pedestrian crossing control. However, if a pedestrian crossing control can be justified based on system connectivity or pedestrian desire line requirements and the distance of the site to the nearest traffic control device is more than 200 m, then the

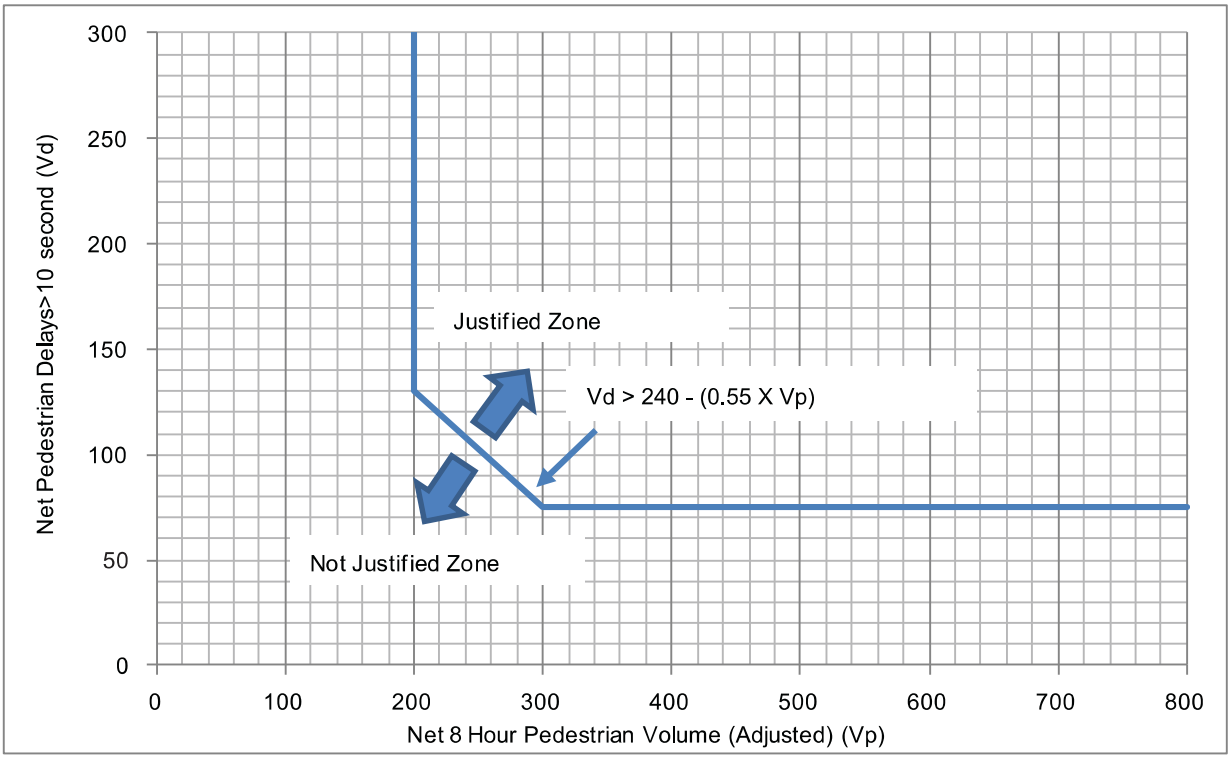


Figure 4: OTM Book 12 Justification 6 – Pedestrian Delay

site is a candidate for a pedestrian crossover. Otherwise, if the distance of the site to the closest traffic control device is less than 200 m, the site is not a candidate for a pedestrian crossing control.

The distance depends on a number of factors such as road type, traffic volume, expected queue length, pedestrian volume, and characteristics of pedestrians expected to use the facility. In the case of Ontario, this value has been set at 200 meters to avoid proliferation of traffic control devices in close proximity of each other. Having control devices in close proximity to each other can result in incorrect driver decisions, which in turn, may lead to collisions with pedestrians and other road users. Close proximity of various devices can also result in traffic flow disruptions and hence, low level of service along a corridor.

This value of 200 meters is consistent with other OTM books limiting the distance between different traffic control devices (see Section 6.1).

5.1.3 Stop and Yield Controlled Intersections

Stop control intersections provide an opportunity for pedestrians to safely cross the major roads of intersections. If a two-way stop control intersection does not satisfy the minimum requirements for an IPS, full traffic signal, or PXO as described in Section 5.1.1 and Section 5.1.2, warrants for all-way stop control must be checked.

Section 2 of OTM Book 5 – Regulatory Signs provides the warrant system for installation of all-way stop control at an intersection. The warrant system is based on minimum traffic volume of the

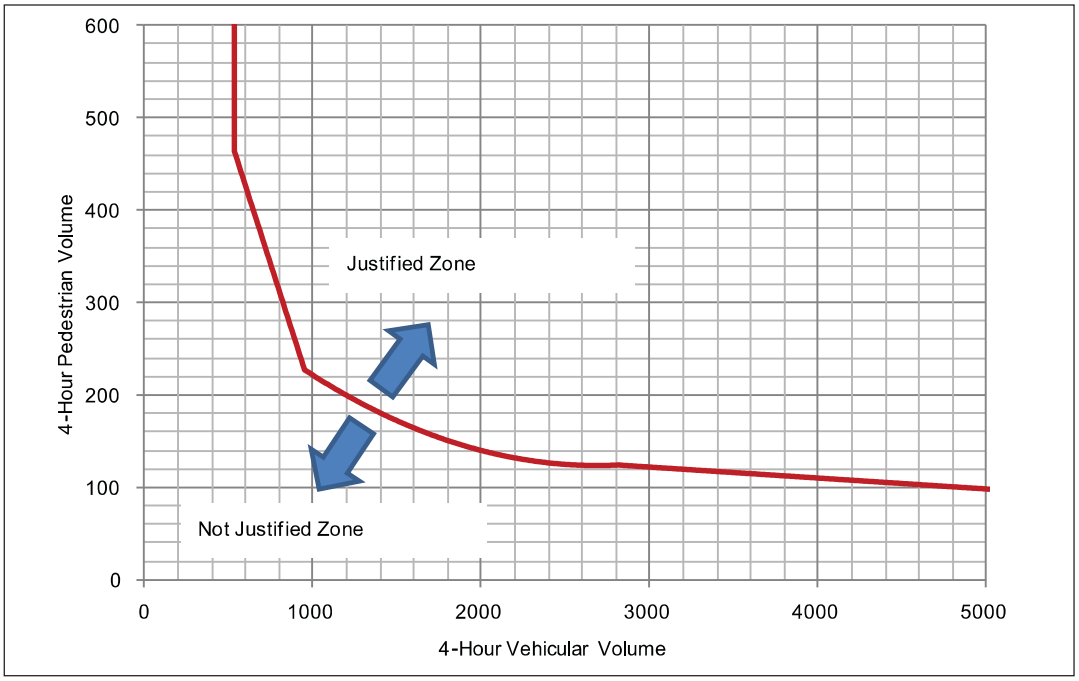


Figure 5: 4-Hour Pedestrian Volume Criterion for Communities of Population Less than 10,000

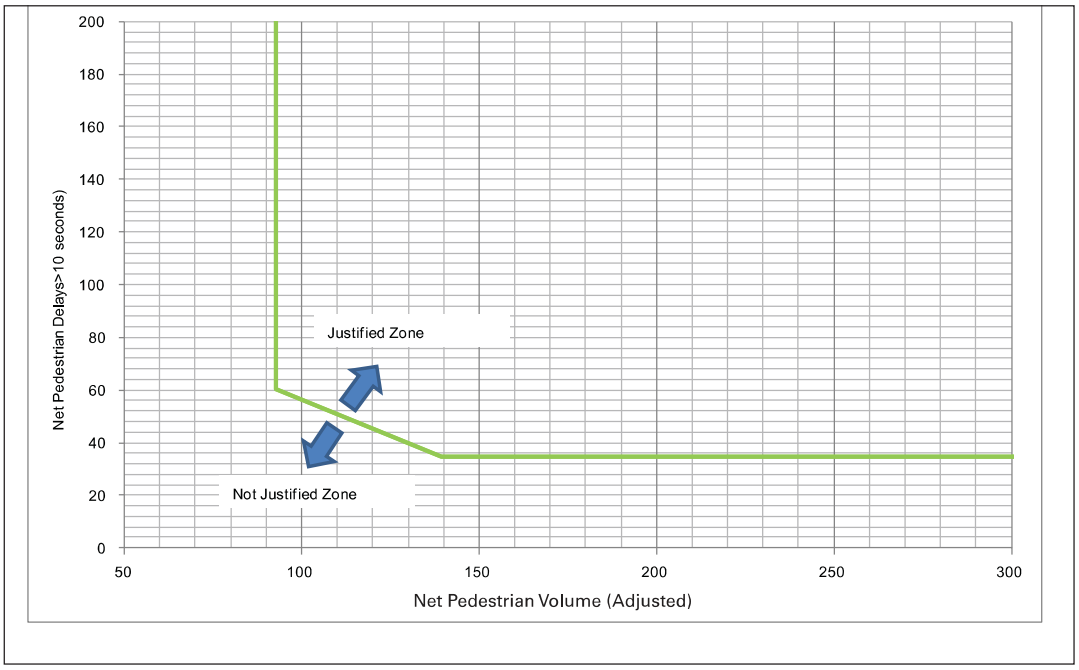


Figure 6: 4-Hour Pedestrian Delay Criterion for Communities of Population Less than 10,000

major and minor road, and past collision history of the intersection.

According to the HTA[1] , every driver approaching a stop sign at an intersection is required to yield right-of-way to pedestrians at the crosswalk (crosswalk defined in Section 6.2.1.1). For intersection locations, where a stop control is not warranted and a pedestrian control is required, a yield sign can be used as an alternative to the stop sign. A yield sign is often installed at intersections with right turn channels. OTM Book 5 provides guidelines for installations of a yield controlled intersection but does not provide any warrant for these types of intersections. It may be noted that right-turn channel locations must be individually assessed for an applicable pedestrian crossing treatment by the road authority. A PXO may be applicable for a particular right-turn channel location.

5.1.4 Implementation of Supervised School Crossing

Designated school crossings are locations close to schools where school children have to cross enroute between home and school. The use of school crossing guards is considered to be a form of pedestrian control at designated crossings during school periods. The crossing guard provides opportunities for children and other pedestrians to cross in safety. School crossing guards are normally stationed at marked school crossings but may be stationed at locations that are controlled crossings (e.g. traffic signals, all-way stop controlled or yield-controlled intersections). According to the HTA[1] Section 176 – School Crossings, school crossing guards may provide a designated right-of-way for all persons as vehicles must yield to a crossing guard. It should be noted that a school crossing in the absence of stop signs, IPS, PXO, MPS or traffic control signals is considered a controlled crossing only when the crossing is being supervised by a school crossing guard. It should be specifically noted that the presence of school crossing signs and markings only in the absence of school crossing guards do not require drivers to yield the right-of-way to pedestrians.

The overall planning process for a school crossing guard includes determining the needs for a school crossing; defining the minimum thresholds required for implementing a supervised school crossing; and maintaining consistency in the location and operation of supervised school crossings. The Ontario Traffic Council (OTC) School Crossing Guard Guide[20] is an information document published in 2005 that provides various guiding principles for the consideration, implementation and maintenance of school crossings. The justification for school crossing guards is often determined by municipal by-laws.

5.2 Treatment System Selection

The preliminary assessment component of the DST described in Section 5.1 is used to identify which type of controlled pedestrian crossing treatment system is warranted at a site.

The second component of the DST is the guidance for pedestrian crossing treatment Selection to assist practitioners to identify which treatment system is applicable to the site based on traffic and geometric characteristics of the site.

Pedestrian Crossing Treatment systems provided in Section 4.2 are applicable to the application environments as specified in the Table 6.

The following sections provide the guidance to select the type of pedestrian crossing treatment for a specific pedestrian control crossing.

5.2.1 Traffic Signal Selection

The selection of a traffic signal as a pedestrian crossing treatment is based on OTM Book 12. Section 5.1.1 provides the guidance for checking the warrants for traffic signals (full traffic signal, IPS, or MPS) as a pedestrian crossing treatment.

Traffic control signals may be installed provided that any of Justifications 1 to 6, are met and it is

Table 6: Treatment Systems by Application Environment

Type of Crossing	Treatment System	Mid-block	Intersection	Roundabout	Right-turn Channel
Traffic Signal	Full Signal		•		
	Intersection Pedestrian Signal		•		
	Mid-block Pedestrian Signal	•			
Pedestrian Crossover	Level 1 Type A	•	•		
	Level 2 Type B	•	•	•	
	Level 2 Type C	•	•	•	
	Level 2 Type D	•	•	•	•
Stop or Yield Control			•		•
Crossing Guard		•	•	•	•

determined that conditions are satisfactory for the installation of traffic control signals. Where traffic control signals are installed, provisions for pedestrian crossings must be considered.

IPS should be installed at intersections where traffic volume is low and a full traffic signal is not warranted based on Justification 1 through 5 of OTM Book 12. In this case, the justification of an IPS should be made on the basis of Justification 6 being fulfilled.

Justification for MPS should be based on the Justification 6 as indicated in OTM Book 12.

5.2.2 Pedestrian Crossover Selection

The selection of an appropriate PXO treatment (i.e. Level 1 Type A, Level 2 Type B, Level 2 Type C, and Level 2 Type D) is based on the Pedestrian Crossover Selection matrix provided in this section.

The Pedestrian Crossover Selection Matrix has been developed based on the following criteria:

Consistency with Section 140(5) of the HTA: According to the HTA[1], the application of PXOs is limited to roads with a posted speed limit of 60 km/h or less.

Consistency with OTM Book 12: According to Section 4.9 of OTM Book 12:

- A PXO can be installed on roadways with a maximum of 4 lanes of two-way traffic or 3 lanes of one-way traffic.
- Vehicular traffic volumes are collected during the 8 or 4 hours with the highest pedestrian volumes.
- A PXO must not be used where the road volume exceeds 35,000 AADT.
- PXOs should not be installed within 200 m of other signal-protected pedestrian crossings.

Consistency with the TAC PCCG: The TAC's PCCG[14] was developed based on the seminal research conducted by Zegeer[18] which focused on pedestrian safety. To ensure that the safety of pedestrians is paramount, the same variables and vehicular volume ranges are used in this matrix.

Compliance Rate: The compliance rate of drivers to the PXOs is a multivariate function. For example, the compliance rate decreases as the posted speed limit increases for most pedestrian

crossing control treatment systems. The findings of research by Turner et al[19] were considered in the development of the selection matrix to maximize compliance rates of drivers.

Conspicuity: It is important that the treatment systems are conspicuous to drivers. As a result, a more conspicuous treatment system utilizing overhead-mounted signs is recommended where there is a potential for blockage of ground mounted signs (e.g. multilane roads).

The selection matrix for PXO treatment systems is shown in Table 7. The range of traffic volumes for various pedestrian crossovers provided in the Selection Matrix is based on the criteria presented in previous paragraphs of this Section. The upper limit of traffic volumes in Table 7 is equivalent to 35,000 AADT, since a PXO must not be used where the road volume exceeds this value according to OTM Book 12 as noted above. A generally accepted factor of 2.0 was used to convert the 35,000 AADT to 17,500 vehicles during an 8-hour period. A factor of 0.526 was used to convert 8-hour period volume to 4-hour period based on the study conducted by MTO in 2013 to develop a 4-hour warrant system for Justification 6 of OTM Book 12. The vehicular volume ranges used for different pedestrian crossovers in the Selection Matrix are similar to the Decision Support Tool provided in TAC's PCCG, simply converted from AADT into 8-hour and 4-hour periods by applying the above noted factors. The types of pedestrian crossovers to be used in Ontario context for these traffic volume ranges were finalized based on extensive consultation with stakeholders.

Four variables are used to select a PXO for a site:

- 8-hour or 4-hour two-way vehicular volume of the roadway at the location of the crosswalk.
- Posted speed limit of the roadway.
- Total number of lanes for the entire roadway cross section.
- Presence of raised pedestrian refuge (i.e., refuge island or median).

To use Table 7, first the appropriate row associated with the vehicular volume of a site and the posted speed limit of the site is selected. It should be noted that either 8-hour or 4-hour vehicular volumes can be utilized.

Next the column representing the total number of lanes for the site is selected. The intersection of the row and the column will be one of the cells of the table. The content of the cell represent the suggested PXO type. The vehicular volume in Table 7 provides the option for practitioners to use 8-hour vehicular volume during the highest pedestrian volume or 4-hour vehicular volume during the highest pedestrian volumes.

For example, a Level 2 Type D PXO is suggested for a site with 8-hour vehicular volume of 3000 vehicles, posted speed limit of 50 km/h with 2 lanes. The hatched cells in this table show that a PXO is not recommended for sites with these traffic and geometric conditions. Generally a traffic signal is warranted for such conditions.

It should be noted that the Selection Matrix will be used irrespective of the type of the environment, such as one-way/two-way roadways, roundabouts, intersections, etc.

It should be noted that if the use of a PXO is desired based on the connectivity or desired lines only (i.e. pedestrian and vehicular volume conditions are not fulfilled), then Table 7 can still be used based on speed and geometry of the roadway (use top two rows of the matrix).

5.2.3 Stop Control Applications

Stop control (two-way or all-way) at an intersection provides a safe opportunity for pedestrians to cross the major roads of intersections. The selection of stop control must be based on guidelines provided in OTM Book 5 – Regulatory Signs.

Pedestrian crossing: where the protection of pedestrians, school children in particular, is a prime concern. This concern can usually be addressed by other means, such as crossing school guards.

Table 7: Pedestrian Crossover Selection Matrix

Two-way Vehicular Volume			Posted Speed Limit (km/h	Total Number of Lanes for the Roadway Cross Section[1]			
Time Period	Lower Bound	Upper Bound		1 or 2 Lanes	3 lanes	4 lanes w/raised refuge	4 lanes w/o raised refuge
8 Hour	750	2,250	≤50	Level 2 Type D	Level 2 Type C[3]	Level 2 Type D[2]	Level 2 Type B
4 Hour	395	1,185					
8 Hour	750	2,250	60	Level 2 Type C	Level 2 Type B	Level 2 Type C[2]	Level 2 Type B
4 Hour	395	1,185					
8 Hour	2,250	4,500	≤50	Level 2 Type D	Level 2 Type B	Level 2 Type D[2]	Level 2 Type B
4 Hour	1,185	2,370					
8 Hour	2,250	4,500	60	Level 2 Type C	Level 2 Type B	Level 2 Type C[2]	Level 2 Type B
4 Hour	1,185	2,370					
8 Hour	4,500	6,000	≤50	Level 2 Type C	Level 2 Type B	Level 2 Type C[2]	Level 2 Type B
4 Hour	2,370	3,155					
8 Hour	4,500	6,000	60	Level 2 Type B	Level 2 Type B	Level 2 Type C[2]	Level 2 Type B
4 Hour	2,370	3,155					
8 Hour	6,000	7,500	≤50	Level 2 Type B	Level 2 Type B	Level 2 Type C[2]	Level 1 Type A
4 Hour	3,155	3,950					
8 Hour	6,000	7,500	60	Level 2 Type B	Level 2 Type B		
4 Hour	3,155	3,950					
8 Hour	7,500	17,500	≤50	Level 2 Type B	Level 2 Type B		
4 Hour	3,950	9,215					
8 Hour	7,500	17,500	60	Level 2 Type B			
4 Hour	3,950	9,215					

Type A Type B Type C Type D

Approaches to roundabouts should be considered a separate roadways.

[1]The total number of lanes is representative of crossing distance. The width of these lanes is assumed to be between 3.0 m and 3.75 m according to MTO Geometric Design Standards for Ontario Highways (Chapter D.2). A cross sectional feature (e.g. bike lane or on-street parking) may extend the average crossing distance beyond this range of lane widths.

[2]Use of two sets of side mounted signs for each direction (one on the right side and one on the median)

[3] Use Level 2 Type B PXO up to 3 lanes total, cross section one-way.

The hatched cells in this table show that a PXO is not recommended for sites with these traffic and geometric conditions. Generally a traffic signal is warranted for such conditions.

If a two-way stop control does not satisfy the minimum requirements for an IPS, full traffic signal or PXO as described in Section 5.2.1 and Section 5.2.2, warrants for all-way stop control must be checked. OTM Book 5 provides the warrant system for installation of all-way stop control at an intersection. The warrant is based on minimum traffic volume of the major road, minor road, and past collision history of the intersection.

5.2.4 Yield Control Applications

For pedestrian crossing treatments at intersections that are not warranted for traffic signals, stop controls, or pedestrian crossovers, the yield-control provides an alternative opportunity for pedestrians to make a safe and convenient crossing.

According to the HTA[1] , the vehicles approaching the yield sign shall slow down to a reasonable speed or stop if necessary and shall yield the right-of-way to traffic in the intersection or approaching on the intersecting highway so closely that it constitutes an immediate hazard and having so yielded may proceed with caution. At intersections if the yield sign is installed before the crosswalk, vehicles must yield to pedestrains and other conflicting vehicles. A yield sign cannot be used at other locations to provide the right-of-way to pedestrains.

Applications for yield-controlled intersections are prescribed in the HTA[1] and OTM Book 5 – Regulatory Signs. In OTM Book 5 Section 3, installation conditions and location criteria for the consideration of yield-controlled intersections are prescribed.

5.2.5 Supervised School Crossing Applications

Scenarios in which a school crossing guard may be used (provided that the highway speed limit does not exceed 60 km/h) include:

- Mid-block locations with the required marked crossing and school crossing signs found often in front of, or adjacent to a school site. The crossing is uncontrolled when not supervised by the crossing guard.
- Conventional stop-controlled intersections (stop signs) on the side street only.
- All-way stop-controlled intersections.
- Intersection pedestrian signals and midblock pedestrian signals.
- Pedestrian crossovers.
- Roundabouts.
- Traffic control signals.

A school crossing must not be implemented on a roadway with a posted speed limit in excess of 60 km/h. Section 5.1.4 provides the guidelines for use of crossing guard as a pedestrian control treatment at designated crossings.