

Pedestrian Intersection Safety Countermeasure Handbook

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Overview

A set of pedestrian intersection safety countermeasures to be used in determining appropriate intersection cross-walk safety upgrades.



www.pedbikeimages.org

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(www.pedbikeimages.org/ Dan Burden)

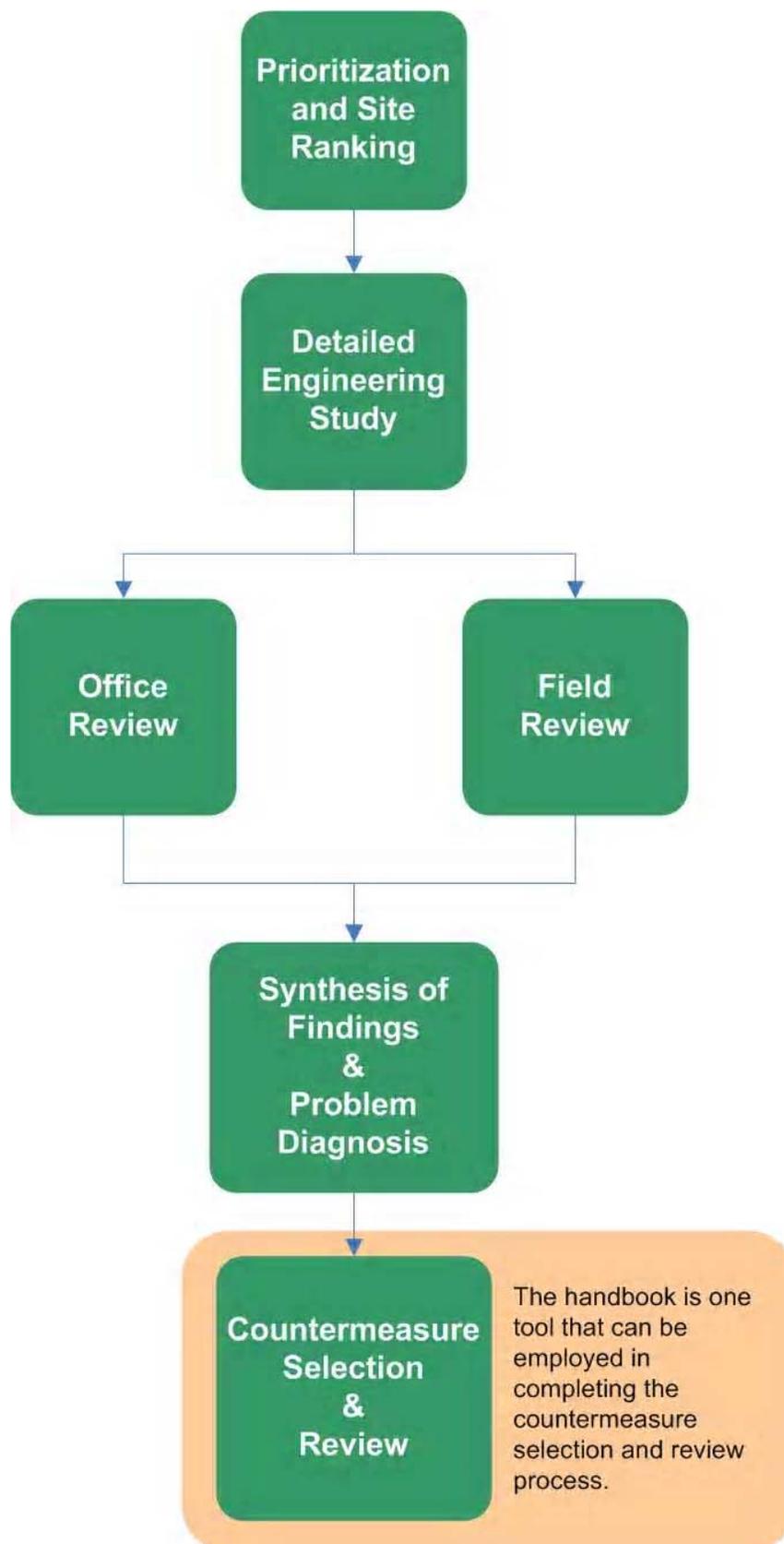
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Introduction

Introduction

The purpose of this document is to assist practitioners during the countermeasure selection and review process – one element of an overall road safety evaluation program. We have illustrated the City of Ottawa’s pedestrian intersection safety evaluation program in the figure at right in order to provide the reader with an understanding of when a countermeasure selection and review process should be conducted.

This handbook was prepared for the City of Ottawa as one tool in its pedestrian intersection safety evaluation program. More specifically, the handbook is intended as an aid in selecting the most appropriate safety treatments once a problem diagnosis has been made.



A Note on Sources

A carefully focused literature search was the foundation of this handbook. The intent was to seek research on countermeasures that demonstrated a safety improvement at pedestrian crosswalks. The Federal Highway Administration (FHWA) began work in this area in the mid 1990's and we have referenced much of this work – particularly the Pedestrian Safety Guide and Countermeasure Selection System – to develop this handbook for the City of Ot-

tawa.

There are several pedestrian-related safety countermeasures that have not been included in this handbook. This is based solely on the fact that there was no scientific evidence that these countermeasures demonstrated a safety benefit at pedestrian crosswalks at intersections. It will be acknowledged that road safety engineering in general, and pedestrian safety engineering in particular, are ever

changing sciences.

As a result, the City of Ottawa may choose to consider other countermeasures despite their not being included in this document. In such an event, we would strongly recommend that a thorough engineering evaluation be carried out to ensure they are appropriate for the situation to which they are applied.

How to Use this Handbook

The pedestrian intersection safety countermeasure handbook is a series of countermeasure sheets that focus on mitigating the key risks typically encountered at urban and suburban intersection crosswalks. It is intended to supplement the City of Ottawa pedestrian intersection safety countermeasure selection tool and provide background and contextual information that the software tool may not provide.

The one-sheet format is intended to allow the user to easily access information on a specific countermeasure without having to wade through unrelated data. However, it is recom-

mended that you read the document in its entirety at least once to understand the scope of its contents and their organization. This will allow the user to make more effective use of the handbook on an as-needed basis.

Each countermeasure sheet is formatted in the same manner and consists of one page. Each sheet introduces the concept of the countermeasure, followed by some considerations to keep in mind if considering such a countermeasure and then the purpose for implementing the countermeasure. Photographs and illustrations are provided to better communicate the ideas in the text.

The user must keep in mind that the countermeasures presented in the handbook are concepts and that countermeasures will vary by jurisdiction. We have approached the subject in this manner to allow flexibility in both the planning and design stages of implementation as well as the ability to work within the City of Ottawa policy framework. The photos in this handbook are intended to illustrate the concepts only and may not represent a specific installation in the City of Ottawa.



(McCormick Rankin Corporation)

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Signals and Signs



Install Traffic Signals

If warrants are met, traffic signals can be installed at unsignalized intersections. A traffic signal will assist pedestrians in crossing busy streets by providing gaps in the traffic flow. In the past, walking times to cross a street have typically been calculated based on a 1.2 metres/second walking speed. However, consideration of a slower walking speed (i.e. 1.0 metres/second) would better accommodate children, the elderly or mobility challenged pedestrians.



An example of a traffic signal, including pedestrian signals. Signals can help to reduce both pedestrian and vehicle delays and improve levels of service for all road users. (www.pedbikeimages.org/ / Dan Burden)

Things to consider

- The traffic signal cycle length should be kept to a minimum to reduce pedestrian delay. Pedestrians are more sensitive to delay than drivers.
- Fixed time traffic signals should be used to consistently allow crossing opportunities. Actuated pedestrian signals should only be installed where pedestrian volumes are infrequent or accessible signals are required for special needs users.
- Traffic signals should only be installed if City of Ottawa traffic signal warrants are met.

Purpose

- To provide intervals in traffic at an intersection where pedestrians can cross the street.



Pedestrian Signals

Pedestrian signals (i.e. the walking person and the hand) are typically implemented at signalized intersections and are most appropriate when traffic signal indications are not visible to pedestrians, when an exclusive pedestrian signal phase is in place, when complex signal timing and phasing have been implemented, and at crosswalks in the vicinity of schools. Larger pedestrian symbols may be required at crossings of wide roadways to ensure the symbols are visible at a greater distance.



The above pedestrian signals on Carling Avenue are located in the centre median and at the far side of the intersection to improve conspicuity. (McCormick Rankin Corporation)

Things to consider

- Ensure that the pedestrian signals are visible to the pedestrians crossing at that particular crossing.
- The walk interval/phase should be long enough for elderly persons and children to cross the width of the roadway.
- At locations with demand-actuated walking phases, research findings tell us that automatic detection technology is preferred to that of push-button actuation as nearly 50% of pedestrians do not activate a push-button.
- Each site should be evaluated following the City's pedestrian signal warrant procedure to determine if pedestrian signal warrants are met.

Purpose

- To indicate an appropriate time for pedestrians to cross the roadway
- To provide an adequate pedestrian clearance time (i.e. flashing hand) to indicate that the traffic signal will be changing

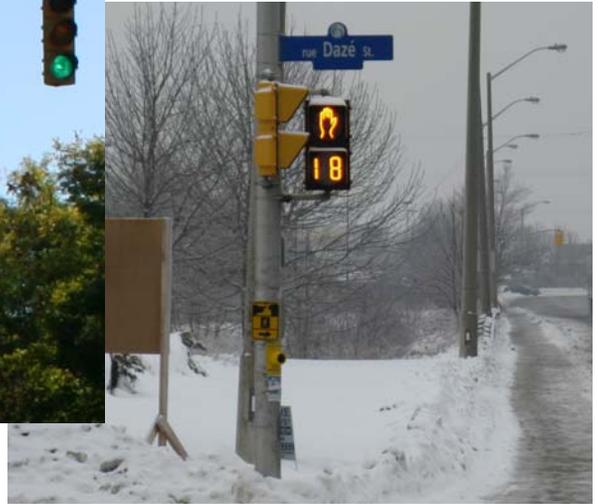


Supplementary Pedestrian Signals

Research indicates that supplementary pedestrian signal heads provide valuable information to pedestrians and drivers which can result in reduced safety risks. The most common supplementary pedestrian signals are countdown signals.



A countdown pedestrian signal head at the intersection of Vanier Parkway and Donald Street. (McCormick Rankin Corporation)



An example of countdown pedestrian signal head. (City of Ottawa)

Things to consider

- Ensure that the pedestrian signals are visible to the pedestrians crossing at that particular crossing.
- The walk interval/phase should be long enough for elderly and children to cross the width of the roadway.
- At locations with demand-actuated walking phases, automatic detection technology is preferred.

Purpose

- To indicate an appropriate time for pedestrians to cross the roadway
- To provide a pedestrian clearance time to indicate that the traffic signal will be changing



Increased Walking Time

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Increased Walking Time

Typically pedestrian signals at a signalized intersection allow a walking speed of 1.2 metres/second (4 feet/second) and this is considered to be the typical walking speed of an average adult. Recent research has demonstrated that crossing times calculated using 1.2 metres/second may not be sufficient for some pedestrians. In areas where there are children, teenagers, the elderly, or special needs users tend to require more time to cross a roadway. A more appropriate walking speed for this user group is 1.0 metres/second (or less).



Elderly populations generally take additional time to cross the street and may warrant the assumption of a slower walking speed when timing pedestrian signals. This is of particular concern at wide intersection. (www.pedbikeimages.org / Darn Burden)

Things to consider

- Increased crossing time at a signalized intersection may be warranted if there is an increase in pedestrians that are children, teenagers, the elderly or those with special needs.
- A walking speed of 1.0 metres/second or less is suggested for signal phasing planning purposes.

Purpose

- To provide sufficient crossing time at a signalized intersection for children, the elderly and special needs users



Pedestrian Signal Timing

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Pedestrian Signal Timing

There are several pedestrian signal timing treatments that can be implemented to address pedestrian crossing conflicts and issues. These include a pedestrian “scramble” phase, an exclusive pedestrian phase and a leading pedestrian interval (LPI) phase. A scramble phase stops all vehicles and pe-



An example of an intersection with a pedestrian scramble phase. The diagonal pavement markings indicate that pedestrians are permitted to cross in these directions. (www.treehugger.com / Michael Richard)

destrians are permitted to cross the intersection in any direction including diagonal movements. An exclusive phase permits pedestrians to use the designated crosswalks while vehicles get a red signal indication. Lastly, an LPI phase allows pedestrians to have about 5 seconds of exclusive advance green time to enter the crosswalk so they become more visible from the driver’s perspective.

Things to consider

- Fixed-timed traffic signals are generally more appropriate for scramble phases and exclusive phases.
- Wider intersections require longer crossing times and may not be appropriate locations for these types of countermeasures.
- Scramble phases are most appropriate in downtown areas with high pedestrian volumes but have the potential to increase confusion for the visually impaired.
- All three treatments may help reduce the risks associated with pedestrians and right and left turning vehicles.

Purpose

- To provide exclusive pedestrian crossing phases (i.e. scramble and exclusive phases), eliminating the pedestrian-vehicle conflicts where turning vehicles are present



Two-stage Signalized Crossing

Two-stage crossings are typically implemented at signalized intersections with long crosswalks but can also be implemented at unsignalized intersections as well. A two-stage crossing allows pedestrians to cross one direction of travel at a time

and to wait in the middle of the roadway at a centre median/refuge island. If the crossing is signalized, pedestrians are required to activate the push button in the centre median and wait for the “Walk” symbol to cross the second set of travel lanes. Two-stage signalized crossings are typically implemented where there are high vehicle volumes on a wide arterial street that would otherwise require a long “Walk” phase, or in areas where children or elderly pedestrians are known to walk.



The above photo of a pedestrian crossing on Carling Avenue provides a two-stage crossing for pedestrians with a push-button provided within the median refuge island (McCormick Rankin Corporation)

Things to consider

- A centre refuge island or median should have adequate curb ramps and refuge area to accommodate all pedestrians in the middle of the roadway.
- Consideration should be given to automatic pedestrian detection, especially where pedestrians are not accustomed to using push button devices.

Purpose

- To accommodate pedestrian signals at long crosswalks that require long walking times or where pedestrians require longer crossing times



Push Button Location & Signage

Pedestrian activated push buttons are common at signalized intersections, however, their purpose is sometimes not clearly understood. This is mainly a function of how well they have been placed at an intersection. Research shows that there is pedestrian contempt for using a push button to activate the “Walk” symbol at a crosswalk. It is imperative, therefore, that pedestrians to be able to locate the push button and determine which crosswalk is associated with which button. Supplementary signage can be used to indicate that the push button needs to be activated to get a “Walk” symbol. The sign should also define what the flashing “Don’t Walk” symbol means.



In the example above the pedestrian push button is not accessible and presents a significant challenge to mobility challenged pedestrians. (NCHRP Accessible Pedestrian Signals: A Guide to Best Practices)



The example to the left at the intersection of Baseline / Prince of Wales is an example of an accessible area around the push button. (McCormick Rankin Corporation)

Things to consider

- Pedestrian signals requiring push button activation should have buttons placed in a logical and convenient location and should clearly indicate the crossing to which each button applies.
- Push buttons must be situated in such a manner as to be fully accessible in all seasons.

Purpose

- To clearly indicate where the push button is located, what crosswalk it relates to, and how to use the push button
- To ensure that all pedestrians can access and understand the push button



Accessible Pedestrian Signals

The installation of an accessible pedestrian signal system (APS) provides improved information to special needs users such as the visually impaired by adding sound to conventional pedestrian signal heads. Visually impaired pedestrians crossing at signalized intersections must wait to listen for vehicles traveling in the direction they want to go. This situation becomes more complicated when the intersection is skewed or a channelization island is present. In the case of audible signals, two distinct sounds are typically provided to assist users in determining which direction to travel. APS signals require push button activation and have push button locators to further assist users.



The above APS push-button is one example of the many types that provide a locator tone to help visually impaired pedestrians find it and provides audio and vibrotactile feedback corresponding to the "walk" indication in the crossing direction indicated by the tactile arrow. (www.pedbikeimages.org / Dan Burden)

Things to consider

- Consideration should be given to the noise impacts associated with audible pedestrian signals and they may not be well suited to residential areas.
- As with any push button device, the APS activation button should be well positioned and clearly indicate which crossing direction it is associated with.

Purpose

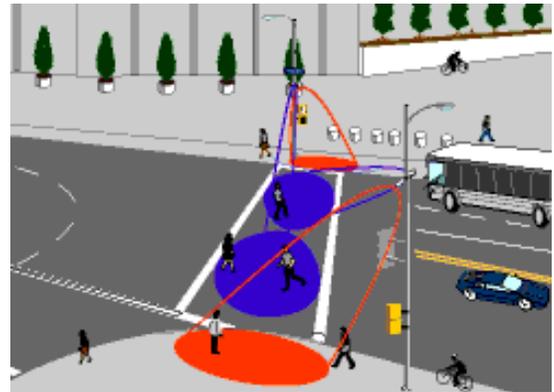
- To provide audible or tactile information to special needs pedestrians



CITY OF OTTAWA Automatic Pedestrian Detection

Automatic Pedestrian Detection

Research shows that pedestrian push button devices at crosswalks are only activated by a portion of pedestrian users. Therefore, new and innovative technologies are required to overcome the risks associated with not using a push button device. In recent years, several automatic pedestrian detection technologies have been developed and have been put to use. When a pedestrian waiting to cross the roadway has been detected, the “Walk” signal will be activated. In addition, automatic detectors can be programmed to extend the crossing time for slower pedestrians such as the elderly or special needs users.



Microwave or a similar technology detect the presence of pedestrians waiting and crossing the crosswalk, eliminating the need for a push-button and sometimes adjusting signal timing if necessary (www.walkinginfo.org / ITS Technologies)

Things to consider

- Automatic detection systems are not widely used and there may be compatibility issues with coordinated signal systems.
- Given that this is a new technology, their reliability under various environmental conditions is not well documented.

Purpose

- To provide improved pedestrian compliance at a signalized crosswalk
- To increase walking times for slow moving pedestrians



Advance Left Turn Phase

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Advance Left Turn Phase

The implementation of an advance left turn phase for vehicles would typically be implemented at a traffic signal that currently does not already have this in place. Essentially, it is an exclusive phase that is intended to reduce the pedestrian-vehicle conflicts at an intersection. During an advance vehicle phase at a signalized intersection pedestrians are required to wait until the end of the advance phase before they are given the “Walk” symbol.



An advance left turn phase for vehicles allows the majority of turning vehicles to clear the intersection before pedestrians enter the crosswalk, limiting the potential for conflict. (City of Ottawa)

Things to consider

- Prior to implementing this treatment a traffic operations evaluation should be carried out at the intersection to ensure an advance left turn phase is appropriate.
- Advance left turn phases may only be required during specific times of the day to address sites that experience relatively high volumes of left turning vehicles.
- In situations where pedestrian push button activation is required, this particular safety countermeasure is only effective if pedestrians activate the button. This issue can be overcome by implementing automatic pedestrian detection (see countermeasure sheet 2.9).

Purpose

- To reduce the number of pedestrian-vehicle conflicts at intersections that experience relatively high volumes of left turning vehicles.



Crosswalk Signage

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Crosswalk Signage

Signs provide vital information to the users of the street so that appropriate decisions are made at the correct time. Signs provide directional assistance, travel information, warnings or regulatory guidance. Compliance with standardized signing practices helps ensure that driver and pedestrian expectations are met and encourages better compliance and behaviour. The use of too many signs creates visual clutter and could promote non-compliance. Sign maintenance is also an important part of providing information to the users of the road.

Supplementary signs may be used to provide relevant information and remind drivers and pedestrians of their responsibilities at crosswalks. (McCormick Rankin Corporation)



Things to consider

- The use of non-standard signs violates driver and pedestrian expectation and can cause confusion.
- Nighttime sign visibility should be checked regularly to ensure that signs are effective under low light conditions.
- Supplementary signage at crosswalks for both drivers and pedestrians has shown to offer a safety benefit. Supplementary signage should be concise, have a consistent message and be posted in the same location at all crosswalks.

Purpose

- To provide timely information to road users approaching and at a crosswalk



CITY OF OTTAWA Supplementary School Signage

Supplementary School Signage

In addition to the standard school crosswalk signs or a crossing guard, there are other supplementary traffic control devices that can be installed on the approach to a crosswalk in the vicinity of schools. Such treatments include the use of fluorescent yellow-green sign sheeting on the crosswalk warning and regulatory signs, the use of active flashers on crosswalk warning signs or the use of a reduced speed limit during school hours. Of course, an education campaign for children and drivers is an important component to improving road safety risks near schools.



In the above left photo, an example of a variable speed limit and flashing beacons warn drivers that school children are present ([www.pedbikeimages.org/Dan Burden](http://www.pedbikeimages.org/DanBurden)). On the right, a City of Ottawa school area warning sign is supplemented by a speed radar sign display. (City of Ottawa)

Things to consider

- Policies must be established for the use of supplementary signage or traffic control devices to ensure their consistent application throughout the jurisdiction.
- The implementation of a reduced speed zone during school hours will require additional speed management countermeasures and/or increased enforcement.

Purpose

- To provide additional information for drivers approaching a crosswalk in the vicinity of a school



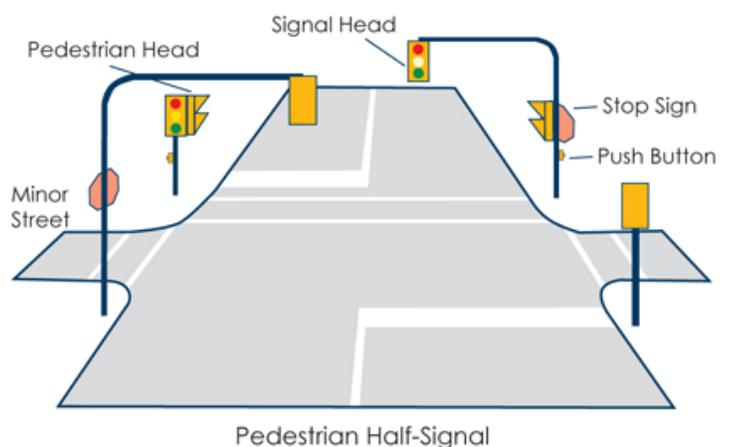
Pedestrian Half Signals

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Pedestrian Half Signals

Pedestrian half signals, also referred to as “intersection pedestrian signals” in the City of Ottawa’s Ottawa Pedestrian Plan, provide signal control for vehicles on the major street as well as pedestrians crossing the major street. Traffic on the minor street are controlled by a stop sign. They have been in use in Canada since the 1960’s and are currently used in Ontario, British Columbia, Alberta and Nova Scotia. Typically, pedestrians use a push button to activate the half signals

that stop traffic on the major street so they can cross. Otherwise, the traffic signals display a green light. Minor street traffic must comply with the stop sign control at all times.



Half-signals interrupt major street traffic only when activated by a pedestrian push-button. A typical configuration is shown above. (Halifax Regional Municipality)

Things to consider

- There are concerns that pedestrian half signals may not be respected by driver’s due to the combined traffic signal and stop sign controls at the intersection.
- Careful consideration should be given to their application during the planning stages if there are no other pedestrian half signals in the area.
- Each candidate site must be evaluated using the City’s pedestrian signal warrant procedure and there may be a need for consultations with the Ward Councillor and others as required.

Purpose

- To provide intervals in traffic at an unsignalized intersection so pedestrians can cross the street.



(Virginia Department of Transportation)

3

Pedestrian Facility Design



Raised Pedestrian Crosswalk

Raised Pedestrian Crosswalk

A raised pedestrian crosswalk is similar to a speed table, with the flat top providing an elevated crosswalk. Typically, the flat top of a raised pedestrian crosswalk is 3 to 4.6 meters wide and is at a slightly lower elevation than the sidewalk. This feature encourages



In this photo, a raised crosswalk is placed across a channelized slip lane to help reduce vehicle speeds and improve awareness of pedestrians. Note the texturized pavement and curb ramp that help transition from the sidewalk to the crosswalk. (www.pedbikeimages.org / Dan Burden)

drivers to yield to pedestrians, and at the same time helps to reduce vehicle speeds.

Things to consider

- Detectable warnings, markings and a curb ramp for pedestrians should be installed to clearly define the transition between the sidewalk and roadway.
- This safety countermeasure could be considered at all crosswalks across a channelized right turn lane (i.e. an urban smart channel).
- Should be considered as part of an overall traffic calming plan.
- Should be designed to ensure that adequate drainage is maintained on the street.
- Include input from local emergency services representatives during the planning and design stages.

Purpose

- To reduce pedestrian-vehicle conflicts
- To provide a well defined space for pedestrians and vehicles
- To reduce the potential for high-speed or erratic vehicle movements into and out of accesses
- Improve visibility between vehicles and pedestrians



Texturized Crosswalk Material

Highly visible crosswalks help drivers be more aware of pedestrians crossing the road and one such treatment is through the use of texturized and/or coloured materials. Of course, reflective pavement markings are still required to maintain visibility at night. A texturized crosswalk will also provide a vibratory feedback to drivers as they drive over the crosswalk and act as a reminder that pedestrians may be present in the area.



Texturized and colored crosswalks help to provide contrast against the asphalt pavement making them more visible to drivers. (www.pedbikeimages.org / Dan Burden)

Things to consider

- The texturized material should be designed to maintain its visibility over a long period of time.
- The use of uncommon materials other than asphalt or concrete should be coordinated with other departments within the organization (i.e. the maintenance department). This will ensure that situations such as differential settlement (that lead to standing water in the roadway and crosswalk) are minimized
- Ensure that slippery surfaces or excessively bumpy surfaces are avoided as they can become a tripping hazard or difficult for wheelchairs and strollers.

Purpose

- To increase driver-awareness of the need to share the roadway
- To make the crosswalk more visible to drivers



Enhanced Crosswalk Pavement Markings

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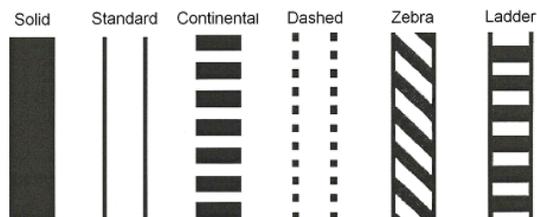
Enhanced Crosswalk Pavement Markings

Marked crosswalks identify a preferred location for pedestrians to cross a roadway. Guidance on standard crosswalk markings is provided in the Manual of Uniform Traffic Control Devices for Canada as well as the City's warrant for enhanced markings. Enhanced markings may be more appropriate in some situations and can be in the form of a solid painted area, ladder, zebra, continental or zig zag marking patterns.

("Safety Effects of Marked versus Unmarked Crosswalks at Uncontrolled Locations." Zegeer C.V., J.R. Stewart, H.H. Huang, P.A. Lagerwey)



At this Bronson Avenue intersection, enhanced markings help to improve crosswalk visibility (McCormick Rankin Corporation)



Things to consider

- Crosswalk markings alone are unlikely to reduce pedestrian safety risks. Ideally, crosswalks should be used in conjunction with other treatments, particularly on high volume, multi-lane roadways.
- The crosswalk marking pattern must be placed in the area of a mountable curb ramp so that pedestrians requiring the use of the ramp remain within the marked crosswalk area.
- Alternatives to painted markings is the use of inlay or thermoplastic tape. Both are highly retro-reflective and less slippery than paint.

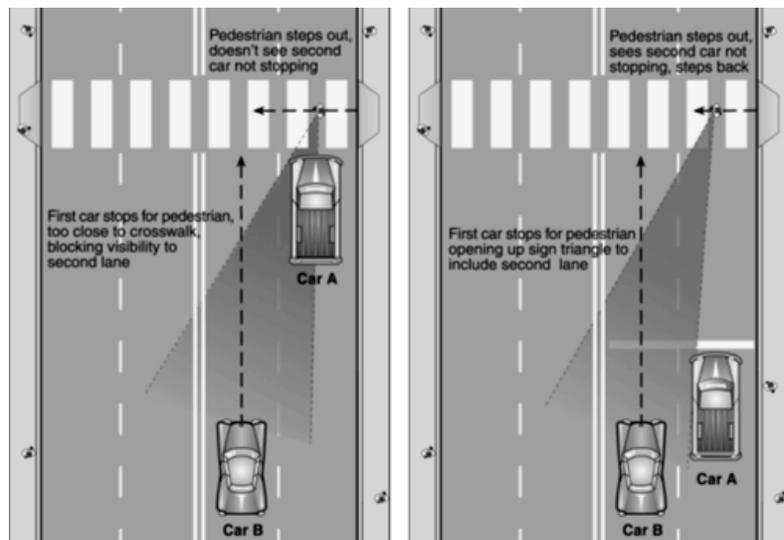
Purpose

- To warn drivers to expect pedestrian crossings
- To indicate preferred crossing locations



Advance Markings at Crosswalks

Moving a yield line or stop bar further away from crosswalks at intersections will improve the visibility between pedestrians and drivers. The installation of a “Stop here for pedestrians” sign supplementing the new yield line or stop bar location has shown to have significant safety benefits for pedestrians.



This diagram illustrates the improvement in visibility between drivers and pedestrians that can be attained when vehicles stop further back from the crosswalk. The increased space also creates a buffer between vehicles and pedestrians. (www.walkinginfo.org)

Things to consider

- The effectiveness of this treatment will depend on driver compliance at the yield line for the crosswalk.
- If relocated too far in advance of the crosswalk drivers may choose to ignore the line and stop closer to the crosswalk.
- An alternative treatment may be to provide a wider crossing that allows more space for the pedestrians, while stopping vehicles in advance of the crosswalk.

Purpose

- To improve visibility between pedestrians and drivers



Enhance Illumination at Crosswalks

Enhance Illumination at Crosswalks

The proper placement of lighting and its uniformity can help reduce the road safety risks as well as increase comfort and security at a crosswalk. Pedestrians often assume that drivers can see them at

night and may be deceived by their own ability to see the oncoming headlights. Without sufficient overhead lighting (both in the crosswalk and at refuge areas), motorists may not be able to see pedestrians in time to stop. Pedestrian crossing areas may be supplemented with brighter or additional lighting.



An example of enhanced lighting at a pedestrian crosswalk that is focused at the conflict areas.
([www.flickr.com / photo femme](http://www.flickr.com/photo/femme))

Things to consider

- Ensure that pedestrian crosswalks are well lit particularly at the conflict areas between pedestrians and vehicles.
- Install lighting on both sides of wide streets and streets in commercial districts.
- Use uniform lighting levels in the vicinity of the crosswalk.

Purpose

- To enhance the safety of all roadway users, particularly pedestrians
- To enhance commercial district areas
- To improve nighttime security



Curb Extension / Bulb-out

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Curb Extension / Bulb-out

Curb extensions or bulb-outs extend the sidewalk and refuge area out into the street creating additional landing space for waiting pedestrians. Other benefits include a shortened crossing distance and improved visibility of the pedestrian. Curb extensions at an intersection crosswalk prevent motorists from parking too close to the corner (blocking the sightlines) or blocking a curb ramp. Where they are installed drivers are generally encouraged to reduce their operating speed.



The Figure above shows a curb extension on Holland Avenue in an area of on-street parking. (McCormick Rankin Corporation). The Figure at left is an example of how a curb extension helps to make a pedestrian more visible by locating the refuge area closer to the travel lane. (www.pedbikeimages.org/ Dan Burden)

Things to consider

- Curb extensions facilitate additional space for pedestrians in areas of narrow sidewalks.
- Curb extensions should be designed to accommodate large turning vehicles where necessary to prevent them from mounting the curb and putting pedestrians at risk.
- Curb extensions are most appropriate in areas with on-street parking and may be appropriate for installations where on-street parking is being considered.
- In some locations snow removal may be a challenge.
- Careful consideration should be given to sites where bicycle lanes have been installed.

Purpose

- To improve visibility of pedestrians from driver's perspective
- To shorten the crossing distance and reduce pedestrian exposure
- To encourage pedestrians to cross at designated crosswalks



Raised Medians

Medians are raised barriers in the centre of a roadway that can serve as a place of refuge for pedestrians using a crosswalk. Raised medians are most useful on high volume, high speed roadways and should be designed to provide tactile cues for pedestrians to clearly indicate the transition from the pedestrians refuge area and the roadway. Various median designs can be implemented including a continuous median, intermittent median, or a centre crossing island serving only the pedestrians using the crosswalk. If a continuous median is being considered, an evaluation of traffic turning movements in the vicinity of the median should be carefully considered.



Median refuge islands allow pedestrians to focus on crossing one direction of traffic at a time and provide a refuge area to wait for a gap in traffic partway through the crossing. There must, however, be space to accommodate the volume and mix of pedestrians using the crossing (i.e. wheelchairs, strollers, etc.). (McCormick Rankin Corporation)

Things to consider

- Ensure that there is adequate right-of-way width during the planning stages to accommodate a centre median along with the necessary travel lanes, sidewalks, bike lanes and boulevards.
- Landscaping in the medians should not obstruct the visibility between a pedestrian standing in the median and approaching drivers.
- A raised median with a crosswalk should be made fully accessible with curb ramps and detectible warnings.

Purpose

- To provide a refuge for pedestrians crossing the street
- To manage vehicle speeds by effectively narrowing the travel way
- To provide space for additional landscaping/streetscaping treatments



Prohibition of Pedestrian Crossings

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Prohibition of Pedestrian Crossings

Prohibiting pedestrians from using a particular crossing will reduce or eliminate conflicts between vehicles and pedestrians. However, it is difficult to discourage pedestrians from using a crossing at an intersection as pedestrians will tend to cross a roadway at a point that is most convenient for them. Typically, prohibiting pedestrian crossings only occur at intersections with very long crossing distances or high volumes of turning traffic (such as a double left turn situation).



Physical barriers and regulatory signs can be used to prohibit pedestrians from making certain movements. (www.pedbikeimages.org / Dan Burden)
The photo at right illustrates an example at an Ottawa intersection. (City of Ottawa)

Things to consider

- In addition to signs, physical barriers can be used to reinforce the message that pedestrian crossings are prohibited.
- The decision to prohibit pedestrian crossings should only be made after evaluating the impacts to neighbourhood walking routes.
- This particular safety countermeasure should only be considered where the risks to pedestrians are increased and other mitigating measures have already been considered.

Purpose

- To restrict pedestrians from using a high risk crossing



Adequate Pedestrian Waiting Areas

Ensuring there is an adequate pedestrian refuge at the ends of a crosswalk enhances the walking environment, provides a connection between the sidewalk and the crosswalk and provides a refuge area for pedestrians as they wait to cross the roadway.



In this photo, a crosswalk is provided across a channelized right turn lane at the Baseline / Prince of Wales intersection. At this location there is no curb ramp, a very rough texturized sidewalk treatment not conducive to mobility challenged or pedestrians requiring assistive devices, and a very limited refuge area. These types of conditions present significant challenges for pedestrians. (McCormick Rankin Corporation)

Things to consider

- Areas of high priority include crosswalks with high pedestrian volumes, near transit stops, schools or parks.
- A pedestrian refuge area should be free of obstacles that can obscure sight-lines between drivers and pedestrians.

Purpose

- To provide a landing and waiting area at the ends of a crosswalk
- To enhance the pedestrian walking environment



Sidewalk Continuity

Sidewalks and walkways are “pedestrian lanes” that provide people with space to travel within the public right-of-way, separated from the roadway and vehicles. Such facilities improve mobility and accessibility for pedestrians and provide access for all types of pedestrian travel — particularly to/ from a crosswalk.



Lack of adequate sidewalks leading to and from crosswalks can limit mobility for all pedestrians and can lead to risky and unpredictable pedestrian behavior. (McCormick Rankin Corporation)

Things to consider

- In retrofitting streets that do not have a continuous or accessible system, locations near cross-walks, transit stops, schools, parks, public buildings and other areas with high concentrations of pedestrians should be the highest priority.
- Street furniture placement should not restrict pedestrian flow.
- Wider sidewalks should be installed near schools, at transit stops and in downtown areas and locations of high concentrations of pedestrians.
- Sidewalks should be continuous – particularly with crosswalks—and should be fully accessible to pedestrians.

Purpose

- To provide a connection between the neighbourhood sidewalk system and the crosswalk under study.



Mountable Curb Ramps

CITY OF OTTAWA

Mountable Curb Ramps

Curb ramps provide a smooth transition between the sidewalk and the roadway which is of special importance for people using wheelchairs, strollers, walkers, crutches, handcarts, bicycles and also for pedestrians with mobility impairments. Curb ramps should be installed at all locations where pedestrian crossings exist. By conducting audits of existing crosswalk facilities agencies can identify locations where curb ramp upgrades are required.



An example of a curb ramp to provide an adequate transition between the sidewalk and roadway. This particular installation has a texturized and coloured pad at the bottom of the ramp to assist special needs pedestrians but its use is not standard practice in Ottawa. (www.pedbikeimages.org / Dan Burden)

Things to consider

- While curb ramps are needed at all crosswalks, priority locations include: downtown areas, transit stops, near schools and parks, medical facilities, shopping districts and near residences of people with accessibility needs.

Purpose

- To provide access to crosswalks and street crossings.



(www.brokencitylab.org/tags/cities / Justin Langlois)

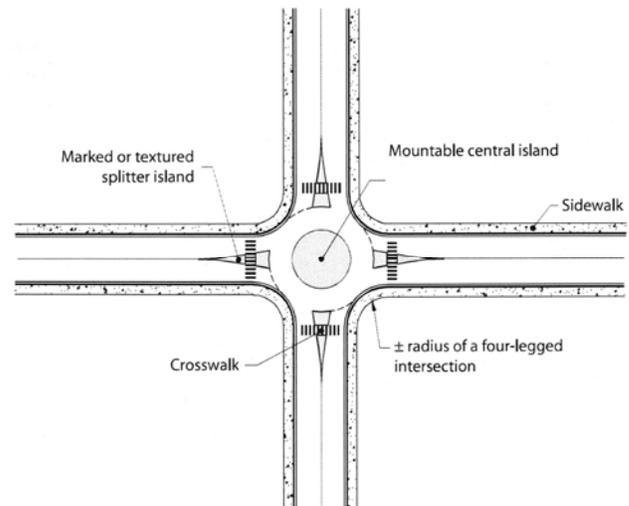
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Intersection Design



Mini Roundabout

Mini roundabouts, not to be confused with compact roundabouts, are very small diameter roundabouts typically installed at the intersection of two local streets. They have a central island that is completely mountable and can usually be installed in the existing right of way with only minor adjustments to the curb limits of the intersection. Mini roundabouts usually replace stop sign control at an intersection and the right-of-way rules for a roundabout apply (i.e. yield on entry). They are considered to be a traffic calming or speed management measure as they reduce vehicle speeds through the intersection. This is a benefit to pedestrians crossing the street.



A mini-roundabout helps to manage speeds on low volume residential streets. As shown in the illustration the crossing distance for pedestrians is similar to a conventional intersection. (Québec Ministère des Transports)

Things to consider

- Mini roundabouts should be designed with a very small radius to reduce vehicle speeds and have a minimal impact on curb lines and adjacent properties.
- Properly designed mini roundabouts should not have landscaping in their central island and should be mountable in the event that large vehicles (such as a fire truck) are required to travel through the intersection.
- Prior to installing a four-way stop at an intersection, consideration should be given to a mini roundabout.
- Mini roundabouts are not suitable for public transit routes.

Purpose

- To reduce vehicle speeds at the intersection
- To reduce collisions at the intersection of two local streets



Modern Roundabout

CITY OF OTTAWA

Modern Roundabout

A modern roundabout is a circular intersection that requires all vehicles to slow and yield prior to entering the counterclockwise flow. If properly designed, roundabouts will slow high speed traffic entering an intersection which benefits pedestrians that cross at the intersection. A modern roundabout has splitter islands on each approach that function similar to a raised centre median. This feature allows pedestrians to concentrate on one direction of travel at a time as they cross the roadway. In addition, the crosswalk is set back from the



yield line so that drivers first focus on the crosswalk, then focus on entering the intersection.

An example of a pedestrian crosswalk at a roundabout. If designed properly, the splitter island on the approach to a roundabout acts as a median refuge and allow pedestrians to cross one direction of travel at a time. (McCormick Rankin Corporation)

Things to consider

- Ensure that there is sufficient right-of-way to implement a roundabout.
- A roundabout intended to improve pedestrian safety is generally not appropriate at intersections with multi-lane roads.
- A properly designed roundabout approach should have splitter islands and designed to significantly reduce traffic speeds entering the intersection.
- A roundabout may present navigational challenges for the visually impaired.

Purpose

- To improve intersection safety by eliminating higher severity vehicle collisions
- To reduce vehicle speeds through an intersection and crosswalk
- To provide a gateway into a neighbourhood



Raised Intersection

A raised intersection is similar to that of a raised crosswalk except that it encompasses the entire intersection. The crosswalks on each approach to the intersection are raised as well—enabling pedestrians to cross the road at the same elevation as the sidewalk. This type of countermeasure encourages drivers to reduce their speed entering the intersection and yield to pedestrians crossing the roadway.



Example of a raised, 3-leg intersection with textured pavements. ("Cambridge Plans a Livable Community." Parenti, Jeff. FHWA Public Roads Magazine. November/December 2006. Volume 70, Article 3.)

Things to consider

- Should be designed to ensure adequate drainage is maintained on the street.
- Detectable warnings or markings should be installed to clearly define the transition between the sidewalk and roadway.
- Not appropriate for high volume or high speed roads or streets with steep grades.
- Include input from local emergency services representatives during the planning and design stages.
- Should be installed as part of an overall traffic calming plan.

Purpose

- To reduce vehicle speeds
- To enhance the pedestrian crossing environment



Reduce Curb Radius

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Reduce Curb Radius

One of the common pedestrian crash types involves pedestrians being struck by a right-turning vehicle at an intersection crosswalk. A wide radius typically results in high speed turning movements. Reconstructing the corner radius to a smaller size will reduce turning speeds, shorten the crossing distance for pedestrians and improve the visibility between drivers and pedestrians.



The photo above shows an example of a large radius corner where vehicles can make high speed turns (www.pedbikeimages.org / Libby Thomas). The photo at left shows a small radius corner typical of a residential street (www.pedbikeimages.org / Dan Burden).

Things to consider

- Curb radii should be designed and sized appropriately for the nearby land uses. If the radii are too small, large trucks or buses may mount the curb and put the pedestrian at considerable risk.
- At skewed intersections, the corners with an obtuse angle should be designed with as small a radius as possible to prevent high speed turns.

Purpose

- To implement a safer intersection/crosswalk design
- To slow right turning vehicles at the crosswalk location
- To improve visibility between drivers and pedestrians, reduce crossing distances, and provide space for curb ramps



Right Turn Lane Channelized Island

Right Turn Lane Channelized Island

Right turn channelized islands can be implemented at wide intersections with large corner radii and high speed right turns. If designed properly the addition of a channelized island can help reduce the speed at which right turns are made. In addition, the channelized island provides a refuge for pedestrians and allows the pedestrian to cross a wide street in stages.



Channelized right-turn slip lane islands provide refuge and reduce the overall width that must be crossed by pedestrians. This example at the Vanier Parkway/ Donald Street intersection has vegetation that blocks sightlines to pedestrians waiting to use the sidewalk. (McCormick Rankin Corporation)

Things to consider

- Most appropriately implemented at high volume intersections with large corner radii.
- Visually impaired pedestrians may have navigational issues with a right turn channelized island.
- If this safety countermeasure is not designed properly it can increase risks for pedestrians using the crosswalk.

Purpose

- To slow right turning traffic speed at large radius intersections
- To reduce the crossing distance for pedestrians

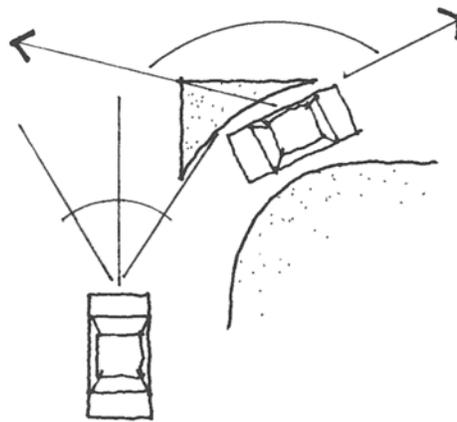


Improve Right Turn Slip Lane Design

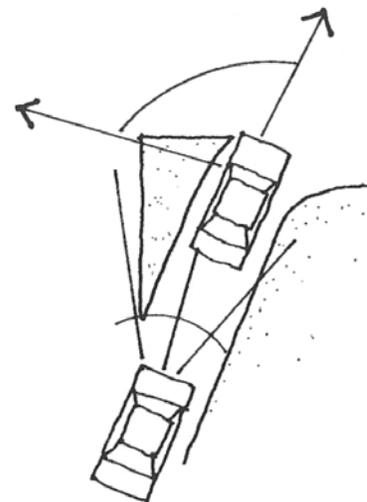
CITY OF OTTAWA

Improve Right Turn Slip Lane Design

Also known as the City's Urban Smart Channel, this countermeasure is only appropriate where a channelized right turn slip lane is currently installed. Generally, right turn slip lane designs are viewed as a negative from a pedestrian due to the emphasis on convenient and fast turning movements for vehicles. The problem for pedestrians is that many slip lanes have been designed for unimpeded vehicular movement (i.e. a lane-away design). In an area of pedestrian activity and crosswalks, the channelized island should be designed to slow vehicles and have clear visibility of a crossing pedestrian.



Poor slip lane design promotes high speed, low visibility, and the driver's attention and head to be turned away from crossing pedestrians. (FHWA Pedsafe diagrams)



Improved slip lane design promotes good all around visibility and reduces speeds.

Things to consider

- The shape of the channelized island should be altered so that the pedestrian crosswalk is in clear view of the driver as they enter the right turn, not during or after the turn.
- Any altered design must still accommodate large vehicles and have the appropriate crosswalk signage .

Purpose

- To separate right turning traffic at intersections with large turning radii.
- To slow right turning vehicle speeds
- To reduce the crossing distance for pedestrians
- To improve the driver's visibility of crossing pedestrians



Remove Sightline Obstructions

Remove Sightline Obstructions

Sidewalks and walkways leading to crosswalks should be kept clear of utility poles, sign posts, vegetation and other obstacles that could obscure the view from both a driver and pedestrian perspective. Such areas should be properly maintained including the removal of debris, vegetation and snow. In addition, walking areas in the vicinity of a crosswalk should be well lit and have good sightlines.



Obstacles such as hydro poles, utility cabinets, and street furniture can seriously impede sightlines between drivers and pedestrians at intersections. They can also impact the refuge area available when waiting for signals, especially for pedestrians in wheelchairs (www.pedbikeimages.org/ Dan Burden).

Things to consider

- Ensure there is adequate space for a refuge area adjacent to the crosswalk that has a clear and unobstructed view of on-coming vehicles.
- During the planning stages, ensure that vegetation is set-back from the crosswalk and that there is sufficient space for snow storage during the winter months.

Purpose

- To provide clear visibility between drivers and pedestrians
- To enhance the pedestrian walking environment



(McCormick Rankin Corporation)

5

Roadway Design



Transit Stop Relocation

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Transit Stop Relocation

Well designed transit routes and accessible stops are essential to a usable system. The proper placement of bus stops is key to user safety. For example, placing bus stops on the near side of an intersection or crosswalk may block the pedestrian's view of approaching traffic and the approaching driver's view of the pedestrian. Far side bus stops generally encourage pedestrians to cross behind the bus—improving the sightline and visibility issue.



An example of a transit stop located on the near side of a crosswalk. Far side transit stops are generally safer from a pedestrian's perspective due to better visibility between pedestrians and drivers. (www.pedbikeimages.org / Dan Burden)

Things to consider

- Ensure adequate access to and from the transit stops.
- Ensure a clear and comfortable path for passing pedestrians and accommodate additional space for wheelchairs and strollers.
- Locate transit stops on the far side of an intersection or marked crosswalk.

Purpose

- To provide safe, convenient and inviting access for transit users.



Reduce Lane Widths

Implementation of reduced travel lane widths is intended to maintain the same number of travel lanes for vehicles. However, the effective travel lane width is reduced and will help reduce vehicle operating speeds. Reducing lane widths can be achieved through a perceived narrowing such as reconfiguring the lane markings (i.e. reduce lane width from 3.6 to 3.4 meters), adding bicycle lanes in the curb lane, adding on-street parking, or through a physical narrowing such as relocating curb and gutter towards the centre of the roadway.



Lane narrowing can be an effective means of reducing vehicle speeds and focusing drivers' attention. (www.pedbikeimages.org / Dan Burden)

Things to consider

- Roadway narrowing may reduce traffic volumes as they divert to other parallel roadways. A thorough traffic circulation evaluation should be carried out prior to implementation.
 - Bicycle lanes or wide curb lanes are encouraged if vehicle volumes and speeds are high.
-

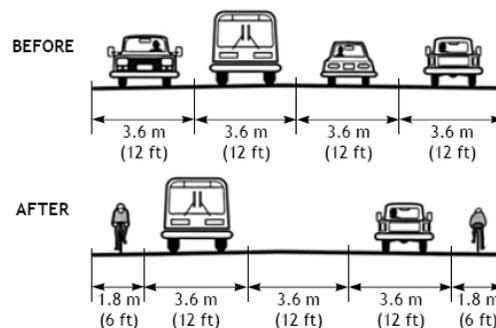
Purpose

- To reduce vehicle speeds
- To redistribute space to other users of the road



Lane Reductions

Some roads are difficult to cross due to the number of lanes—creating a wide crossing. Reducing the number of vehicle travel lanes on a multi-lane roadway can reduce the pedestrian exposure to vehicles. For example, 4-lane streets (i.e. two lanes in each direction) have successfully been converted to a 3-lane cross-section in some locations (i.e. one travel lane in each direction with a centre left turn lane). This is sometimes called a “road diet”.



Reducing the number of lanes on a roadway can be an effective means of managing speeds and traffic volumes while improving the environment for pedestrians and bicyclists. (FHWA University Course on Bicycle and Pedestrian Transportation <above>; pedbikeimages.org / Libby Thomas <left>)

Things to consider

- Roadway traffic operational analysis and overall road safety needs are to be considered before reducing the number of lanes on the approaches to a crosswalk.
- Ensure that there are adequate street connections
- Depending on conditions, it may be possible to add on-street parking while allowing for bicycle lanes on both sides of the street—instead of providing a centre turn lane
- Consideration could be given to designs that incorporate raised medians and left-turn bays, however, winter maintenance issues must be considered.

Purpose

- To provide space for pedestrians, bicyclists, and parked cars
- To reduce pedestrian exposure to vehicles
- To improve neighbourhood aesthetics



Bicycle Lanes

The addition of bicycle lanes on a roadway may require either a reduction in the number of travel lanes or a narrowing of the existing lanes. This is expected to reduce vehicle operating speeds which will in turn benefit pedestrians. Bicycle lanes also provide a buffer between vehicles and pedestrians and may translate into better compliance when drivers are required to yield to crossing pedestrians.



The photo above shows how a bicycle lane can provide a buffer between vehicles and pedestrians. The photo at left illustrates how bicycle lanes help narrow the travel lanes and may help to reduce vehicle speeds.
(www.pedbikeimages.org/ Dan Burden)

Things to consider

- The appropriateness of adding on-street bicycle facilities should be evaluated prior to implementation.
- Provide adequate space between the bike lane and parked cars so that open doors do not create a hazard to bicyclists.
- On high speed, high volume roadways it may be more appropriate to provide a multi-use path to separate bicyclists and pedestrians from traffic.

Purpose

- To narrow the roadway to encourage lower motor vehicle speeds
- To provide additional separation between pedestrians and vehicles
- To reduce the distance pedestrians must travel across vehicle lanes



On-street Parking

On-street parking can be both a benefit and a detriment to pedestrians. On-street parking increases positive separation between the roadway and the sidewalk, narrows the effective crossing distance at crosswalks and encourages slower vehicle speeds. In addition, on-street parking encourages pedestrian access (more than off-street parking lots) and can foster a more vibrant pedestrian environment. However, where sightline issues exist, parking should be removed immediately up and downstream of crosswalks.



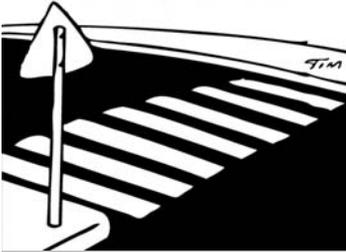
An example of on-street parking. It provides a buffer between traffic and pedestrians and narrows the roadway—helping to reduce vehicle speeds. However, on-street parking can limit the visibility of pedestrians. (www.pedbikeimages.org/ Dan Burden)

Things to consider

- Parking may take up space desired for other uses such as wider sidewalks or bicycle lanes.
- Approaches to crosswalks and intersections should be cleared and consideration should be given to curb extensions to enhance pedestrian safety.
- Guidelines suggest that on-street parking should be set-back from the crosswalk by 6m to 15m. The use of curb extensions may reduce these requirements and maximize the number of parking spaces provided.

Purpose

- To provide a buffer between the sidewalk and moving traffic
- To aid in speed reduction by increasing the friction along the street and narrowing the perceived roadway width



Access Management

In some cases accesses to residential or commercial buildings at or adjacent to crosswalks may create safety issues if these accesses are excessively wide, excessively sloped, have large turning radii, multiple adjacent driveways and driveways that are not well defined.

Examples of access improvements include closing or relocating the driveway away from the crosswalk, narrowing or tightening the width of the access, reducing the access turning radii or converting to right-in, right-out only vehicle movements.



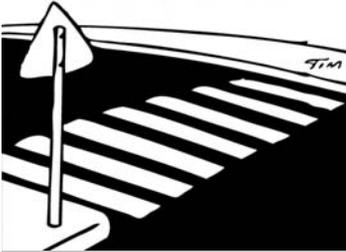
An example of poor access management adjacent to a crosswalk. In this case, there is no pedestrian refuge at the end of the crosswalk and vehicles make high speed movements in and out of the parking area. (McCormick Rankin Corporation)

Things to consider

- It is best to properly design and consolidate new driveways.
- Every opportunity should be taken to reduce wide and open accesses and consolidate existing driveways in the vicinity of crosswalks.
- All accesses should be set-back from an intersection crosswalk area of influence.
- It is important to remove or relocate large signs and vegetation on the corners of driveways near crosswalks to provide visibility between drivers and pedestrians.
- Sidewalks should be continuous across an access as per the City's By-Law.

Purpose

- To reduce pedestrian-vehicle conflicts
- To provide a well defined space for pedestrians and vehicles
- To reduce the potential for high-speed or erratic vehicle movements into and out of accesses
- Improve visibility between vehicles and pedestrians at accesses



Converting Traffic Flow to One-way

Typically, converting two-way traffic flow to one-way flow can simplify the crossing task for pedestrians as they only have to concentrate on vehicles traveling in one direction. Despite reducing pedestrian-vehicle conflict risk to some degree, one-way streets tend to have higher operating speeds than two-way streets. Of course, implementing one-way flow must be considered in the context of a larger neighbourhood traffic circulation plan and traffic calming plan.



An example of a pedestrian crossing a multi-lane street with one-way traffic flow. In this situation, pedestrians are only required to look for vehicles travelling in one direction. However, vehicle speeds may increase with the introduction of one-way flow. (www.pedbikeimages.org / Dan Burden)

Things to consider

- One-way flow will restrict access to residences or commercial business to some degree.
- Other speed management and traffic calming measures may be required along with a conversion to one-way flow.
- Will introduce the “multiple threat” conflict for pedestrians crossing a multi-lane one-way street.
- Conversion costs may be high due to the required changes to signal systems, pavement marking changes, signing changes and parking by-law changes.

Purpose

- To reduce potential conflicts between pedestrians and vehicles
- To make it easier for pedestrians to cross the roadway by focusing on vehicles traveling in one direction



Converting Traffic Flow to Two-way

CITY OF OTTAWA

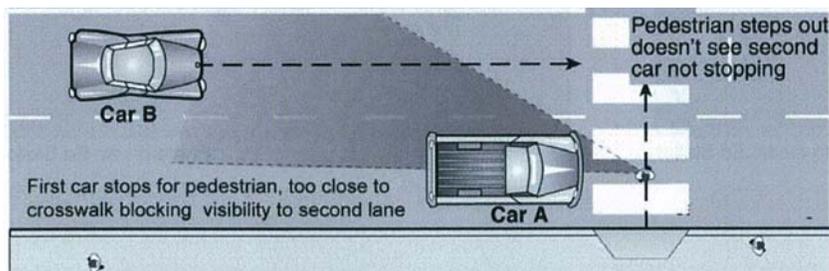
Converting Traffic Flow to Two-way

This is only applicable to roadways that currently have one-way flow. The key benefits are the elimination of the “multiple threat” conflict that exists on multi-lane approaches to a crosswalk on a one-way street, and the reduction of vehicle operating speeds.



The photo at left is an example of two-way flow. (McCormick Rankin Corporation)

The drawing below is an example of the “multiple threat” situation on a multi-lane approach to a crosswalk. This risk would be eliminated by introducing two-way vehicle flow. (ITE Pedestrian Mobility and Safety Audit Guide)



Things to consider

- If the area is part of a coordinated signal system, converting to two-way flow may reduce or eliminate any benefits of the coordination or signal progression.
- Conversion costs may be high due to the required changes to signal systems, pavement marking changes, signing changes and parking by-law changes.

Purpose

- To reduce operating speeds on a one-way street
- To provide better local access to businesses and residences
- To reduce the potential “multiple threat” conflicts that exist for pedestrians on multi-lane approaches to a crosswalk



(www.pedbikeimages.org / Libby Thomas)

6

Traffic Calming / Speed Management



Speed Humps & Tables

CITY OF OTTAWA

Speed Humps & Tables

Speed humps and tables are raised portions of the roadway that are typically installed between intersections as a traffic calming and speed management measure. They should not be confused with a speed bump. Numerous designs for speed humps and tables exist and the length of the ramp sections, length of the flat top, and height can all impact the comfortable speed at which driver can negotiate this feature.



Speed humps and tables are often used to help reduce vehicle speeds in advance of pedestrian crossing areas. (Dan Burden / McCormick Rankin)

Things to consider

- Should be designed to ensure adequate drainage on the street is maintained.
- Include input from local emergency services representatives during the planning and design stages.
- The aesthetics of speed humps and tables can be improved through the use of coloured and texturized pavements and specialized paving materials.
- Not recommended to be installed on a horizontal curve.
- Should be installed as part of a system of traffic calming features.

Purpose

- To reduce vehicle speeds
- To enhance the pedestrian environment at a crosswalk



Midblock Chicanes

CITY OF OTTAWA

Midblock Chicanes



The photos above and at right provide examples of a chicane located between intersections. They require a vehicle to shift laterally and if designed properly will reduce operating speeds. (www.pedbikeimages.com / Dan Burden)

Chicanes are much like midblock chokers, however they are offset to force drivers to shift their driving path. The result is a narrow roadway and slower vehicle speeds. Careful design is required when considering chicanes. If they do not extend out from the curb far enough or have a large space between installations they can be ineffective. Conversely, they should be designed to preserve enough lateral space to permit shared lanes to accommodate cyclists.



Things to consider

- If a chicane is not properly designed it can have a marginal effect on travel speeds.
- Ensure that bicycle lanes, bicycle safety, and proper drainage is adequately addressed at the design stage.
- Include input from local emergency services and road maintenance representatives during the planning and design stages.
- Chicanes may reduce the number of on-street parking spaces.

Purpose

- To reduce vehicle speeds on the approach to an intersection and crosswalk
- To narrow excessively wide midblock areas of streets
- To add additional space along the sidewalk for landscaping or street-scaping



Midblock Chokers

Chokers are curb extensions that narrow a street between intersections. They are categorized as a traffic calming or speed management measure and have the effect of physically narrowing the street width. Chokers can be designed to narrow a two-lane two-way street



to one lane which can have a dramatic effect on operating speeds. They are most appropriate for two-lane two-way streets with low traffic volumes.

An example of a Choker treatment that narrows the roadway yet still allows on-street parking to take place. (www.pedbikeimages.org / Dan Burden)

Things to consider

- If a choker is not properly designed it can have a marginal effect on travel speeds.
- Ensure that bicycle lanes, bicycle safety, and proper drainage is adequately addressed at the design stage.
- Include input from local emergency services and road maintenance representatives during the planning and design stages.
- Chokers may reduce the number of on-street parking spaces.
- Should be installed as part of a system of traffic calming features.

Purpose

- To reduce vehicle speeds on the approach to an intersection and crosswalk
- To narrow excessively wide midblock areas of streets
- To add additional space along the sidewalk for landscaping or street-scaping



Serpentine Street Design

CITY OF OTTAWA

Serpentine Street Design

A serpentine street design refers to the use of a winding street pattern with built-in visual enhancements as well as a physical narrowing of the roadway through a neighbourhood. This should be part of an overall traffic calming and speed management plan to reduce vehicle speeds. A serpentine street design can be part of a streetscaping upgrade or could be implemented during the construction or rehabilitation of a roadway corridor. The opportunities for significant landscaping can be used to create a park-like atmosphere. This particular treatment can be more costly relative to other traffic calming and speed management treatments.



Example of a serpentine street in an urban residential district. (NCHRP 17-18(3) The American Association of State Highway and Transportation Officials Strategic Highway Safety Plan / Cara Seiderman)

Things to consider

- May be more suitable to implement this treatment during a roadway rehabilitation for paving, curb and gutter or utility upgrades.
- Consideration must be given to driveway accesses and locations as well as maintaining sightlines at the driveways.
- Is intended to be part of an overall traffic calming and speed management system.

Purpose

- To physically narrow the roadway and add a horizontal alignment shift to help reduce vehicle speeds
- To change the “look and feel” of the streetscape as part of an overall traffic calming and speed management plan



Woonerf (Street for Living)

In Dutch, a woonerf is a “street for living” and refers to a common space that is created for pedestrians, bicycles and low speed vehicles. They are characterized as narrow streets without curb and gutter, no sidewalks and vehicles are slowed by placing trees and apurtenances in the street. Therefore, this type of treatment is only suitable for low volume, low speed roadways that serve a specific neighbourhood. In some locations where woonerfs have been implemented, drivers are encouraged to travel less than 20km/h and create space for the local residents. A street that has been designed under the woonerf philosophy must be clearly marked so drivers are aware and adjust their driver behaviour.

Things to consider

- A woonerf is not appropriate for roadways facilitating through vehicle travel and where non-residents require access to services.
- The roadway design must keep vehicle speeds very low. This type of treatment is intended to be part of an overall traffic calming and speed management plan.



An example of a streetscape design following the Woonerf principles.
(www.pedbikeimages.org / Dan Burden)



A sign indicating a Woonerf street.
(www.pedbikeimages.org / Charlie Zegeer)

Purpose

- To create a low volume roadway with local accesses
- To create a public space for social and possibly commercial activities



Neighborhood Gateway

CITY OF OTTAWA

Neighbourhood Gateway

A gateway is a physical or geometric landmark that indicates a change in the driving environment for a higher speed roadway to a lower speed roadway. Typically gateways are used to identify neighborhoods and commercial districts within a larger urban setting. They are usually installed with other traffic calming and speed management treatments such as lane narrowing, centre medians, and roundabouts.



Concept of a gateway theme and speed management measures installed on an arterial roadway that bisects a community. (McCormick Rankin Corporation rendering)

Things to consider

- Traffic-slowing effects will depend upon the device chosen and the overall speed management plan for the area.
- Include input from local emergency services and road maintenance representatives during the planning and design stages.

Purpose

- To create an expectation for motorists to drive more slowly and watch for pedestrians when entering a commercial, business, or residential area from a high speed roadway
- To identify a neighbourhood or area



Landscaping and Streetscaping

The use of landscaping treatments along a street can provide separation between motorists and pedestrians, reduce the visual width of the roadway (in turn helping to lower vehicle speeds), and provide a more pleasant street environment. Landscaping can include trees, shrubs, and flowerpots and can be located in the boulevard between the sidewalk and roadway or in the centre median. Plants must not block visibility between pedestrians and motorists.



An example of median and boulevard landscaping in a residential area (www.pedbikeimages.org / Dan Burden)

Things to consider

- Vegetation should not block sightlines (now or in the future) for either drivers or pedestrians.
- Maintenance responsibility should be established between the municipality and land owners.

Purpose

- To enhance the aesthetics of the street environment
- To create a visual narrowing of the roadway in an attempt to slow vehicle speeds



Street Paving Treatments

CITY OF OTTAWA

Street Paving Treatments

The specific type of paving material is important to the function and look of a roadway. This countermeasure is intended as a type of traffic calming or speed management treatment and may include materials such as coloured asphalt, brick pavers or cobblestones. Careful consideration is a must during the planning stages as some materials may be noisy, unsuitable to pedestrians, wheelchairs and bicycles, and may be an issue during winter maintenance. One method of pavement improvement carried out by the City of Ottawa is to utilize high friction asphalt pavements such as microsurfacing to restore skid resistance.



A special paving treatment has been applied on a quiet street in Columbus, Ohio (www.pedbikeimages.org/ Dan Burden).

Things to consider

- The design and maintenance of a specific paving treatment must consider the long term impacts so that the visibility of the crosswalk location is maintained.
- Slippery and bumpy surfaces (i.e. cobblestone) may be suitable for vehicles but not for bicycles and wheelchairs.
- Bumpy or rough surfaces may create adverse road noise which may be undesirable in a residential area.

Purpose

- To send a visual cue about the function of a street
- To clearly define the separate space for pedestrians vehicles and bicycles
- To enhance the aesthetics of the street environment



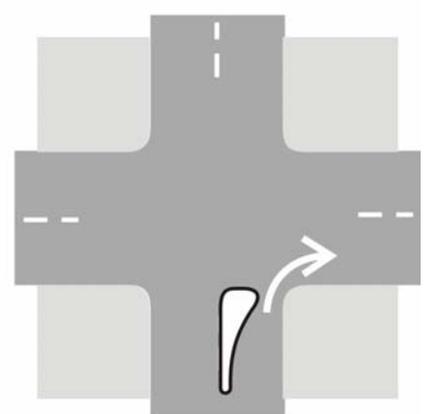
DIAGONAL



STAR



TRUNCATED



FORCED
TURN

(PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System)

7

Traffic Management

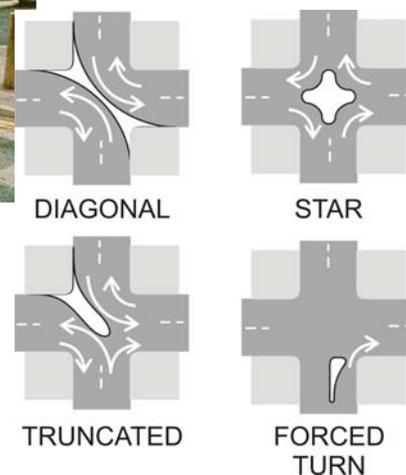


Traffic Diverters

A diverter is an island built in an intersection of two local streets—typically in a residential neighbourhood—to prevent specific vehicle movements. By eliminating some of the vehicle movements at an intersection, this treatment reduces the number of pedestrian-vehicle conflict points. There are four basic types of diverters: diagonal, star, forced turn, and truncated. Diverters must be used in conjunction with other traffic management tools.



The above photo illustrates a diagonal diverter with removable bollards for emergency access. To the right are examples of the four basic types of traffic diverters. (FHWA University Course on Bicycle and Pedestrian Transportation)



Things to consider

- Consider less restrictive traffic management treatments first.
- Planning for diverters requires a detailed evaluation of traffic pattern impacts.
- Diverters are considered to be an intersection treatment and do not generally address mid-block speeding issues.
- Emergency vehicle operations and access should be considered during the planning and design stages

Purpose

- To discourage or prevent traffic from infiltrating or “cutting through” a neighbourhood.
- To minimize the number of pedestrian/vehicle conflict points at a crosswalk



Right-Turn-on-Red Movements

Right-turn-on-red (RTOR) movements at a signalized intersection have long posed safety issues for pedestrians in the crosswalk. Often, drivers do not come to a complete stop or do not notice pedestrians as they look for gaps in the conflicting traffic stream. In addition, drivers may pull forward (waiting to turn right) and block the crosswalk. Careful examination of the impacts of restricting RTOR movements is required as it may increase the number of right-turn-on-green conflicts during concurrent signal phases.



These photos illustrate the signage associated with right-turn-on-red prohibitions in the City of Ottawa. (City of Ottawa)

Things to consider

- Specific time of day restrictions may be more appropriate to implement and additional measures may be required such as a leading pedestrian interval (LPI) or exclusive pedestrian phases.
- Enforcement may be an issue and should be considered prior to implementation.
- Signs should be clearly visible to right-turning drivers stopped in the curb lane at the crosswalk.

Purpose

- To improve pedestrian safety by reducing the number of pedestrian-vehicle conflicts at a signalized crosswalk



Prohibit Vehicle Movements

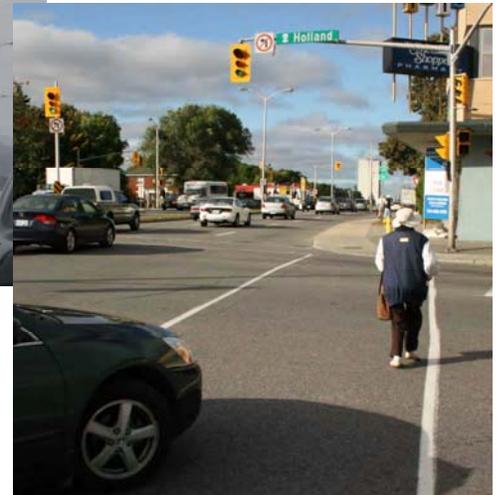
Prohibit Vehicle Movements

This treatment limits the possible turning movements by a vehicle at an intersection in an attempt to reduce the number of pedestrian-vehicle conflicts. Typically, turning movements such as left turns or right turns are restricted. Prohibiting vehicle movements is most appropriately applied to situations where there is a high number of

conflicts between turning vehicles and pedestrians in a crosswalk.



The above intersection is under multiple turn prohibitions at varying times of the day (City of Ottawa). In high pedestrian areas, turn restrictions are useful at reducing pedestrian-vehicle conflicts as well as reducing conflicts between turning and through traffic. The photo at right illustrates one of the potential types of pedestrian-vehicle conflicts that can occur. (McCormick Rankin Corporation)



Things to consider

- Consideration should be given to restricting right-turn-on-red movements (a similar treatment) or specific time of day restrictions instead of a full time restriction.
- The decision to prohibit vehicle movements at an intersection should be carried out as part of an overall neighbourhood traffic pattern review.
- Although bicyclists are defined as a vehicle by the Highway Traffic Act, they are generally exempt from traffic turning movement restrictions.
- Caution should be used in posting turn restriction signs so that they do not contribute to sign clutter (as in the photo above) and can be easily read by drivers.

Purpose

- To restrict vehicle movements and reduce the number of pedestrian-vehicle conflicts at a crosswalk



Partial Closure of an Intersection

Partial Closure of an Intersection

This countermeasure involves the creation of a one-way access to a street. Typically, it is implemented where a local street connects to an arterial roadway and only inbound or outbound movements from the local street are permitted. This could also be referred to as a semi-diverter. A partial street closure eliminates some of the pedestrian-vehicle conflict points and reduces the crossing width for pe-



This is an example of a partial intersection closure that prevents vehicles from entering the street. As a note, the signage illustrated here is not consistent with the practices of the City of Ottawa for this type of treatment. (www.pedbikeimages.org / Dan Burden).

Things to consider

- Will require that emergency services are included in the planning and design stages.
- A traffic pattern impact review will be required to determine the neighbourhood impacts of restricting vehicular movements.
- May not reduce travel speeds approaching intersection but will reduce the pedestrian exposure at the crosswalk.
- Consideration should be given to bicycle movements at the intersection and where possible, two-way bicycle flow should be maintained.

Purpose

- To reduce the number of pedestrian-vehicle conflict points for a particular approach to an intersection
- To reduce the crossing distance and exposure of pedestrians at a particular crosswalk



Closing an Intersection Leg

Closing an approach to an intersection typically involves converting a 4-leg intersection to a 3-leg intersection—creating a cul-de-sac. This particular countermeasure can be applied as a traffic calming and speed management measure, a traffic management measure or a means to eliminate the pedestrian-vehicle conflicts on a particular approach to an intersection. A full street closure is more appropriate for a local street.



In this example, one leg of the intersection has been converted to a pedestrian-only space. (McCormick Rankin Corporation)

Things to consider

- Will require that emergency services are included in the planning and design stages.
- A traffic pattern impact review will be required to determine the neighbourhood impacts of creating a cul-de-sac.
- Ensure that adequate access (i.e. sidewalk or trail) is provided for pedestrians crossing the street closure area.

Purpose

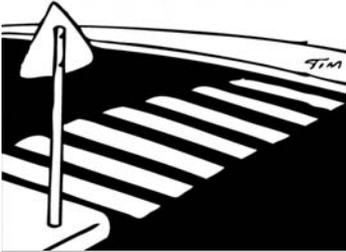
- Completely eliminates traffic access to a street
- To eliminate the conflicts between pedestrians and vehicles on one approach to an intersection.



(www.pedbikeimages.org / Dan Burden)

8

Maintenance / Awareness /
Education / Enforcement



Red Light Cameras

Red Light Cameras

Red light cameras are installed at signalized intersections and are intended as a form of enforcement. Drivers that violate the red light indication on a traffic signal and proceed through the intersection will be photographed and a citation

will be issued. Over time, this benefits pedestrians crossing the roadway by reducing the number of vehicles that violate the red light indication.



Red light cameras can be an effective means of reducing pedestrian collisions by improving vehicle compliance to traffic signals. (City of Ottawa / McCormick Rankin Corporation)

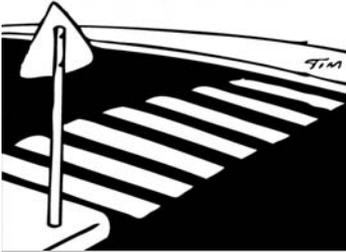


Things to consider

- An education and media awareness campaign should precede the installation and use of red light cameras in a jurisdiction
- Red light cameras will be most effective at signalized intersections where there is a history of red light violations by drivers.
- Although red light cameras may reduce higher severity collisions (such as right angle) they may contribute to increased rear-end collisions.

Purpose

- To enforce red light violations and help reduce the safety risks for pedestrians



Speed Monitoring Radar Sign

A speed monitoring radar sign is basically a sign board that can either be mounted on a trailer or the ground and displays the speed of a passing vehicle. They can be used by police departments and departments of public works for enforcement purposes. Speed monitoring radar signs can also be used in conjunction with neighbourhood speed awareness and education programs. Speed trailers are a temporary or periodic treatment to supplement a traffic calming and speed management system.



Two examples of how a mobile speed trailer is used to help with education and enforcement by indicating drivers' current speed in relation to the posted speed limit. (City of Ottawa)

Things to consider

- Occasional police enforcement is needed to supplement the speed monitoring radar sign.
- Speed monitoring radar signs should be used as part of a traffic calming and speed management system.
- Their placement should not block sightlines between pedestrians, drivers and other signage or traffic control devices.

Purpose

- To enhance enforcement efforts and help reduce vehicle speed on the approach to a crosswalk



Enforcement

Police enforcement is a key component in preserving right-of-way compliance for all modes of travel and helps to decrease safety risks for pedestrians. There is a number of actions road agencies can take to implement enforcement campaigns designed to protect pedestrians. These include increased police presence around school zones, neighbourhoods, and other areas with high pedestrian activity. In addition, mass media campaigns can be used to make the public aware of upcoming enforcement operations and help establish better driving behaviour.



Increased patrols and the issuance of warnings or fines can be an effective means of improving compliance at crosswalks. (www.pedbikeimages.org/ Dan Burden)

Things to consider

- Enforcement operations should begin with warnings and flyers before moving to issuing citations for violations.
- Enforcement efforts should be conducted with the help of staff support and awareness of the courts.

Purpose

- To increase driver-awareness of the need to share the roadway
- To reduce pedestrian-related collisions



School Crossing Guard

CITY OF OTTAWA

School Crossing Guard

A variety of roadway improvements may be used to enhance the safety and mobility of children in school zones. The use of well trained adult crossing guards has been found to be one of the most effective measures for assisting children in crossing streets safely. Adult crossing guards require training and monitoring and should be equipped with a bright and reflective safety vest and a STOP sign paddle. Periodic police enforcement in school zones may be required where high speeds and non-compliance is an issue.



Example of an adult crossing guard with a STOP sign paddle at a school zone crosswalk. (City of West Jordan, Utah www.wjordan.com)

Things to consider

- Implementation will require discussions between the municipality, the school board and the neighbourhood association.
- This treatment should be part of a larger education campaign and Safe Routes to School community program.

Purpose

- To provide enhanced crosswalk safety in the vicinity of schools



Designate School Pick-up/ Drop-off Areas

CITY OF OTTAWA

Designate School Pick-up/ Drop-off Areas

Many schools are experiencing increased numbers of parents dropping off and picking up children in their cars and the school access and adjacent street were likely not designed to accommodate the increased traffic. This can be of particular concern when cars are stopping adjacent or near crosswalk locations. To mitigate the concern, clearly defined pick-up/drop-off areas must be established away from crosswalk locations. An operational and road safety review



will be required to identify problem areas and make recommendations to minimize pedestrian/child exposure and conflicts.

Lack of adequate pick-up / drop-off provisions can lead to school children crossing the street at undesirable locations, such as the above high-volume street.
(www.pedbikeimages.org / Nina Walfoort)

Things to consider

- Clear separation between crosswalk locations, bus zones and parent pick-up/drop-off areas is required.
- This treatment should be part of a larger education campaign and Safe Routes to School community program.

Purpose

- To provide enhanced crosswalk safety in the vicinity of schools



Crosswalk Marking Maintenance

The pavement markings that define a crosswalk are critical to identifying the preferred crossing location and to warn drivers that pedestrians may be crossing. Over time, the crosswalk pavement markings deteriorate. A regular painting program should be in place to ensure the markings are visible by day and retro-reflective in low light conditions. Consideration should be given to alternative materials such as durable pavement markings like thermoplastic or in-lay tape. Both are highly retro-reflective and less slippery than conventional marking paint.



In the above photo, the deteriorated pavement markings make it difficult for drivers to detect its presence. (www.pedbikeimages.org / Dan Burden)

Things to consider

- Crosswalk markings alone are unlikely to reduce pedestrian safety risks. Ideally, crosswalks should be used in conjunction with other measures (i.e. as curb extensions) particularly on high volume, multi-lane roadways.
- Coordination is required between the maintenance and road safety groups within a road agency to ensure that the crosswalk pavement markings are regularly maintained.

Purpose

- To ensure that the location of the crosswalk is visible to drivers during both day and night



CITY OF OTTAWA Sidewalk and Crosswalk Maintenance

Sidewalk and Crosswalk Maintenance

Sidewalk and crosswalk maintenance is an important component to pedestrian safety. If pavements or concrete sidewalks settle, it is difficult for some pedestrians to use the facility and may increase their risks. Poor drainage at an intersection and crosswalk area can interfere with driver and pedestrian care as they traverse the intersection. In the case of pedestrians, standing water may cause pedestrians to walk outside of the crosswalk or the water can freeze during winter and become slippery. Standing water in the intersection area is a hazard for drivers as well. Poor pavement conditions such as wheel rutting, settled pavement or deteriorated curb and gutter can all contribute to poor drainage.



An example of deteriorated pavement and concrete surfaces is shown at left. The result of poor maintenance is shown above where standing water is located in the crosswalk. These types of conditions can be a hazard to pedestrians and increases agency liability. (www.pedbikeimages.org / Dan Burden / McCormick Rankin Corporation)

Things to consider

- Any planned upgrades to an intersection to remediate deteriorated infrastructure should be reviewed from a road safety perspective to incorporate road safety measures at that time.
- Regular reviews of maintenance policies should be undertaken to ensure that the policies are appropriate for the resources allocated to their implementation.

Purpose

- To ensure that the sidewalk and crosswalk area is free of standing water, ice, or tripping hazards



Snow and Vegetation Removal

Adequate sightlines should be maintained at all corners of an intersection so signs, signals, pedestrians and oncoming vehicles are visible. Vegetation and snow banks are the most easily remedied obstructions and their removal can be carried out as part of a regular maintenance program. Failure to provide visible and conspicuous information to the driver in a timely and appropriate manner will compromise the safety performance of an intersection and crosswalk.



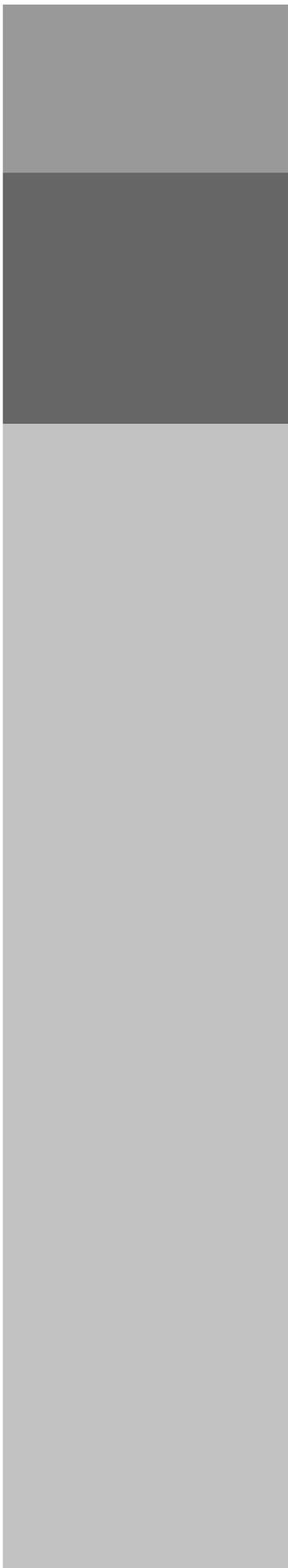
In the example above a sign blocks the driver's ability to see pedestrians crossing at the crosswalk. The example at left illustrates the sightline limitations to the crosswalk due to vegetation. Both of these obstacles are located at the same crosswalk and are relatively inexpensive to remedy. (McCormick Rankin Corporation)

Things to consider

- Adequate space at the corners of the intersection are required to store snow. If space is not available the snow should be removed and transported to another location.
- Vegetation at the corners of intersections should require low maintenance and should not grow to a height that restricts the visibility of small children.
- Where appropriate consultation with the City's By-Law Enforcement and Fence By-Law groups should be carried out.

Purpose

- To ensure that sightlines at the crosswalk are maintained
- To ensure crosswalks and sidewalks are accessible by providing improved/enhanced snow and ice removal techniques



9

Implementation Costs

Implementation Costs

The estimated costs in the Table on the following page include the implementation or installation for each of the countermeasures found in this handbook and are only intended to provide general guidance to the user. These costs do not include ongoing maintenance costs. The following cost structure was used to categorize each countermeasure:

- **Low cost (\$):** Often general maintenance activities such as signage and minor roadway upgrades that can be accomplished for less than **\$10,000**.
- **Medium Cost (\$\$):** Localized intersection widening, lighting or traffic signal installation can usually be achieved within a budget of **\$250,000** per item. However, a combination of these activities would likely cost more than **\$250,000**.
- **High Cost (\$\$\$):** Items such as physical road narrowing or roundabouts would fall into the high cost category which was defined as having a cost of more than **\$250,000**.

Pedestrian Intersection Safety Countermeasure Handbook

			Implementation
Category	Number	Handbook Countermeasure	Cost Estimate
Signals & signs	2.1	Install a Traffic Signal	\$\$
	2.2	Pedestrian Signals	\$
	2.3	Supplementary Pedestrian Signals	\$
	2.4	Increased Walking Time	\$
	2.5	Pedestrian Signal Timing	\$
	2.6	Two-stage Signalized Crossing	\$\$
	2.7	Push Button Location & Signage	\$
	2.8	Accessible Pedestrian Signals	\$\$
	2.9	Automatic Pedestrian Detection	\$\$
	2.10	Advance Left Turn Phase	\$
	2.11	Crosswalk Signage	\$
	2.12	Supplementary School Signage	\$
	2.13	Pedestrian Half Signal	\$\$
Pedestrian facility design	3.1	Raised Pedestrian Crosswalk	\$\$
	3.2	Texturized Crosswalk Material	\$\$
	3.3	Enhanced Crosswalk Pavement Markings	\$
	3.4	Advance Markings at Crosswalks	\$
	3.5	Enhance Illumination at Crosswalks	\$\$
	3.6	Curb Extensions / Bulb-outs	\$\$
	3.7	Raised Medians	\$\$
	3.8	Prohibition of Pedestrian Crossings	\$
	3.9	Adequate Pedestrian Waiting Areas	\$ / \$\$
	3.10	Sidewalk Continuity	\$\$
	3.11	Mountable Curb Ramps	\$
Intersection design	4.1	Mini Roundabout	\$\$\$
	4.2	Modern Roundabout	\$\$\$
	4.3	Raised Intersection	\$\$\$
	4.4	Reduce Curb Radius	\$\$
	4.5	Right Turn Lane Channelized Island	\$\$
	4.6	Improve Right Turn Slip Lane Design	\$\$
	4.7	Remove Sightline Obstructions	\$
Roadway design	5.1	Transit Stop Relocation	\$
	5.2	Reduce Lane Widths	\$ / \$\$
	5.3	Lane Reductions	\$\$
	5.4	Bicycle Lanes	\$ / \$\$
	5.5	On-street Parking	\$
	5.6	Access Management	\$\$
	5.8	Converting Traffic Flow to One-way	\$\$
	5.7	Converting Traffic Flow to Two-way	\$\$
Traffic calming / speed management	6.1	Speed humps and Speed Tables	\$\$
	6.2	Midblock Chicanes	\$\$
	6.3	Midblock Chokers	\$\$
	6.4	Serpentine Street	\$\$\$
	6.5	Woonerf (Street for Living)	\$\$\$
	6.6	Neighbourhood Gateway	\$ / \$\$
	6.7	Landscaping and Streetscaping	\$\$\$
	6.8	Street Paving Treatments	\$\$\$
Traffic management	7.1	Traffic Diverters	\$\$
	7.2	Right-Turn-On-Red Movements	\$
	7.3	Prohibit Vehicle Movements	\$
	7.4	Partial Closure of an Intersection	\$
	7.5	Closing an Intersection Leg	\$\$
Maintenance / awareness / education / enforcement	8.1	Red Light Cameras	\$\$
	8.2	Speed Monitoring Radar Sign	\$\$
	8.3	Enforcement	\$\$
	8.4	School Crossing Guard	\$\$
	8.5	Designate School Pick-up / Drop-off Areas	\$\$
	8.6	Crosswalk Marking Maintenance	\$
	8.7	Sidewalk and Crosswalk Maintenance	\$
	8.8	Snow and Vegetation Removal	\$



10

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City of Ottawa



Prepared by:



Purdy's Wharf Tower II, Suite 1711
1969 Upper Water Street
Halifax, NS
BJ3 3R7

Phone: 902-425-4466
Fax: 902-425-4433
E-mail: ras@delphimrc.com

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