Municipal Technical Advisory Service
INSTITUTE FOR PUBLIC SERVICE

August 18, 2016

City of Brentwood, Tennessee
Mr. Kirk Bednar
City Manager
5211 Maryland Way
P. O. Box 788
Brentwood, Tennessee 37024

VIA ELECTRONIC MAIL

Dear Mr. Bednar:

In response to your request for information on mid-block pedestrian crossing policies and guidelines, the following information is enclosed:

- Pedestrian Crossing Treatment Installation Guidelines – Boulder Colorado
- Policy and Standards for Pedestrian Crossings – Columbia Missouri
- Pedestrian Crossing Treatment Guidelines – Longmont Colorado
- Marked Crosswalk Criteria at Uncontrolled Locations –San Diego California
- Pedestrian Transportation, Midblock Crossing – Federal Highway Administration
- Guidelines for the Installation of Marked Crosswalks – Virginia Department of Transportation

Please let me know if you require further assistance on this matter.

Very truly yours,

Jeffrey J. Broughton
Municipal Management Consultant

City of Boulder

Pedestrian Crossing Treatment Installation Guidelines

November 2011

Prepared for:
City of Boulder Transportation Division
P.O. Box 791
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FOX TUTTLE

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TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

APPENDIX

Executive Summary

Providing safe and efficient pedestrian facilities is a long-established goal of the City of Boulder. Pedestrian facilities are of particular importance as we try to reduce our dependency on the automobile. The decision to travel as a pedestrian is in part subject to the pedestrian's ability and perceived ability to safely and efficiently cross roadways along the travel route. With this in mind, the City of Boulder has established this document to provide a set of criteria, procedures, and policies to guide the installation of crossing treatments. This document, intended to replace the City of Boulder Pedestrian Crossing Treatment Warrants implemented in 1996, incorporates data collected both for the previous document and recently collected for this effort. Specifically, this document summarizes:

- Proposed pedestrian crossing criteria and procedures for evaluating the need for crossing treatments, including a "flowchart" approach
- Specific pedestrian crossing treatments that may be applicable for a particular set of pedestrian volumes, pedestrian types, vehicular volumes, vehicular speeds, and roadway geometry.

When Boulder's original Pedestrian Crossing Treatment Warrants were developed in 1996, there were relatively few studies available at the federal, state, and municipal levels with respect to the installation of crosswalks and other crossing treatments. Over the past few years more studies have been published which assist in the formulation of specific local policies. However, national standards still provide little guidance for the installation of marked crosswalks and treatments, particularly at mid-block locations. Crosswalks and other crossing treatments are typically installed based on engineering judgment. Key issues, such as the circumstances in which a crosswalk should be installed, how much safety benefit crosswalks provide, and the application of various crossing enhancements are still commonly debated topics.

Information recently published by the Federal Highways Administration (FHWA) (Zegeer et al)[1] suggests that on two-lane roadways, marked crosswalks alone at uncontrolled locations have no effect on pedestrian accident rates. The FHWA study goes on to suggest that, on higher volume, multi-lane roadways, marked crosswalks alone (without any other treatments) are associated with higher vehicle-pedestrian accidents rates compared to unmarked locations.

Over the past fourteen years, the City of Boulder has undertaken an extensive evaluation of the effectiveness and safety of various treatments being tested at crossing locations in the City. The City has installed demonstration devices at nearly 40 locations including two-lane and multi-lane crossings. These treatments have included enhanced crosswalk signing, pedestrian-actuated flashing signs, raised crossings on right-turn bypass islands, and other devices. This evaluation has shown that while these devices most often result in a significant increase in driver compliance (yielding to crossing pedestrians) at crosswalks, some of these devices may lead to higher vehicle-vehicle and vehicle-pedestrian accidents at multi-lane, high pedestrian/vehicle volume locations. The results of the data collection to date have been incorporated into these guidelines, though the City of Boulder will continue to evaluate these and other treatments and may make changes to the guidelines over time.

The Pedestrian Crossing Treatment Installation Guidelines are intended to provide a consistent procedure for considering the installation of crossing treatments where needed on a case-by-case basis in the City of Boulder. Implementation of crossing treatments will require funds that could potentially have been spent on other transportation system improvements, and, therefore, must be considered carefully in the funding allocation process.

1.0 DEFINITIONS

This section includes the definitions of some of the common technical terms used in this document.

Average Daily Traffic (ADT)
The amount of vehicular traffic that crosses an imaginary line across a roadway in a 24-hour period. ADT information typically includes both directions of vehicle travel (if on a two-way street).

Controlled Pedestrian Crossing
A pedestrian crossing where motorists are required to stop by either a stop sign or traffic signal (including a HAWK beacon)

Crosswalk Lighting
Street lighting applied at a pedestrian crossing to help approaching motorists see a crossing pedestrian. Crosswalk lighting is at a "vehicular scale" like normal street lighting rather than a "pedestrian scale" that is often used along a sidewalk.

Curb Extensions
A roadway edge treatment where a curbline is bulged out toward the middle of the roadway to narrow the width of the street. Curb extensions are sometimes call "neckdowns", and are often used at the location of a pedestrian crosswalk to minimize the distance and time that a crossing pedestrian must be in the roadway.

Differential Vehicle Queuing
See also Vehicle Queue. A condition on a roadway with two or more travel lanes in a single direction where the line of stopped traffic in one travel lane is significantly longer than the line of stopped traffic in the adjacent travel lane. Differential vehicle queuing across a pedestrian crosswalk can cause a significant safety concern as it increased the potential for "multiple threat" pedestrian accidents.

Gap in Traffic
A gap in traffic is the space between vehicles approaching the pedestrian crossing. Gaps are typically measured in seconds, not distance, as it is the length of the gap in time that a pedestrian must be able to cross in. A directional gap is the gap between vehicles approaching in a single direction. A directional gap can be measured between vehicles in a single lane, or between vehicles approaching in the same direction but in different lanes on a multi-lane approach. If there is no median refuge at the crossing, a pedestrian will need to find an acceptable gap in traffic approaching from two directions at once. This is much more challenging than finding a gap in each approach direction separately.

HAWK Beacon
A pedestrian hybrid beacon is a relatively new type of crossing treatment used to both warn and control traffic at a pedestrian crossing. It actuated by a pedestrian push button, and uses a combination of circular yellow and red traffic signal displays to first warn motorists of a

pedestrian that is about to cross the street, then require the motorist to stop for the pedestrian crossing, and then release the motorist to proceed once the pedestrian has cleared the crossing. The Beacon is a hybrid between a pedestrian traffic signal and a stop sign.

Lane
A portion of the roadway surface designated for motor vehicle travel, typically in a single directions, that is delineated by pavement marking stripes. Types of lanes include: "through lanes" for travel along the length of the roadway, often through intersections; "turn lanes" which are typically on intersection approaches and provide space for left or right turning motorists; "bike lanes" which are designated for bicycle travel in the same direction as the automobile travel, are typically narrower than vehicle lanes, and are usually located along the outside edges of the roadway.

Marked Crosswalk
A pedestrian crossing that is delineated by white crosswalk pavement markings. Marked crosswalks typically also are delineated by a variety of traffic signs. Marked crosswalks would also have curb ramps if there is curb and gutter in an area.

Median Refuge
An area in the middle of a roadway where a crossing pedestrian can take shelter from approaching traffic in either direction. In the context of these guidelines, the median refuge must include a raised median of some width (see Section 2.2.4 for a description of types of median refuges). A median refuge allows a pedestrian to cross each direction of approaching traffic in a separate step. By using the refuge, the pedestrian must only find an acceptable gap in traffic for one approach direction at a time.

Minimum Pedestrian Volume Threshold
The minimum amount of pedestrian crossing traffic (typically in a one hour period) that must be present to "warrant" the installation of a pedestrian crossing treatment. See Section 2.2.3.

Motorist Compliance Data
Observations made and recorded at a pedestrian crossing where it is determined if the approaching motorist complied with their legal requirement to yield to a crossing pedestrian who is in or about to enter the crosswalk.

Multiple Threat Accidents
A type of pedestrian accident that occurs on a roadway with two or more lanes in the same direction. A motorist that stops for a crossing pedestrian can obscure the view of the pedestrian from another motorist approaching in the adjacent travel lane. If the second motorist does not slow down it creates the potential for a crossing pedestrian to step out in front of a high speed approach vehicle with potentially dire consequences.

Multi-Use Path Crossing
A location where a sidewalk designated as a multi-use path intersects a roadway at-grade, and the path extends on both sides of the roadway.

Neckdowns
See Curb Extensions

Pedestrian Traffic Signal
A conventional traffic signal with circular red, yellow, and green displays for motorists and Walk/Don't Walk signals for pedestrians that is applied at a pedestrian crossing. Typically a pedestrian signal would be applied in a mid-block location since it would be considered a normal intersection related traffic signal if it were to be applied at an intersection.

Raised Median
An area in the middle of a roadway, commonly separating vehicles traveling in opposite directions, that is surrounded by curb and gutter and is physically raised above the surrounding pavement where vehicles travel. Raised medians often contain landscaped areas. See also Median Refuge.

Rectangular Rapid Flash Beacons (RRFBs)
RRFBs are small rectangular yellow flashing lights that are deployed with pedestrian crossing warning signs. They are typically actuated by a pedestrian push button and flash for a predetermined amount of time, to allow a pedestrian to cross the roadway, before going dark. RRFBs are warning devices and do not themselves create a legal requirement for a vehicle to stop when they are flashing. Boulder's pedestrian actuated flashing signs are an example of RRFBs.

School Crossing
School Crossing defined as a crossing location where ten or more student pedestrians per hour are crossing

Uncontrolled Pedestrian Crossing
An established pedestrian crossing that does not include a traffic signal, a HAWK beacon, or a stop sign that requires motor vehicles to stop before entering the crosswalk. For example, Boulder's crosswalks with signs and/or pedestrian actuated flashing yellow lights are considered "uncontrolled".

Vehicle Queue
A line of stopped vehicles in a single travel lane, commonly caused by traffic control at an intersection.

2.0 CROSSING LOCATION EVALUATION PROCEDURES AND CONSIDERATIONS

2.1 Evaluation Steps

Evaluation of an individual crossing location for potential crossing treatments in the City of Boulder should include the following four basic steps:

Step 1: Identification and Description of Crossing Location

Step 2: Physical Data Collection

Step 3: Traffic Data Collection and Operational Observations

Step 4: Apply Data to Figure 1, Table 1, and Figure 2 to Determine Appropriate Treatments

The Crossing Location Evaluation Worksheet is included on the following page which will guide staff through these steps. A detailed discussion of each of these procedures is provided in the following text.

Step 1: Identification and Description of Crossing Location

a) Identify the pedestrian crossing location including the major street and specific location of the crossing (i.e.: cross-street, street address, intersection path or trail, etc.).

b) Determine if the crossing location connects both ends of a multi-use path. If it does, the minimum pedestrian volume requirements are not required to be met to apply the treatments prescribed in Table 1 (see the policy discussion in Section 2.4 for more information).

c) Note the posted speed along the major street at the crossing location.

d) Identify the existing traffic control (if any) and any existing crossing treatments (signs, markings, or physical treatments), street lighting, and curb ramps.

Step 2: Physical Data Collection

a) Determine the existing roadway configuration including the number of lanes and the presence of painted or raised medians at the crossing location.

b) Identify the nearest marked or protected crossing and measure the distance to this crossing.

c) Measure the stopping sight distance (SSD) on all vehicular approaches to the crossing. If the SSD is less than eight times (8x) the posted speed limit (in feet), determine if

improvements (such as removal of obstructions) and/or lowering of the posted speed limit are feasible means to mitigate the inadequate SSD.

Step 3: Traffic Data Collection and Operational Observations

a) Gather or collect pedestrian crossing volumes during the peak hours of use. This will typically involve AM, mid-day, and PM peak hours. Locations near schools may only require two hours of data collection (AM and PM peak hours corresponding to school opening and closing times). All pedestrian volumes should include and differentiate between pedestrians and bicyclists and should note separately the number of young, elderly, and/or disabled pedestrians. For locations where school crossing traffic is anticipated, the volume of student pedestrians (school age pedestrians on their way to/from school) should also be separately noted.

   Whenever possible, pedestrian and bicycle volumes should be collected during warm-weather months (May through September) and during fair weather conditions to represent peak crossing activity (i.e.: no snow, rain, or high winds). Counts should be scheduled to coincide with events such as “walking Wednesdays” if appropriate, and at a time when nearby businesses are open. If school traffic is an issue, the counts should be scheduled on school days when classes are in session. Given the potential fluctuation in pedestrian traffic from day to day, it may be necessary to collect up to three days of data (use additional Crossing Location Evaluation Worksheets as needed) to determine if an enhanced pedestrian crossing treatment is warranted as follows:

   - Collect pedestrian data on day one. If the minimum pedestrian volume threshold (see Figure 1) is exceeded, no further pedestrian data collection is needed. If the threshold has not been exceeded, but at least 50% of the minimum pedestrian volume was observed, proceed to a second day of data collection.

   - Collect pedestrian data on day two. If the minimum pedestrian volume threshold is exceeded, no further pedestrian data collection is needed. If the threshold has not been met but again the volume is at least 50% of the minimum threshold, proceed to a third day of data collection.

   - Collect pedestrian data on day three. If the minimum pedestrian volume still has not been met, then no marked pedestrian crossing treatment is warranted by pedestrian crossing volume.

b) Gather or collect hourly and average daily traffic (ADT) volumes for automobile traffic along the major roadway at the crossing location. A one day sample should be adequate, with hourly volumes collected during the same hour as the pedestrian crossing volumes. [Note: City Staff is currently evaluating the benefit of including vehicle gap and/or pedestrian delay data collection to this step]

c) Due to the potential for vehicular traffic queues to impact safety at the crossings, the presence of queues extending from downstream signals or intersections back into the crossing location should be observed, as well as any "differential" queuing that may occur on a lane to lane basis. While collecting automobile traffic data, the formation of

vehicle queues from adjacent intersections should be noted. If one or both directional queues reaches back to the crossing location, the number of times per hour that it reaches the crossing location should be noted and the maximum queue length should also be recorded. If there is more than one through lane in each direction, it should be noted if the queues reaching back to the crossing are approximately the same length in each lane, or is there a significant differences in the length of the queues in each lane. If the queues are routinely of different length as they extend beyond the crossing location, notes should be made as to the potential cause of the differential queuing.

Step 4: Apply Data to Figure 1, Table 1, and Figure 2 to Determine Appropriate Treatments

a) Using the available data, utilize *Figure 1 – Pedestrian Crossing Treatment Flowchart* and *Table 1 – Criteria for Crossing Treatments at Uncontrolled Locations* (if applicable) to determine appropriate treatment(s) for signalized, stop-controlled, or uncontrolled locations. Also consider and incorporate the information in Section 2.2 and in Figure 2 as appropriate.

2.2 Additional Evaluation Considerations

The following information should be considered by the user of these guidelines when determining the appropriate pedestrian crossing treatment:

2.2.1 Types of Crossing Treatments at Uncontrolled Locations

(See also Table 1)

Table 1 identifies six primary types of uncontrolled crossing treatments for consideration depending on the physical roadway conditions, vehicle volume, pedestrian volume at the potential crossing location, etc. The crossing types are as follows:

Crossing Type A:

- Marked crosswalk
- "State Law – Yield to Pedestrians" signs mounted on the side of the roadway at the crossing, with diagonal down arrow placards (W16-7P)
- standard advance pedestrian warning signs (W11-2) mounted in advance of the crossing
- If the location is a school crossing then standard S1-1 signs should be used

Crossing Type B:

- Same as Type A above, plus
- "State Law – Yield to Pedestrians – Within Crosswalk" signs (R1-6) mounted on flexible bollards on the centerline (if no median present) or mounted on sign posts in the median, if median is present

Crossing Type C:

- Same as Type B above plus
- Add neckdowns (curb extensions) and median refuge island to shorten the pedestrian crossing distance and increase the visibility of pedestrians to approaching motorists

Crossing Type D:

- Marked crosswalk
- Median refuge island [Note: If a median refuge can not be constructed on a 2-way street then go to Crossing Type F]
- "State Law – Yield to Pedestrians" signs mounted on the side of the roadway and in the median at the crossing, with diagonal down arrow placards (W16-7P)
- Pedestrian actuated Rectangular Rapid Flash Beacons (RRFBs) mounted with the "State Law…." Signs
- standard advance pedestrian warning signs (W11-2) mounted in advance of the crossing
- If there are 2 approach lanes in a single direction install advance yield lines and "Yield Here To Pedestrians" (R1-5) signs
- If the location is a school crossing then standard S1-1 signs should be used
- Consider adding curb extensions if on-street parking exists and storm drainage can be accommodated
- [Note: If pedestrian volume falls above the RRFB limit line on Figure 2, go to Crossing Type F]

Crossing Type E:

- Where speed limit is initially greater than or equal to 45 miles per hour
- Determine if the speed limit can be effectively reduced to 40 mph AND a raised median refuge island can be installed
- If so, go to Crossing Type D
- If not, go to Crossing Type F

Crossing Type F:

- Crossing has 3 or more through lanes in a given direction or is otherwise not suitable for an uncontrolled marked crosswalk
- Consider HAWK beacon, pedestrian traffic signal, or grade-separated pedestrian crossing
- Refer to Figure 2 when considering crossing treatment type
- Must consider corridor signal progression, grades, physical constraints, and other engineering factors

In Table 1 there are two columns that list:

- # or lanes crossed to reach a refuge
- # of "multiple threat" lanes per crossing

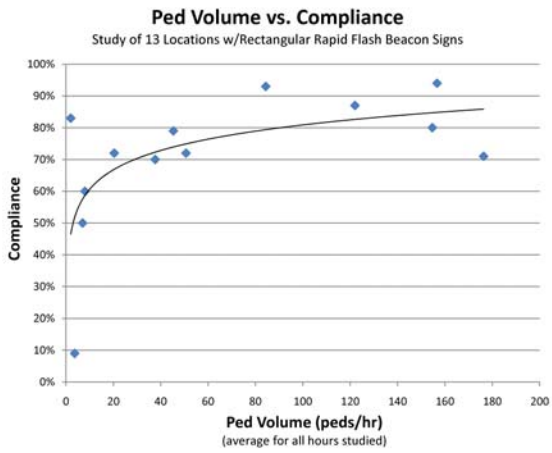
This information does not directly play in to the use of Table 1, but they do provide important context for the user as they help distinguish the crossing types and support the difference in recommended crossing treatments. These topics are discussed in more detail below.

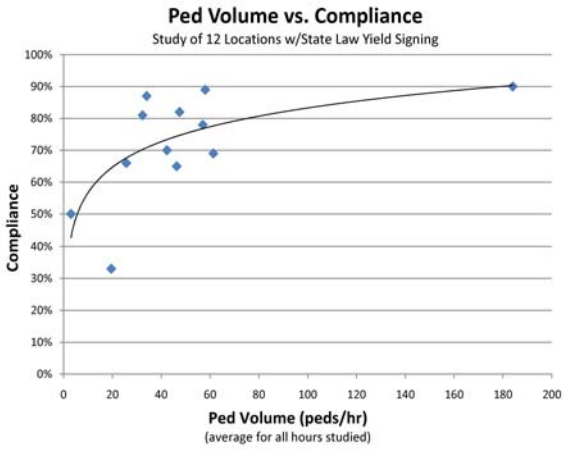
2.2.2 Minimum Vehicle Volume For Treatments

Recognizing the limited availability of resources to implement crossing treatments within the City, crossing treatments should generally not be installed at locations where the ADT is lower than 1,500 vehicles per day. Exceptions may be made at school crossing locations where the peak hour vehicle traffic exceeds 10% of the ADT. School crossings are defined as locations where 10 or more student pedestrians are crossing per hour. Treatments for roadways with greater than 1,500 vehicles per day should be installed based on the criteria in Figure 1, Table 1, and the information in Figure 2 (a or b depending on the speed limit).

2.2.3 Minimum Pedestrian Volume for Treatments at Uncontrolled Crossing Locations

The City of Boulder has evaluated crosswalk enhancements at uncontrolled crossing locations over the years and has determined that there is a clear relationship between driver compliance (yielding) and the pedestrian and/or bicycle crossing volume. Data collected at Boulder crosswalks where rectangular rapid flash beacon signs (RRFB) or State Law-Yield signs were installed shows that driver compliance typically increases with higher crossing volumes. It is theorized that the primary reason for this relationship is that drivers tend to ignore enhanced crossing treatments over time at locations where they infrequently see pedestrians crossing. The following graphs illustrate this relationship:





The above data also illustrates that, below roughly 20 pedestrians per hour, driver compliance decreases significantly. Thus, the base threshold for consideration of an enhanced crossing treatment at an uncontrolled location is 20 pedestrians per hour. This threshold is consistent with recent national guidance and policies adopted by other states and cities, as determined through literature research.

The Minimum Pedestrian Volume Thresholds are as follows:

- 20 peds per hour* in any one hour, or
- 18 peds per hour* in any two hours, or
- 15 peds per hour* in any three hours
- 10 school aged pedestrians traveling to/from school in any one hour

* Young, elderly, and disabled pedestrians count 2x towards volume thresholds
** School Crossing defined as a crossing location where ten or more student pedestrians per hour are crossing

2.2.4 Definition of a Pedestrian Median Refuge and Minimum Median Refuge Width

A pedestrian refuge median is a useful tool in increasing the safety and efficiency of a pedestrian crossing, and the presence (or not) of a median refuge will influence the type of pedestrian crossing treatment that can be considered (see Table 1). In this context a pedestrian refuge median is defined as a location in the middle of a pedestrian crossing where a pedestrian can take refuge, thereby separating their crossing into two steps, across each direction of approaching traffic separately. Separating the crossing into two directional crossings greatly increases the number of acceptable gaps for pedestrians to safely cross a roadway. A pedestrian refuge must include some type of raised median as described below:

- A painted center median or a painted turn lane can never be considered a pedestrian refuge.

- A raised median nose at an intersection (next to a left turn bay for example) can only be considered a pedestrian refuge for the adjacent crosswalk if the median is at least 4 feet wide AND the left turn volume is less than 20 vehicles per hour. This low left turn volume means that during most pedestrian crossings there will not be a vehicle in the left turn lane and the pedestrian will be "shadowed" by the width of the median and the adjacent turn lane as they cross the street.

- A raised median at a mid-block pedestrian crossing can only be considered as a refuge if it is at least 6 feet wide (preferably 8 feet wide) and includes curb ramps or a walkway at grade through the median. A median of this width will allow over two feet on each side for splash protection; it will store a group of pedestrians; and it will accommodate the storage of a bicycle without it overhanging into the traffic lanes. For multi-use path crossing locations, a 10' median refuge width is desirable to better accommodate bicycles with child trailers, recumbent bicycles, and tandem bicycles.

2.2.5 Distance to Nearest Marked or Protected Crossing

The Pedestrian Crossing Treatment Flowchart in Figure 1 includes consideration of spacing criteria for an uncontrolled crossing to the nearest marked or projected crossing. The flowchart requires that a new uncontrolled mid-block crossing be at least 300 feet from the nearest crossing. However, the flowchart allows this spacing criteria to be waived if the proposed crossing serves a multi-use path, or the pedestrian crossing volume exceeds twice the minimum threshold.

As with this entire PCTIG, this criteria is also subject to engineering judgment. In urban conditions where Boulder's typical block length is 400 feet, the engineer may want to consider allowing a minimum spacing of 200 feet, provided that the resultant pedestrian crossing:

- does not cross any auxiliary lanes (left or right turn lanes or their transitions) where it is anticipated that vehicles will be changing lanes and may be distracted from observing pedestrians in the crosswalk
- is not in an intersection influence area where it will create undue restriction to vehicular traffic operations.

2.2.6 Conditions That May Limit the Use of Rectangular Rapid Flash Beacons at Pedestrian Crossings

The City of Boulder has been using pedestrian actuated rectangular rapid flash beacons (RRFBs) at pedestrian crossings on four lane roadways for many years, and these "flashing signs" have greatly increased motorist yielding to pedestrians at these unsignalized crosswalks. However, the City has also learned that the use of RRFBs may not be appropriate in locations where there is a combination of both high traffic volumes and high pedestrian volumes. In these extreme conditions there may be an increase in traffic accidents and/or traffic delay that make

the use of RRFBs inappropriate. In these cases, the use of conventional pedestrian traffic signals or the HAWK signals may be more appropriate.

While the decision not to use RRFBs at a pedestrian crossing should be based on engineering judgment, the limit line in Figure 2 has been prepared to aid in this determination.

2.2.7 Selecting Between a Pedestrian Traffic Signal, HAWK Beacon, or RRFBs

Pedestrian traffic signals may be considered for application at high volume pedestrian crossings based on engineering judgment. The MUTCD contains warranting procedures for conventional pedestrian traffic signals based on automobile and vehicle traffic volumes to help determine if a pedestrian signal is appropriate. These signals are typically considered when there are over 130 pedestrians an hour crossing a roadway.

Hybrid Beacons (HAWK beacons) may also be considered and the MUTCD contains warranting guidelines that utilize automobile traffic, pedestrian traffic, automobile speeds, and pedestrian crossing distance. HAWK beacons may be installed where the crossing volume is as low as 20 pedestrians per hour, depending on the crossing distance, automobile traffic volume, and engineering judgment.

As noted above, the City of Boulder has been successful in using RRFBs to increase motorist yielding to pedestrians at unsignalized crossings, typically where there are two travel lanes in each direction. A minimum crossing volume of 20 pedestrians per hour is typically required, as discussed in Section 2.1.3. However, also as noted in Section 2.1.6, there may be cases where the combination of high pedestrian and traffic volumes may make application of RRFBs inappropriate. Figure 2a and Figure 2b illustrate City of Boulder recommendations for the use of RRFBs overlain on the MUTCD Hawk beacon and Pedestrian Traffic Signal warrant guidelines. The City of Boulder recommendations are based on safety and operational evaluations performed over the years at high volume RRFB locations.

In many cases, either HAWK beacons or RRFBs could be considered for application, and the final decision should be based on engineering judgment. Factors that should be considered include: automobile, bicycle and pedestrian volumes, vehicular speeds, crossing distances, the presence of a median or not, potential impact to corridor signal progression, proximity to signalized intersection, and vehicle queue formation.

2.2.8 Signal Progression and Traffic Operational Considerations

The installation of RRFBs, HAWK beacons, or pedestrian traffic signals can all have a significant impact on the automobile traffic operation in a corridor. The automobile and pedestrian crossing volumes, the spacing to the adjacent signalized intersections, the type of pedestrian population (college students, elementary students, elderly, a mix) should all be considered when selecting the crossing treatment type and how it will be operated. Where practical, HAWK beacons and pedestrian traffic signals should be coordinated with the signal progression in the corridor to minimize the impact of the new traffic signal on corridor traffic flow. However, coordinated signals may be less responsive to pedestrian actuation, and the delay in

pedestrian service may result in some pedestrians crossing against the signal rather than waiting. Not coordinating the pedestrian crossing signals may result in unacceptable increases in automobile congestion and delay.

RRFBs used at high volume pedestrian crossings in congested roadway corridors can also have a significant impact on automobile congestion and compromise effective signal progression. The RRFB limit line in Figure 2 can help minimize this problem.

Once again, engineering judgment will need to be applied to reach the best compromise for all involved.

2.2.9 Differential Vehicle Queue Lengths and Pedestrian Safety

A pedestrian crossing of a roadway with two or more lanes in a single direction has the potential for "multiple threat" type accidents. A multiple threat accident is when one lane of traffic stops for a pedestrian and obscures the view of the crossing pedestrian to a motorist in the adjacent travel lane. The result is that a pedestrian can step in front of a vehicle that is approaching too fast to stop. This condition is exacerbated when there are vehicle queues that back across the pedestrian crossing. If the queue in one lane backs into the crossing and is much longer than the queue in the adjacent lane, a motorist would commonly assume that the stopped traffic in one lane is the result of the queuing (which may usually be the case). Now if a vehicle in one lane stops for a pedestrian, instead of the queue, there is an even greater chance for a multiple threat accident.

Therefore it is important for the engineer to be aware of the formation of queues to and across the pedestrian crossing from a downstream intersection. It is even more important for the engineer to be aware of routine occurrence of one queue longer than the other across the pedestrian crossing. The Operational Observations section of the Crossing Location Evaluation Worksheet has a place to note this occurrence.

When deciding to install an uncontrolled crossing treatment (or not), the engineer should consider if differential vehicle queue lengths is an issue, and if so, can they be mitigated (say by signal timing adjustments at the downstream intersection). If differential queues can not be minimized, it may be reason to not install an unprotected crossing treatment (such as Type A, B, or C).

2.2.10 Unmarked Pedestrian Crossing Facilitation

Staff is aware of the fact that there are locations where pedestrians regularly cross arterial roadways yet the crossing does not serve a multi-use path or a school, and the pedestrian volume is below the minimum thresholds in Figure 1 for installing the types of marked and signed treatments detailed in Table 1. These locations typically occur on 4-lane roadways (such as at the intersection of 23rd/Canyon) or 6-lane roadways (such as at the intersection of Broadway/Ash), and often serve transit stops in the area. In some cases, subject to engineering judgment, it may be appropriate to install treatments that facilitate pedestrian or bicycle

crossings but stop short of the signed and marked crossing treatments defined in Table 1. This type of treatment or pedestrian facilitation may include curb ramps and/or a raised median refuge, but no effort is made to attract pedestrians to this crossing. The treatments simply acknowledge the low volume, but regular pedestrian crossing that occurs at a location. Installing these treatments does not endorse the use of the crossing nor attempt to attract new users to the crossing. They simply acknowledge that the crossing is occurring, will not likely go away, and some level of facilitation can make it safer for the pedestrians or bicyclists that are using the crossing already. The only other option would be to ignore the crossing, but staff does not believe this is an appropriate response. These treatments will only be considered if the location is more than 300 feet from the nearest signed and marked pedestrian crossing (whether it is controlled or uncontrolled), and it is believed that there is little potential to redirect pedestrians to a more defined crossing location.

2.2.11 Pedestrian Crossing Treatments at Higher Speed Roadways with Rural Character

Even though most Boulder streets have speed limits of 35 mph or less, there are some locations, particularly on the edges of the city, where speed limits are 40 or 45 miles per hour and roadways are transitioning between City and Boulder County jurisdiction. County roads may increase to 50 miles per hour just beyond City limits. In this context, there may be conditions that necessitate the installation of pedestrian crossings where speeds are higher and special consideration is warranted. Boulder County Transportation staff also encountered these situations (ex. 75th St. from Jay to Lookout). For reference, Boulder County staff has utilized Boulder's PCTIGs as a starting point and modified them to address this type of higher speed roadway where pedestrian crossings may be needed. The County's approach is to require there to be a refuge median and enhanced signing at any crossing where the speed limit is 40 or 45 (although they currently do not use RRFBs). Where speed limits are greater than 45, the County considers if the speed limit can reasonably be lowered to effect a slower travel speed before declining to install an at grade crossing.

In this context, it is recommended that engineering judgment be applied and consideration be given to providing an uncontrolled at-grade crossing treatment only if the speed limit can be effectively reduced to 40 mph and a raised refuge median is constructed has part of the crossing treatment (See Treatment Type E).

Crossing Location Evaluation Worksheet

Rev. 11/2/11

STEP 1 - LOCATION DESCRIPTION

Major Street: _____ Crossing Location: _____

Is this a multi-use path crossing? ☐ Yes ☐ No Posted Speed Limit: _____ mph

Existing Traffic Control: ☐ Stop Sign ☐ Traffic Signal ☐ Uncontrolled

Existing Crossing Treatments (if any): _____

_____

Nearby Pedestrian Generators (School, transit stop, commercial, etc.): _____

_____

STEP 2 - PHYSICAL DATA

Roadway Configuration:
☐ 2-Lane
☐ 3-Lane w/Striped Median
☐ 3 Lane w/Raised Median
☐ 4 Lane
☐ 5 Lane w/Striped Median
☐ 5 Lane w/Raised Median
☐ 6 Lane
☐ Other: _____

Crossing Distance By Direction: _____ ft total _____ ft to median *(if applicable + note direction)* _____ ft to median *(if applicable + note direction)*

Nearest Marked or Protected Pedestrian Crossing: _____ Distance to: _____ft

(*For uncontrolled location only*) Stopping Sight Distance (SSD) = _____ ft _____ ft.

Is SSD ≥ 8x Speed Limit? ☐ Yes ☐ No If No, are improvements to SSD feasible? ☐ Yes ☐ No

STEP 3a - TRAFFIC DATA

Pedestrian Crossing Volumes / Bicycle Crossing Volumes:

	AM	**Mid-Day**	**PM**	**Other**
Time:	to	to	to	to
Date/Day of Week:	/	/	/	/
Major Street Vehicular Volume (**Hourly**):				
# of Transit Boardings (if applicable)				
# of Young Peds / Bicyclists	/	/	/	/
# of Elderly Peds				
# of Disabled Peds				
# of Non-Y/E/D Peds / Bicyclists	/	/	/	/
TOTAL PEDS (Actual) (Include All Bicyclists in Total Sum)				
TOTAL PEDS (**Adjusted** for 2x Y/E/D				

Major Street Vehicular Volume (**Daily**): ADT = _____ veh/day

Crossing Location Evaluation Worksheet *(Continued)*

STEP 3b - OPERATIONAL OBSERVATIONS

Nearest Intersection (Direction #1): Cross Street Name: _____

Located _____ ft to the ☐N ☐S ☐E ☐W of crossing location

Signalized? ☐Y ☐N Distance from Crossing _____ ft

	AM	Mid-Day	PM	Other
How many times per hour did the downstream vehicle queue back up into pedestrian crossing?				
If multiple lanes per direction, are queue lengths approximately equal?	Y N	Y N	Y N	Y N
If NO (above),which lane is longer (inside, outside, middle) and by how much (feet)?				

Nearest Intersection (Direction #2): Cross Street Name: _____

Located _____ ft to the ☐N ☐S ☐E ☐W of crossing location

Signalized? ☐Y ☐N Distance from Crossing _____ ft

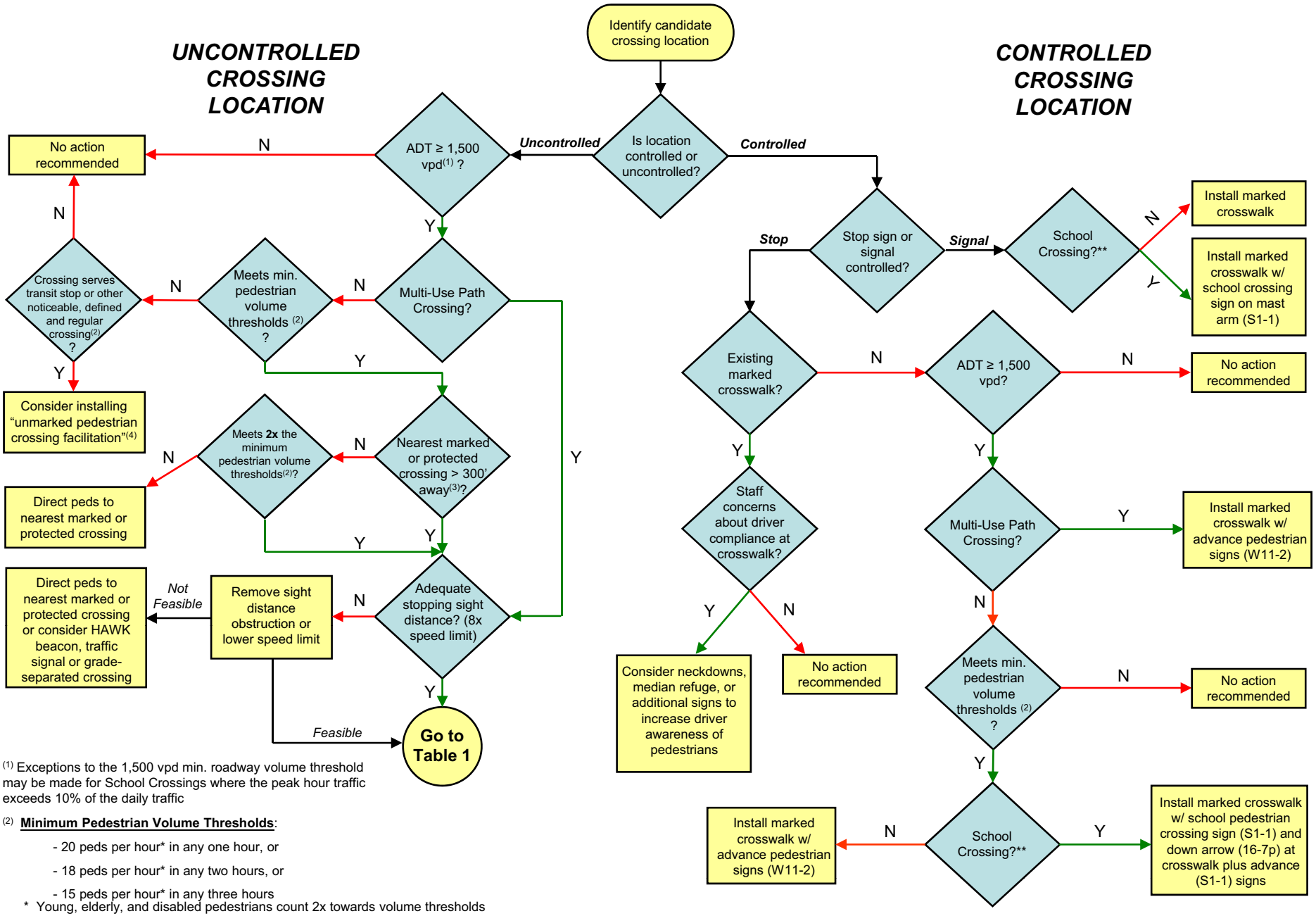
	AM	Mid-Day	PM	Other
How many times per hour did the downstream vehicle queue back up into pedestrian crossing?				
If multiple lanes per direction, are queue lengths approximately equal?	Y N	Y N	Y N	Y N
If NO (above),which lane is longer (inside, outside, middle) and by how much (feet)?				

STEP 4 - APPLY DATA TO FIGURE 1 and TABLE 1

Recommended Treatment(s): _____

_____

_____



(1) Exceptions to the 1,500 vpd min. roadway volume threshold may be made for School Crossings where the peak hour traffic exceeds 10% of the daily traffic

(2) **Minimum Pedestrian Volume Thresholds**:

- 20 peds per hour* in any one hour, or
- 18 peds per hour* in any two hours, or
- 15 peds per hour* in any three hours

* Young, elderly, and disabled pedestrians count 2x towards volume thresholds

** School Crossing defined as a crossing location where ten or more student pedestrians per hour are crossing.

(3) Distance to nearest marked or protected crossing may be reduced to 200' in urban conditions, subject to engineering judgment, where 1) the crosswalk does cross any auxiliary lanes, and 2) crossing treatments and crossing activity would not create undue restriction to vehicular traffic operations.

(4) An "unmarked pedestrian crossing facilitation" is any treatment that improves a pedestrian's ability to cross a roadway, short of the marked, signed and enhanced crossings detailed in Table 1. Installation of this type of pedestrian facilitation is subject to engineering judgment and may include curb ramps and/or a raised median refuge. However, no effort is made to attract pedestrians or recommend that pedestrians cross at this location. The treatments simply provide an improvement for a low volume pedestrian crossing where pedestrians are already crossing and will like continue to cross.

City of Boulder Pedestrian Crossing Treatment Installation Guidelines

Figure 1 – Pedestrian Crossing Treatment Flowchart

City of Boulder Pedestrian Crossing Treatment Installation Guidelines

Table 1 - Criteria for Crossing Treatments at Uncontrolled Locations

Roadway Configuration	# of lanes crossed to reach a refuge[1]	# of multiple threat lanes[2] per crossing	Roadway ADT and Posted Speed															
			1,500-9,000 vpd				9,000-12,000 vpd				12,000-15,000 vpd				> 15,000 vpd			
			≤ 30 mph	35 mph	40 mph	≥ 45 mph	≤ 30 mph	35 mph	40 mph	≥ 45 mph	≤ 30 mph	35 mph	40 mph	≥ 45 mph	≤ 30 mph	35 mph	40 mph	≥ 45 mph
2 Lanes (one way street)	2	1	A	B	C	E	A	B	C	E	B	B	C	E	B	C	C	E
2 Lanes (two way street with no median)	2	0	A	B	C	E	A	B	C	E	B	B	C	E	B	C	C	E
3 Lanes w/Raised Median	1 or 2	0 or 1	A	B	D	E	A	C	D	E	B	D	D	E	C	D	D	E
3 Lanes w//Striped Median	3	0 or 1	C	C	D	E	C	C	D	E	C	C	D	E	C	D	D	E
4 Lanes (two way street with no median)	4	2	A	D	D	E	B	D	D	E	B	D	D	E	D	D	D	E
5 Lanes w/Raised Median	2 or 3	2	A	B	D	E	B	C	D	E	B	C	D	E	C	C	D	E
5 Lanes w/Striped Median	5	2	D	D	D	E	D	D	D	E	D	D	D	E	D	D	D	E
6 Lanes (two way street with or without median)	3 to 6	4	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

Notes:

1. Painted medians can never be considered a refuge for a crossing pedestrian. Similarly, a 4 foot wide raised median next to a left turn lane can only be considered a refuge for pedestrians if the left turning volume is less than 20 vehicles per hour (meaning that in most cases the left turn lane is not occupied while the pedestrian is crossing).
2. A multiple threat lane is defined as a through lane where it is possible for a pedestrian to step out from in front of a stopped vehicle in the adjacent travel lane (either through or turn lane).

Treatment Descriptions:

A ***Install marked crosswalk with enhanced road-side signs***

Specific Guidance : Install marked crosswalk with "State Law - Yield to Pedestrian" signs mounted on the side of the roadway with standard (W11-2) advance pedestrian warning signs; use S1-1 signs for School Crossing locations.

B ***Install marked crosswalk with enhanced road-side and in-roadway (bollard mounted) signs***

Specific Guidance : Install marked crosswalk with "State Law - Yield to Pedestrian" signs mounted on the side of the roadway and on in-roadway bollards; use standard (W11-2) advance pedestrian warning signs; use S1-1 signs for School Crossing locations.

C ***Install marked crosswalk with enhanced signs and geometric improvements to increase pedestrian visibility and reduce exposure***

Specific Guidance : For 2 or 3-lane roadways, install marked crosswalk with "State Law - Yield to Pedestrian" signs mounted on the side of the roadway and on in-roadway bollards or median mounted signs; use standard (W11-2) advance pedestrian warning signs; use S1-1 signs for School Crossing locations. Add neckdowns or median refuge islands to shorten the pedestrian crossing distance and increase pedestrian visibility to motorists.

D ***Install marked crosswalk with enhanced signs, pedestrian activated RRFBs, and geometric improvements to increase pedestrian visibility and reduce exposure***

Specific Guidance : Install raised median refuge island (unless it is a one-way street or one already exists) to shorten the pedestrian crossing distance and increase pedestrian visibility to motorists. [If a median refuge can not be constructed on a two-way street, Go To Scenario F]. *Install marked crosswalk with "State Law - Yield to Pedestrian" signs WITH pedestrian activated RRFBs mounted on the side of the roadway and on median mounted signs; use standard (W11-2) advance pedestrian warning signs; use S1-1 signs for School Crossing locations. Consider adding neckdowns at the crossing if on-street parking exists on the roadway and storm drain considerations will allow. [Note: If pedestrian volume falls above the RRFB limit line on Figure 2, consider Hawk beacon, pedestrian traffic signal, or grade-separated crossing.]*

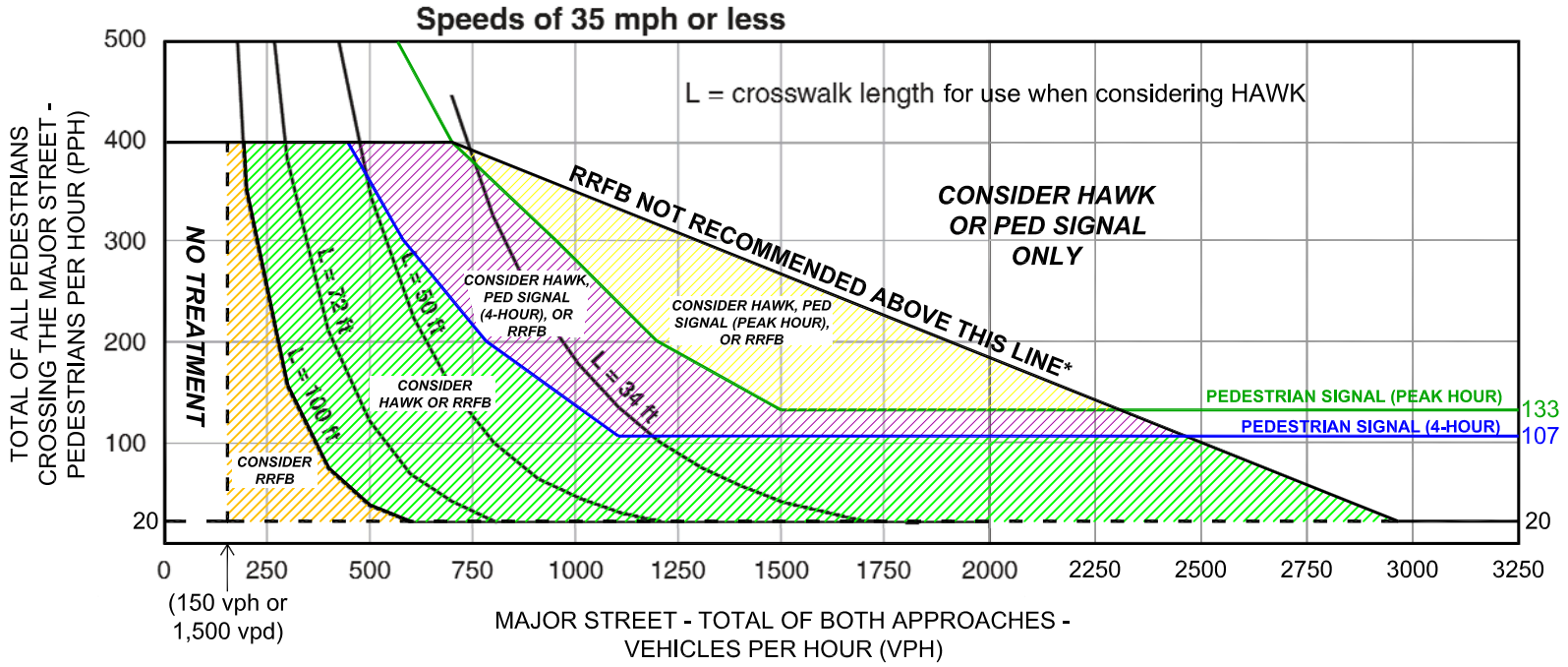
E ***Do not install marked crosswalk at uncontrolled crossing. Determine if the speed limit can be effectively reduced to 40 mph AND a raised refuge median can be installed. If so, utliize Scenario D criteria above. If this is not possible, or if pedestrian volume falls above the RRFB limit line on Figure 2, consider HAWK beacon, pedestrian traffic signal, or grade-separated crossing.***

Specific Guidance : Consider HAWK beacon, pedestrian traffic signal or grade-separated crossing; application of these treatments will consider corridor signal progression, existing grades, phyiscal contraints, and other engieering factors

F ***Do not install marked crosswalk at uncontrolled crossing with 3 or more THROUGH lanes per direction or where the speed limit is ≥ 45 mph and/or there is not a median refuge on a 5-lane crossing. Consider HAWK beacon, pedestrian traffic signal, or grade-separated crossing.***

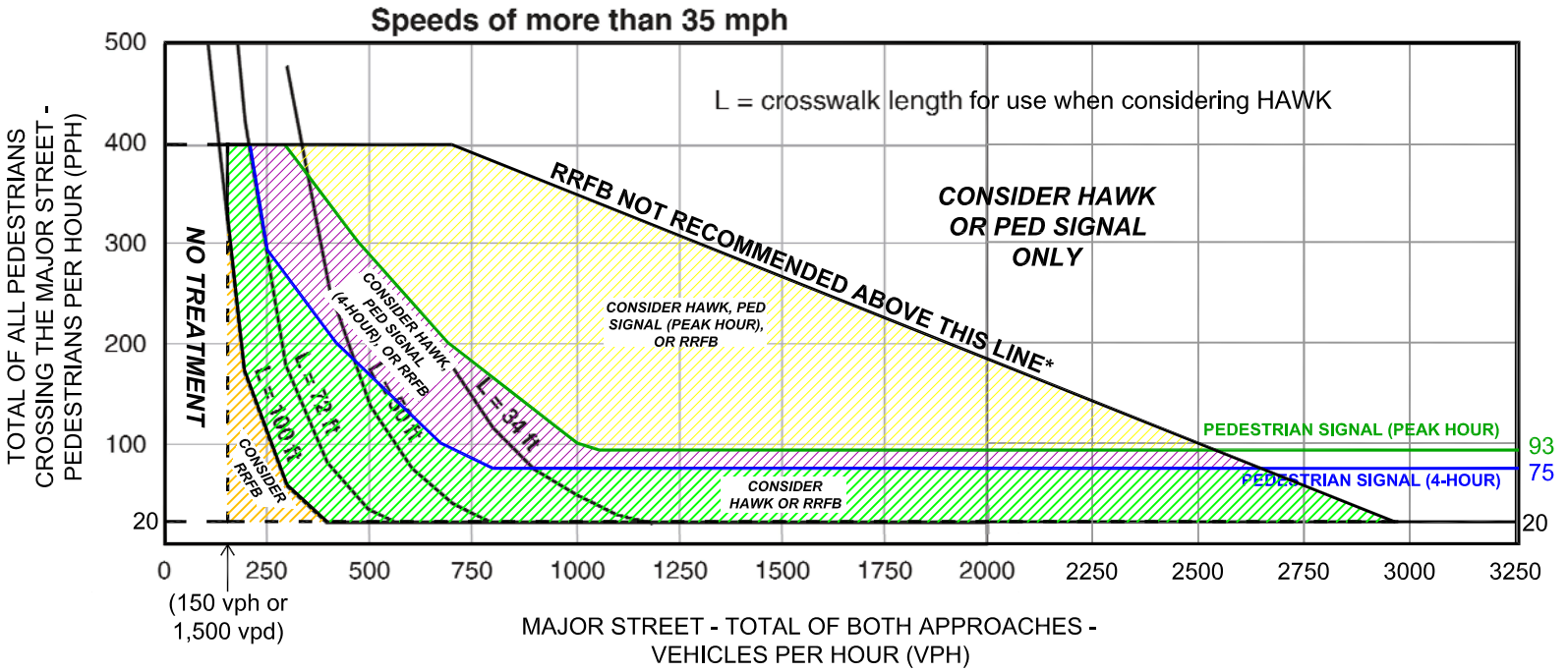
Specific Guidance : Consider HAWK beacon, pedestrian traffic signal or grade-separated crossing; application of these treatments will consider corridor signal progression, existing grades, phyiscal contraints, and other engieering factors

Figure 2a. City of Boulder Guidelines for the Installation of Pedestrian Hybrid (HAWK) Beacons, Pedestrian Signals, or Rectangular Rapid Flash Beacon (RRFB) Signs on Low-Speed Roadways



* RECOMMENDATION BASED ON CITY OF BOULDER SAFETY EVALUATIONS AT EXISTING RRFB SITES AND OBSERVED IMPACTS TO VEHICULAR TRAFFIC OPERATIONS

Figure 2b. City of Boulder Guidelines for the Installation of Pedestrian Hybrid (HAWK) Beacons, Pedestrian Signals, or Rectangular Rapid Flash Beacon (RRFB) Signs on High-Speed Roadways



* RECOMMENDATION BASED ON CITY OF BOULDER SAFETY EVALUATIONS AT EXISTING RRFB SITES AND OBSERVED IMPACTS TO VEHICULAR TRAFFIC OPERATIONS

3.0 SUPPLEMENTAL POLICIES

This section contains discussion of supplemental policies to guide the installation of crossing treatments in the City of Boulder.

3.1 Crosswalk Lighting

Research provided by the FHWA recommends that adequate nighttime lighting should be provided at marked crosswalks to enhance the safety of pedestrians crossing at night. Crosswalk lighting will be provided at all crosswalks utilizing traffic signals, HAWK beacons and RRFBs. Crosswalk lighting will be provided at all other marked crosswalks, unless engineering judgement suggests crosswalk lighting is not needed. The placement and level of crosswalk lighting will be determined by engineering judgement at all crossing treatments.

3.2 Avoiding Overuse of Crossing Treatments

The FHWA recommends that overuse of crosswalk markings should be avoided to maximize their effectiveness. Crosswalks and sign treatments (such as the "State Law – Yield to Pedestrians" and rectangular rapid flash beacon signs) should be used discriminately within the City of Boulder so that the effectiveness of these treatments is not deteriorated by overuse. Although these treatments may be effective at individual locations, overuse of these treatments city-wide may lead to a decrease in their value as drivers become desensitized to them. Minimum pedestrian and vehicular volume criteria have been established in this document with this in mind.

3.3 Multi-Use Path Crossings

Crossing locations where a multi-use path crosses a roadway should include a marked and signed crosswalk at a minimum, regardless of pedestrian crossing volumes, as long as the minimum vehicular volume criteria in Section 2.1.2 is satisfied. This policy is to promote the use of multi-use paths recognizing that roadway crossings often create barriers for pedestrians and bicyclists and may contribute to a lack of use.

3.4 Textured and Colored Pavement Treatments

Textured, brick, and/or colored pavement treatments should typically not be used in lieu of a marked crosswalk. When such treatments are used they are often aesthetic and not considered traffic control devices. Retroreflective pavement markings are required at any location serving as a marked crosswalk. Exceptions are granted for signalized intersection crossings, right-turn bypass (raised) crossings, and for multi-use path crossings at driveways and unsignalized intersections where the City has developed other treatments designed to call attention to the crossings.

3.5 Accessible Crosswalks

It is the goal of the City of Boulder that all crosswalks installed will comply with the Americans with Disabilities Act (ADA) to maximize mobility for all users. Where a new crosswalk is installed in a curbed roadway, curb ramps will include a detectable warning surface. The City intends to retrofit existing non-ADA compliant curb ramps with detectable warning surfaces as part of its on-going sidewalk maintenance program.

3.6 Raised Crossings at Right-Turn Bypass Islands

Raised pedestrian crossings at right-turn bypass islands meet the goals of these guidelines by improving visibility for pedestrians, improving accessibility, and helping to mitigate the speed of right-turning vehicle traffic. City staff will review all new or proposed right-turn bypass movements to determine if a raised crossing should be installed. If deemed feasible, a raised crossing will be incorporated into the design.

3.7 Removal of Treatments

Conditions that contribute to the need for a crosswalk or crossing treatments may change over time, and an existing crosswalk or treatment may no longer be needed. When a roadway surface is to be impacted by reconstruction or resurfacing, a review of any unprotected crosswalks should be performed to determine their use and need. If the use of a crosswalk is less than half of that which would be required for it to be warranted based on the criteria established in these guidelines for a new installation, the crosswalk should not be replaced when the construction or resurfacing is done and any other treatments will be removed. In such cases, residents and property owners within 1000' of walking distance to the crosswalk in question will be notified via mail. In addition, notices will be visibly posted for 30 days prior at the crossing location to inform the public of the intent to remove them. City contact information will be provided on these mailings and notices. Should concerns arise from the public as a result of that mailing or from the notification sign at the crosswalk, staff may then begin a more substantial public process with concerned parties.

4.0 NEXT STEPS

The City of Boulder is committed to providing safe and effective pedestrian crossing treatments and will continue to evaluate the criteria and treatments being used to implement treatments throughout the City. Specifically, City staff will carry out the following "Next Steps" to ensure that the pedestrian crossing treatment program meets the goals defined in this document:

- Continue testing and evaluation of new multi-lane crossing treatments. These treatments may include variations and/or combinations of the existing RRFB signs to increase both driver and pedestrian awareness at crosswalks. As newer technologies continue to develop into more viable options, passive detection devices such as microwave or video detection may also be tested. As performed for existing devices in the City, evaluation of new devices will include both the effectiveness of devices and a safety (accident history) analysis. Although operational impacts can be evaluated within months of installation of a treatment, it should be noted that safety analysis will require years of accident data to provide relevant results.
- As Federal signing standards continue to become more progressive with respect to enhanced pedestrian signing, strive to become compliant with the standards. This can be accomplished through a combination of bringing Boulder's policies/standards more in line with Federal standards as well as utilizing Boulder's significant experience to help shape future changes to Federal standards.
- Continue to evaluate the City's policy towards provision of curb ramps and median breaks at crossing locations where crosswalks are not provided due to speed, volume, or other consideration.
- Stay current with the latest pedestrian crossing research being performed at the federal, state, and municipal level. As more communities strive to increase the viability of pedestrian mode use additional studies and new findings are being made available. The City of Boulder will look to utilize this research to improve its own use of pedestrian crossing treatments.
- Continue to receive feedback from City of Boulder citizens with respect to various crossing treatments and the criteria established in this document to implement these treatments.
- Continue to work with the Transportation Advisory Board and City Council to implement policies, including these guidelines and any future amendments to this document, to promote the use of pedestrian facilities and the safety of people using them.
- Coordinate with the State of Colorado to modify current state law to include the curb ramp area the definition of a legal crosswalk so that it is clear that a motorist should yield to a pedestrian waiting to cross at a crosswalk.
- Develop an implementation plan to upgrade existing, qualifying crossing locations with "State Law – Yield to Pedestrians" signs as prescribed in this document.
- Continue to evaluate the effectiveness of raised crossings at right-turn bypass islands and work to develop a city-wide policy for application of these treatments.
- Collect data at crossing locations where treatments have been requested (or as defined in the Transportation Master Plan) and apply the criteria in this document to create a list

of projects for implementation. Staff will then prioritize the list of projects and perform crossing treatment installations based on funding availability.

APPENDIX

A1.0 Background

Roadway crossings can be barriers to pedestrian travel. The decision to travel as a pedestrian is in part dependent upon the actual and perceived ability to safely and efficiently cross roadways along the pedestrian's intended travel route. The City of Boulder wants to encourage pedestrian travel by providing safe and efficient roadway crossing opportunities. There are a variety of methods available to help facilitate pedestrian crossings on busy roadways, including marked crosswalks, enhanced crosswalks, and traffic signals. Crosswalk enhancements may include alternative signing, pedestrian-activated warning devices that draw attention to the pedestrian and alert motorists to their presence at a crosswalk, and physical enhancements intended to increase pedestrian visibility and/or reduce exposure such as neckdowns, raised crosswalks, and median refuges.

Signalized traffic control measures to reduce pedestrian-vehicle conflicts typically increase delays for both pedestrian and vehicular traffic. This creates a conflict between providing safety and generating operational efficiency for all modes of travel. These guidelines are tailored to meet the needs of the City of Boulder for optimizing safety and minimizing delay. The Pedestrian Crossing Treatment Installation Guidelines will provide a framework for identifying locations where pedestrian crossing treatments are appropriate and should be implemented by the City.

Application of these guidelines should accomplish the following project goals:

- Promote pedestrian travel by providing safe, efficient, and effective roadway crossing opportunities
- Reflect the needs of our diverse range of pedestrian age and ability groups
- Provide for a balance between the demand for treatments and resources to implement them
- Achieve a reasonable balance of impacts to all modes of travel

A1.1 Standards and Policies

Upon beginning the process of determining pedestrian crossing installation criteria, an extensive review of the latest available technical literature was conducted. This current effort was intended to build upon the research conducted during the previous (1996 and 2006 efforts.

The Manual on Uniform Traffic Control Devices (MUTCD) is the national standard for establishing traffic control on roadways throughout the United States and has been adopted by the City of Boulder as the City standard. Although the MUTCD does provide pedestrian crossing warrant criteria for the installation of pedestrian traffic signals, these warrants have been controversial in that signals are typically very hard to justify. According to the Federal Highway Administration's report on pedestrian signalization alternatives (July 1985), "The existing [1978] MUTCD Minimum Pedestrian Volume Warrant is highly impractical for most real-world conditions and is largely ignored by the traffic engineering community." The MUTCD also offers little guidance with respect to the installation of marked crosswalks, stating that

"crosswalks should be marked at all intersections where there is a substantial conflict between vehicular and pedestrian movements" and that an "engineering study should be performed before they are installed at (uncontrolled) locations."

In response to the controversial MUTCD pedestrian volume and school crossing traffic signal warrants, and lack of guidance by the MUTCD with respect to the installation of marked crosswalks, some agencies have developed their own unique policies and procedures. Generally, these documents supplement the basic provisions of the MUTCD with more detailed criteria based on their own research and field studies.

In 1997, the Institute of Transportation Engineers (ITE) adopted the "Design and Safety of Pedestrian Facilities"[2] as a Recommended Practice. This document built on MUTCD policies and guidelines and provided thresholds for the installation of marked crosswalks at uncontrolled locations based on those developed by Steven A Smith and Richard L. Knoblauch[3]. These guidelines provide recommended thresholds for marked crosswalks based on minimum hourly pedestrian volume, average daily traffic volumes, roadway configuration (laneage and presence of median refuges).

In 2002 the FHWA published a report titled, "Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines"[1]. Based on a five-year safety analysis at 1,000 marked crosswalks and 1,000 unmarked crossing locations, this report provides recommendations for installing marked crosswalks and enhancements based on roadway volume, speed, and laneage. The report suggests that on two-lane roadways, marked crosswalks alone at uncontrolled locations have no effect on pedestrian accident rates. The report also suggests that, on multi-lane roadways with a traffic volume greater than 12,000 vehicles per day, marked crosswalks alone (without any other treatments) are associated with higher vehicle-pedestrian accidents rates compared to unmarked locations.

Several years ago the Virginia Department of Transportation adopted a set of guidelines[4] for the installation of marked crosswalks that built upon the FHWA recommendations and provided more detailed guidance with respect to what types of crosswalk enhancements may be appropriate for a given set of roadway. These guidelines provided five basic levels of devices given the conditions present.

Level 1: standard crosswalk, raised crossing, rumble strips
Level 2: high-visibility crosswalks (retroreflective white markings and textured pavements)
Level 3: refuge islands, split-pedestrian crossover, neckdowns
Level 4: overhead signs and flashing beacons, in-roadway warning lights
Level 5: pedestrian-actuated traffic signals, grade-separated crossings

During the research review, it was noted that the City of Boulder's existing minimum pedestrian volume thresholds (based on the 1996 document) for basic crossing treatments were typically higher than those adopted by the agencies researched. The Virginia guidelines[4], for instance, state a minimum requirement of 20 pedestrians per hour (15 elderly and/or children) or 60 in four hours crossing at the location in question. The City of San Jose, CA[5] have adopted guidelines that require at least 15 pedestrians crossing the street during the highest one-hour period or 25 pedestrians crossing during the highest consecutive two-hour period. This is in comparison to the previously adopted City of Boulder thresholds of 100 pedestrians per hour or 50 pedestrians per hour during the peak four hours. It is believed that this downward trend in

pedestrian volume necessary to warrant treatments is both a result of increased efforts by agencies to accommodate pedestrians and provide safer and more efficient pedestrian facilities.

A1.2 Pedestrian Crossing Enhancements

A wide range of crossing enhancements (treatments used to increase the effectiveness of marked crosswalks) are being used in other communities in the United States and elsewhere which have been considered for use in the City of Boulder. The most comprehensive resource for information relative to these devices, including pros and cons, costs, and effectiveness, is the Alternative Treatments for At-Grade Pedestrian Crossings[6]. Enhancements being used elsewhere include:

- Automated detection
- Curb extensions
- In-pavement lighting
- Flags
- Flashing beacons
- In-roadway signs
- Lane reductions
- Rumble strips
- Markings and legends
- Overhead signs
- Pedestrian railings
- Raised markers (with LEDs)
- Refuge islands
- Street lighting
- Raised crossings
- Pavement treatments

Many of these treatments are being used and/or have been tested as “demonstration” devices in the City of Boulder, with varying degrees of success. Devices used in the City of Boulder have included most of the physical devices shown above, in addition to demonstration devices such as in-pavement lighting, rumble strips, flashing signs, in-roadway signs, and alternative signs and markings (such as the “State Law Yield-to-Pedestrians” signs and advance yield markings).

In 2000, city staff began demonstrating two new enhanced pedestrian crossing treatments. The purpose of these treatments was to draw attention to high volume pedestrian crossing locations and to encourage vehicles to have better compliance with their legal requirement to yield to pedestrians in these locations.

The first demonstration was a new, multi-colored sign which stated “State Law - YIELD to Pedestrians in Crosswalk." The signs were placed on an orange barrel or bollard in the street and mounted on a standard assembly at the side of the street. The other demonstration was pedestrian actuated flashing lights imbedded in a standard pedestrian warning sign, mounted at the side of the road and on medians in the center of the road. These lights flash when a pedestrian pushes a button. Over the past 11 years, staff has been expanding the use of these demonstration devices to other locations within the city.

The City of Boulder will continue to stay abreast of the latest crossing enhancement technologies and research and will continue to test and modify its own applications to maximize the safety and efficiency of these treatments. A discussion of the “Next Steps” involved in this process is included in Section 4.0

A1.3 Evaluation of Demonstration Devices Used in the City of Boulder

Over the past 14 years, the City of Boulder has evaluated driver compliance at crosswalks both before and after the installation of "demonstration devices". The devices evaluated included:

- "State Law–Yield to Pedestrians" Signs and Bollards (used at 2 or 3-lane crossings)
- Pedestrian Activated Flashing (or RRFB) Signs (used primarily at multi-lane crossings)
- Rumble strips

In addition to evaluating the effectiveness of these devices in terms of driver compliance, accident histories were compiled to compare the safety effects of the demonstration devices both before and after installation.

The evaluations have showed that the "State Law -Yield" and RRFB devices are effective at getting more vehicles to comply with state law and yield to pedestrians in crosswalks than if not installed. They accomplish this with a relatively minor impact to vehicle delay. In addition, the evaluation showed that at locations with "State Law – Yield to Pedestrians" signs, there were very few examples of increased accident frequency for either rear-end collisions or accidents involving pedestrians or bicyclists being hit by a motor vehicle. The majority of accident frequencies either stayed the same or was reduced at locations studied.

At locations using the pedestrian-actuated flashing signs, there were increases in rear-end collision frequencies at some locations and increases in the frequency of pedestrians or bicycles being hit in the crosswalk at several locations. Injury accident frequencies also increased at many locations. It should be noted that, since these devices were installed primarily at multi-lane crossing locations, the effectiveness of these devices cannot be directly compared to the "State-Law" signs.

While the pedestrian-actuated flashing signs do not change the rules of the roadway, the effectiveness of encouraging vehicles to yield to pedestrians has resulted in more vehicles stopping for pedestrians, which has further resulted in more rear-end collisions (this same phenomenon exists when new traffic signals are installed in the roadway). It is possible that the increased compliance of motor vehicles yielding to pedestrians is also resulting in some pedestrians and bicyclists using less caution when they cross which in turn results in an increase in vehicle-pedestrian and vehicle-bicycle accidents.

Further analysis of the safety effects of these devices is recommended so that a larger sample of data may be obtained and accident trends related to physical and environmental variables may be identified.

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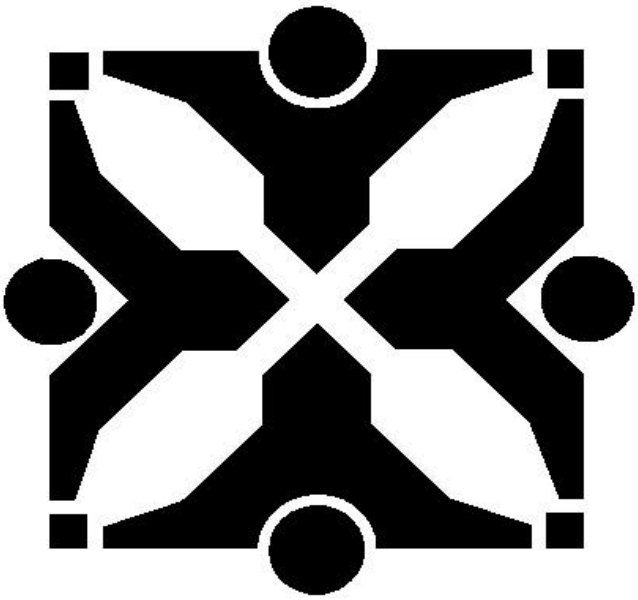
POLICY AND STANDARDS FOR PEDESTRIAN CROSSINGS



City of Columbia, Missouri

Policy Resolution 134-00

Policy and Standards for Pedestrian Crossings

Table of Contents

I. Mission Statement

Public Works Department Pedestrian Crossing Mission:

> ***It shall be the mission of the Public Works Department to provide for pedestrian crossings of public streets in such manner to increase the safety of pedestrian users and encourage pedestrian traffic in accordance with the concepts of a walkable community.***

II. General

A. Residential Streets

Speeds and volumes on residential streets should be lower than on higher classification streets and should not normally require pavement markings or signs to indicate crosswalks. Requests for crosswalks on these streets may be an indication of other traffic concerns which can be determined by a traffic study. Based on a traffic study, crosswalk markings or other appropriate measures such as traffic calming may be implemented.

B. Mid-block Crossings

A mid-block crosswalk is defined as a crosswalk at a location other than an intersection. State and City laws require motorists to yield to pedestrians in crosswalks. Mid-block crosswalks can be used to improve safety for pedestrians crossing at a specific location. To be effective at improving safety, a mid-block crosswalk should be installed at specific locations where pedestrians would be expected to need to cross the street. If the pedestrian crossings are occurring at random locations within a block and if vehicle volumes are low or moderate (adequate gaps are available) it is likely that most pedestrians will not alter their route by more than a few yards to use the crosswalk. Consideration should be given to the safety of all pedestrians (younger and older pedestrians) who may use a proposed mid-block crosswalk.

Crosswalk locations must allow motorists to safely yield for pedestrians. Sight distance, roadway geometrics and the potential for rear-end type accidents should be evaluated. Streets with two traffic lanes in the same direction present a potential hazard when a vehicle in one lane yields to a pedestrian and obstructs the sight line of the pedestrian for a motorist in the other lane.

The safety of mid-block crosswalks is dependent on the judgement of the pedestrian and the motorist. Engineering standards can help by making crosswalks more visible. Warrant criteria can help by making sure that crosswalks are installed at safe locations. Enforcement of crosswalk laws is very important to improve safety.

C. Major Intersections

A major intersection is defined as an intersection of two streets of collector or higher classification, and intersections within the Central Business District. Intersections of minor streets with streets on the Major Thoroughfare Plan may be studied like major intersections if the Bicycle and Pedestrian Commission

identifies them as desirable crossing locations. Pedestrian exposure to vehicles is increased when vehicle volumes increase. Collector streets and higher classification streets generally carry higher volumes than local residential streets. Chapter 14, Article X of the Columbia Code indicates that pedestrians have the right of way within marked crosswalks and at unmarked crosswalks at intersections. At major intersections, crosswalk markings can provide increased awareness of the presence of pedestrians. Major intersections with all-way stop control and signalized intersections will generally be provided with marked crosswalks. There are three levels of crosswalk markings, standard, enhanced standard, and special emphasis. The highest levels of marking, should be reserved for situations where the pedestrian exposure is the greatest. The level of markings used should be similar for similar conditions to encourage driver familiarity.

D. Traffic Engineering Study

A traffic engineering study is required to determine if the criteria and warrants are met for a marked crosswalk at a particular location, and to determine the level of marking justified. The level of detail required for a traffic engineering study will vary with the location under consideration.

The engineering study includes consideration of:

1. Speed and traffic volume data on streets being crossed
2. Pedestrian volume, age, and level of mobility
3. Location of pedestrian origin and destination points and crossing pattern
4. Existing sidewalk network and sidewalk ramps
5. Sight distances and sight obstructions
6. Street characteristics including grades, curvature, pavement widths, and number of vehicle and bicycle lanes
7. Location of adjacent driveways
8. On-street parking
9. Street lighting
10. Location of drainage structures
11 Distance to nearest protected or marked crossing
12. Traffic signal progression
13. Potential for rear end accidents

E. Maintenance

Crosswalks markings and signs shall be maintained in a high state of visibility and must meet reflectivity standards. All crosswalk markings and signs must be inspected at least twice a year and replaced as needed.

School zone markings and signs must be inspected prior to the beginning of the school year in late summer and re-painted as needed.

III. Warrants and Guidelines for Pedestrian Crossings

A. General

Marked crosswalks are intended to provide pedestrians with a feeling of confidence that it is safe to cross a street at the marked location and to give motorists adequate warning to expect pedestrians to be in the roadway. They are also to encourage pedestrians to cross roadways where there are adequate facilities to accomplish these purposes. Care should be taken to insure that marking crosswalks at some locations does not detract from other similar locations without markings. A Traffic Engineering Study as described in section II. D. is required when evaluating a location for marked crosswalks.

The following are general criteria to be satisfied in addition to the warrant criteria when considering installation of marked crosswalks:

1. Marked crosswalks must connect to established sidewalks at both ends.

2. ADA accessible ramps shall be included at both ends of crosswalk installations unless there are engineering reasons they cannot be provided.

3. Adequate street lighting must be provided for the safety of pedestrians.

4. Street parking must be restricted adjacent to crosswalks to allow for adequate sight lines for both the motorists and the pedestrians. The length of the parking restriction shall be based on an engineering study.

B. Residential Streets

Marked crosswalks will generally not be installed on residential streets. Marked crosswalks will be evaluated for use on residential streets when indicated by one or more of the following:

1. The street intersects with a collector or higher classification street and the average daily traffic volume on the minor street exceeds 1000 vehicles per day.

2. The crossing location is within a designated school zone or is a key element of a designated school walking route plan.

3. A traffic engineering study indicates a safety problem that can be addressed by a marked crosswalk.

Evaluation of marking a crosswalk on a residential street requires an engineering traffic study and satisfying the requirements of III. A.

C. Mid-block Crossings

1. Warrant Criteria

A crosswalk at a mid-block location may be installed when the location satisfies the general criteria of III. A. and meets all of the warrant criteria for a mid-block crosswalk listed below:

a. The crossing volume is not caused by a correctable gap in the sidewalk system.

b. There is minimum distance of 300 feet to nearest protected crossing. A protected crossing is a crossing controlled by stop signs or signals or at a grade separation.

c. Engineering study indicates no unsafe visibility or site conditions would be created.

d. Posted speed is 35 mph or less.

e. On an average day, a minimum of 50 pedestrians cross the street within 50 feet of the proposed crossing, during any one hour.

f. The average daily two-way traffic volume on the street is above 3500 vehicles per day or there are insufficient normal gaps in traffic to allow pedestrian crossing at an average walking speed of 3.5 mph within a three minute interval more than twice during any peak hour period.

When a mid-block crosswalk is warranted the following guidelines shall be used:

- Level 3 markings shall be used
- "Yield to pedestrians" signs shall be placed in advance
- Crossing treatments as shown in Section IV. C. should be considered

2. Exceptions to Warrant Criteria

The pedestrian volume and vehicle volume warrants may be waived for any of the following situations:

a. The crossing location is a key element of a designated school walking route plan

b. A traffic engineering study indicates a safety problem that can be addressed by a marked mid-block crosswalk.

c. The Bicycle and Pedestrian Commission has identified the location as a desirable location to

encourage crossing. Such locations can include, across collector and arterial streets where the distance to the nearest protected crossing or marked crossing is great enough that pedestrians would not logically be expected to use the protected or marked crossing, near transit stops, bike corridors, greenbelt and multi-use path crossings. The presence of pedestrians helps safety by reminding motorists of the crossing. Therefore, when the pedestrian volume is waived, additional emphasis should be given to installing crossing treatments as shown in Section IV. C.

D. Major Intersections

1. Un-signalized Intersections

a. All-way stop-controlled intersection

Provided the general criteria in Section III. A. is satisfied, all-way stop-controlled intersections shall use the following guidelines:

- At a minimum, crosswalks shall have Level 1 markings.
- Level 2 or 3 markings may be used based on crossing length, speed, and volumes.
- "Yield to pedestrians" signs may be placed in advance of all-way stop-controlled intersections.
- When crossing lengths are greater than 36 feet, pedestrian refuge islands shall be evaluated.

b. Partial stop-controlled intersection

Each approach at a partial stop-controlled intersection will be either **stop-controlled** or **uncontrolled**. Crosswalk markings at partial stop-controlled intersections will be evaluated based on the control of the approach being considered as indicated below. **Tee intersections** with heavy turning volumes and highly skewed intersections may require additional consideration.

i. Stop-controlled approaches

Provided the general criteria in Section III. A is satisfied, stop-controlled approaches shall use the following guidelines:

- At a minimum, crosswalks shall have Level 1 markings.
- Level 2 or 3 markings may be used based on crossing length, speed, and volumes
- "Yield to pedestrians" signs may be placed in advance of stop-controlled approaches at intersections.
- When crossing lengths are greater than 36 feet, pedestrian refuge islands shall be evaluated.

ii. Uncontrolled approach to intersection

This section applies to the uncontrolled approaches of partial stop-controlled intersections which are similar to a mid-block crosswalk in that the pedestrian is crossing uncontrolled traffic. The warrants for mid-block crosswalks, as stated in section III. C. 1 shall be used

when evaluating crosswalks across the uncontrolled approaches at an intersection, except that a 50% reduction pedestrian and vehicle volumes is permissible. The Pedestrian and vehicle volumes may be waived as indicated in Section III. C. 2. Provided the general criteria in Section III. A. is satisfied, and the modified mid-block warrants are satisfied, uncontrolled approaches shall use the following guidelines:

- Marked crosswalks on uncontrolled approaches of intersections shall be Level 3 markings.
- "Yield to pedestrians" signs should be placed in advance of crosswalks across uncontrolled approaches at intersections.
- Crossing treatments as shown in Section IV. C. should be considered.

2. Signalized Intersections

Provided the criteria in Section III. A. are satisfied, signalized intersections shall use the following guidelines:

- At a minimum, crosswalks shall have Level 1 markings.
- Level 2 or 3 markings may be used based on crossing length, vehicle speed and volumes.
- Signals shall provide enough time to allow pedestrians to cross the street safely based on a walking speed of 3.5 feet per second, this rate may be reduced at locations where the predominate walking speed is slower.
- Actuated signals should have pedestrian signals (WALK, DON'T WALK) activated by push buttons.
- When crossing lengths are greater than 36 feet, pedestrian refuge islands are to be evaluated.
- Pedestrian signals (WALK, DON'T WALK) shall be installed when the crosswalk crosses more than two lanes of same direction traffic or when the average daily entering traffic volume exceeds 10,000 vpd.

IV. STANDARDS

A. Pavement Markings

Crosswalks shall be a minimum of 6 feet or the same width as the approach walkway if the walkway is wider than 6 feet. When the guidelines and warrants section of this policy indicate the use of crosswalk markings, one of the following three levels of marking shall be used:

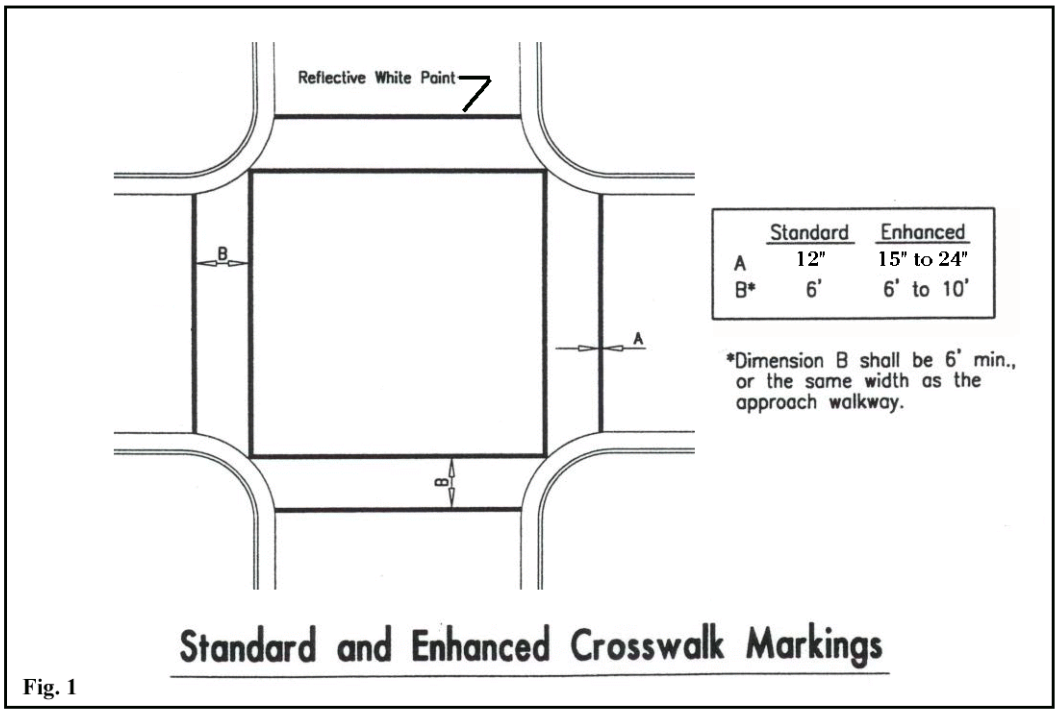


Figure 1 shows standard and enhanced crosswalk markings.

Level 1 - *Standard* crosswalk markings are two 12-inch white lines, 6 feet apart. (Fig. 1)

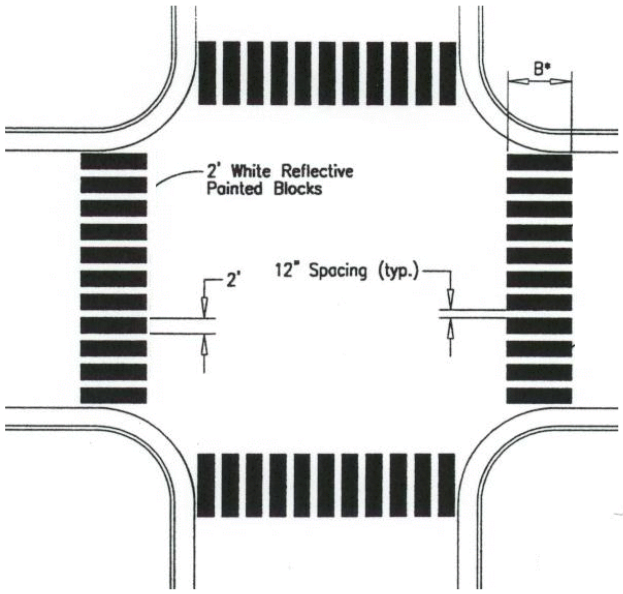
Level 2 - *Enhanced standard* crosswalk markings are similar to standard crosswalk markings except the width of the white lines is anywhere from 15 inches wide to 24 inches wide. (Fig. 1)

Enhanced standard markings may be used when any one of the following apply:

- Crosswalk is wider than 6 feet
- Crossing more than 2 lanes of traffic
- Intersection entering volume exceeds 900 vehicles per hour for any one hour
- "Yield to pedestrians" sign is placed in advance of crosswalk
- Across minor street at two-way stop controlled when major street speed limit exceeds 35 mph

Level 3 - *Special emphasis* crosswalk markings consist of white 2-foot wide bars with a 1-foot space at 90 degrees to the crosswalk. (Fig. 2) The width of the bars and spaces may be increased up to 36 inches at some locations to allow the tires of vehicles to track through the spaces.

Figure 2 shows special emphasis crosswalk markings.



Special Emphasis Crosswalk Markings

Fig. 2

Special Emphasis Markings **may** be used at any of the following locations:

- Within school zones or as shown on a school walking route plan
- When an engineering study indicates the need for additional visibility
- Where crosswalk treatments are used that result in raised pavements

Special Emphasis Markings **shall** be used at the following locations:

- Where mid-block crossings are installed
- Across un-controlled traffic at partial stop-controlled intersections
- Where crossings are installed on streets having an average daily traffic volume of 4000 vehicles per day or more.

High Pedestrian Areas - In business districts, campuses, commercial areas and other high pedestrian areas where pedestrian activity is to be encouraged and where significant distractions to motorists and pedestrians are likely to occur, engineering judgement can be used to implement a higher level of pavement marking than would be indicated by the crosswalk marking standards. Care should be taken to insure that special emphasis markings at some locations do not weaken or detract from other crosswalks where lower level markings are used.

B. Signs

1. **Crosswalk Signs - W11A-2** (Fig. 3)
   The W11A-2 sign shall be used at marked mid-block crosswalks. When a W11A-2 crosswalk sign is used, an M6-2 sign (Fig. 3) with an arrow pointing down at a 45 degree shall be used with the sign. This sign group shall be installed so that a motorist will see the signs on the left side as well as the right side of the crosswalk. Crosswalk signs (W11A-2) may also be mounted over traffic lanes on mast arms to increase awareness of the crossing location.

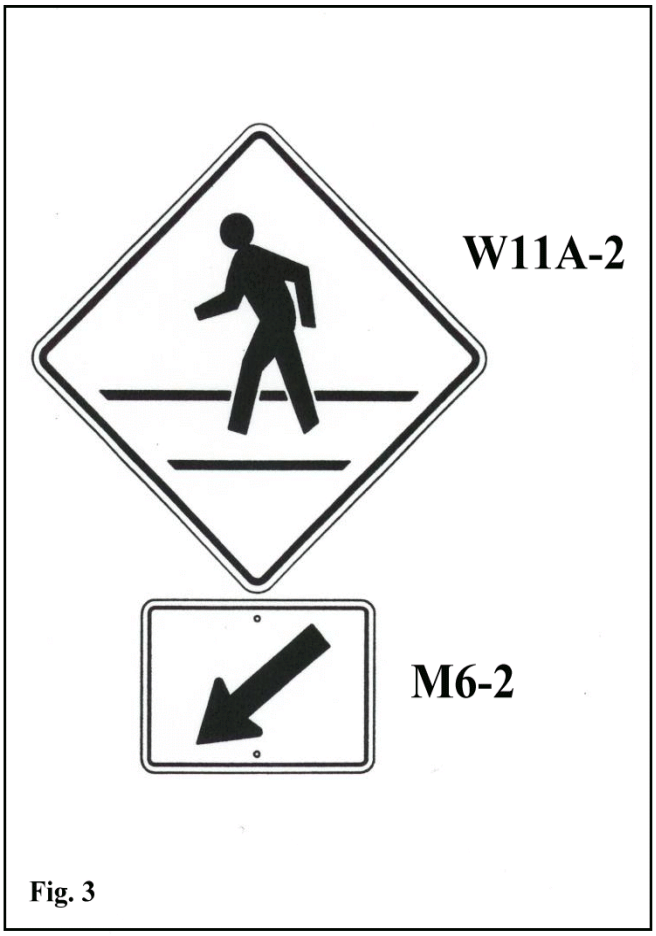


Fig. 3

Figure 3 shows the standard sign group for marking crosswalks.

2. **"Yield to Pedestrian" Signs (YTP)** (Fig. 4)
   To increase public awareness of the law requiring motorists to yield to pedestrians, a "Yield to Pedestrians - It's the Law" sign may be utilized in any of the following situations:
   - In advance of high pedestrian intersections
   - In advance of mid-block crossings
   - In advance of school zones

   When the YTP sign is used, crosswalk markings shall be Level 2 or Level 3.

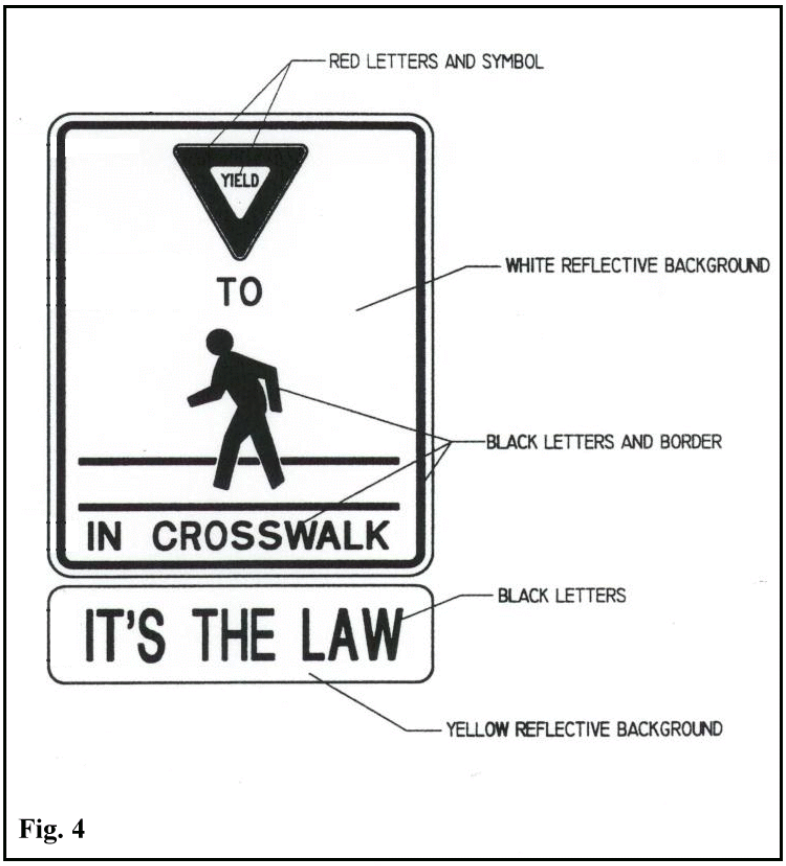


Fig. 4

Figure 4 shows the standard "Yield to Pedestrian Sign"

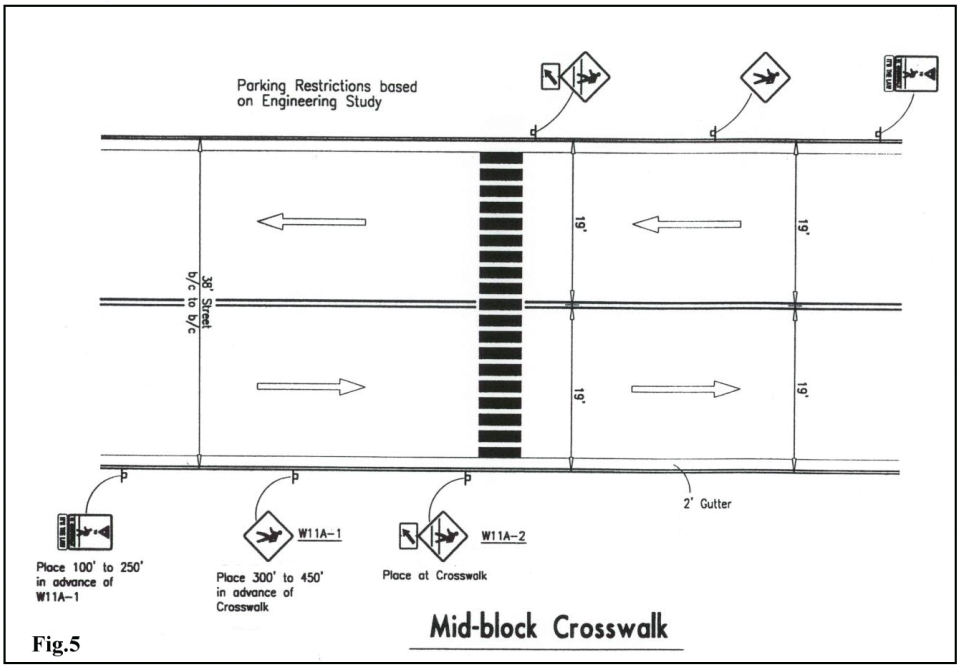


Fig.5

Figure 5 shows a typical mid-block crossing and the relationship of signs.

C. Crosswalk Treatments

The purpose of crosswalk treatments is to improve safety by:

- Reducing vehicle speed at the crosswalk
- Reducing exposure of the pedestrian to vehicles
- Increasing awareness of the presence of pedestrians
- Increasing visibility of the crosswalk

1. Bulb-Outs - Bulb-outs for pedestrians should be considered when warrants exist for pedestrian crossings at mid-block or major intersections and the pavement width is greater than 32 feet. Bulb-outs for traffic calming purposes may be installed on streets of lesser widths but are not considered necessary solely for pedestrian purposes. A typical mid-block crossing with bulb-outs is shown on Fig. 6. The illustration also indicates the location of signing.

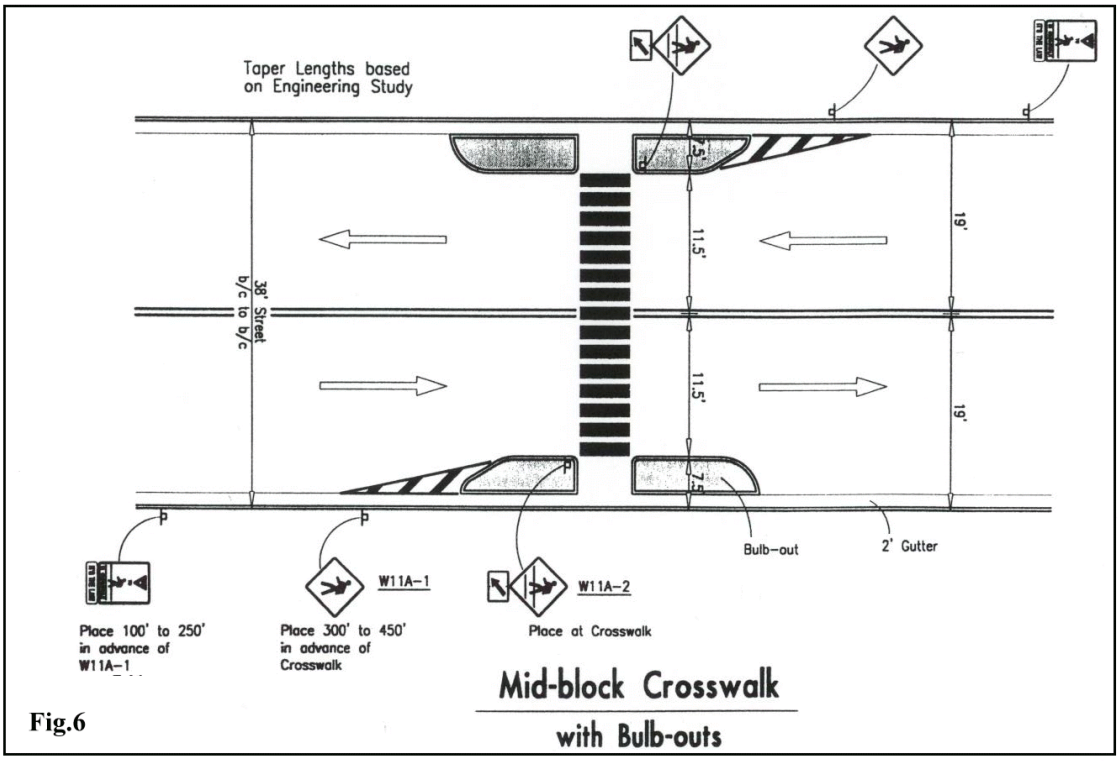


Fig.6

Figure 6 shows a typical mid-block crosswalk with bulb outs.

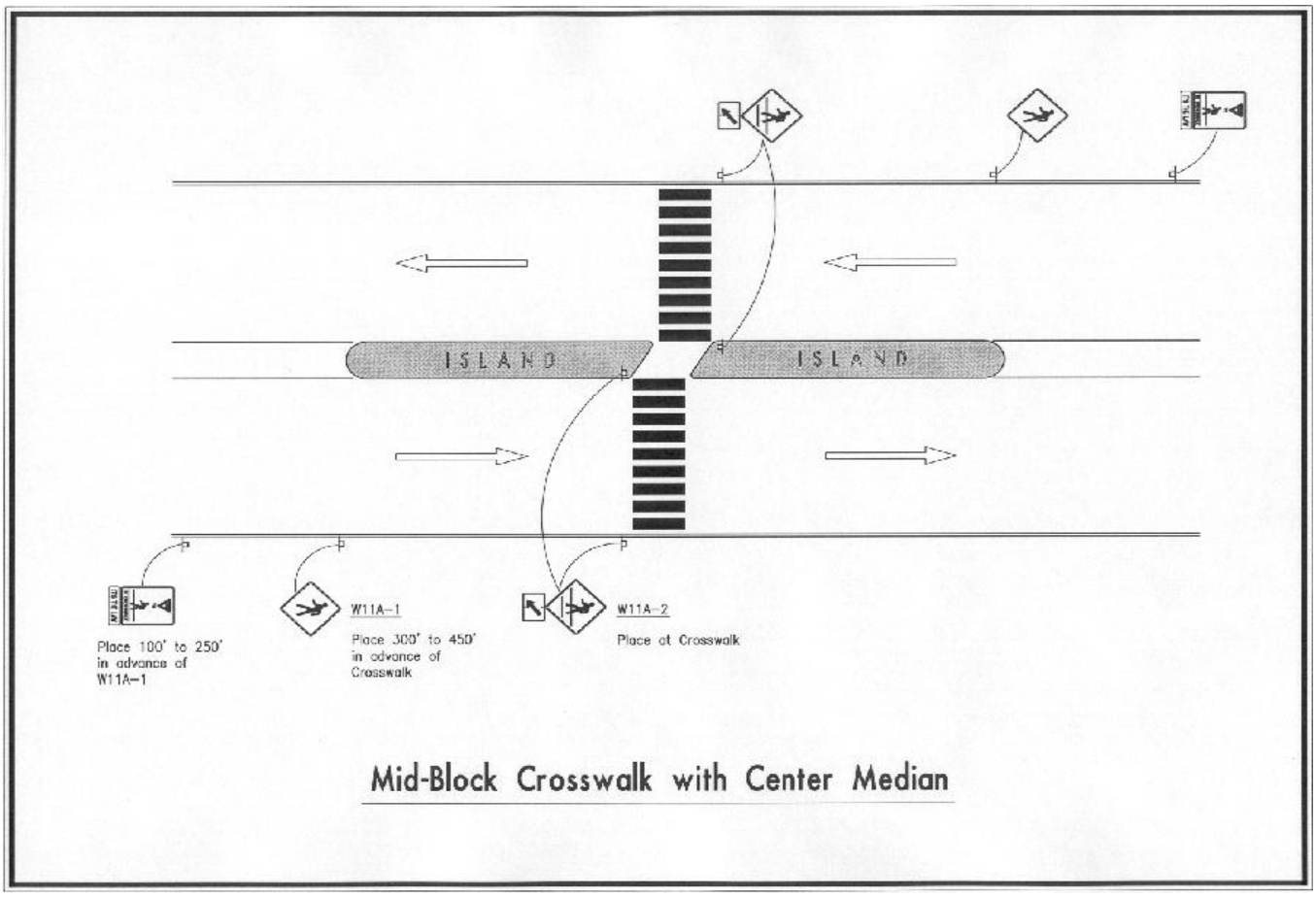


Figure 7 shows a typical mid-block crossing with a center median.

2. **Center Medians** - Center medians can improve crossing safety by providing a pedestrian refuge which will allow the pedestrian to cross each direction of traffic separately. Center medians shall only be installed where pavement widths are sufficient to allow for the safe clearance of pedestrians from moving traffic and the resulting traffic lanes are sufficient in width for the posted speed limit. Crosswalks leading to the center median will be offset to place emphasis on the median as a stopping place for pedestrians. A typical mid-block crossing with a pedestrian median and sign location is shown in Fig. 7. When a center median is used and there is also on street parking, bulb-outs may be considered in conjunction with the center median.

3. **Raised Crosswalks** - The intent of raised crosswalks is to increase visibility of the crosswalk and to decrease the vehicle speeds. Raised crosswalks are to be implemented as shown in the traffic calming policy.

4. **Flashing Yellow Crosswalk Lights** - Flashing yellow lights may be used at mid-block crosswalks if an engineering study indicates a need to increase awareness of the crosswalk location or the presence of pedestrians. Flashing yellow lights do not assign right-of-way. Improper interpretations of the purpose or meaning of flashing lights can lead to conflicting movements and should be considered when evaluating the use of flashing yellow lights.

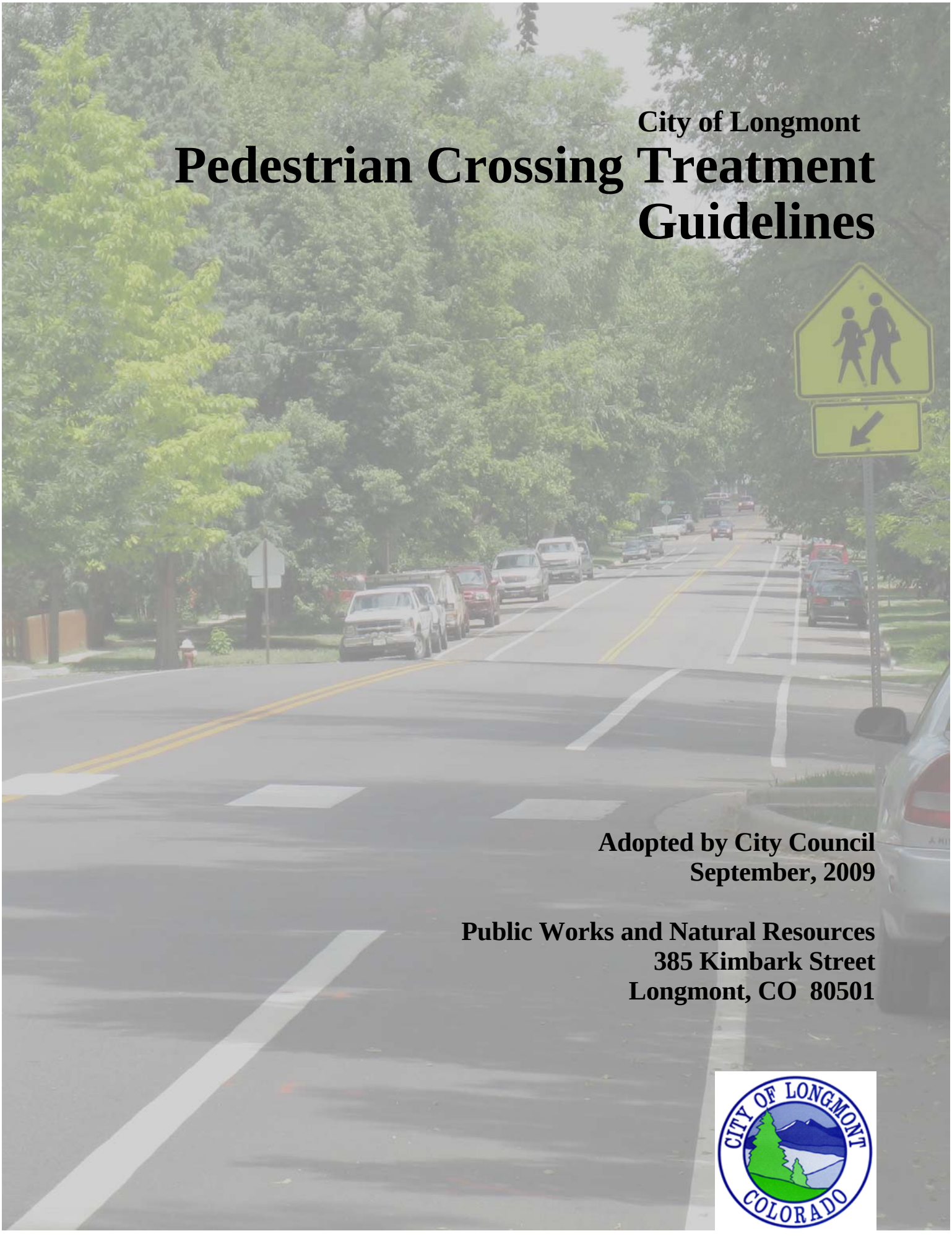
For flashing yellow lights to be effective, they must command respect from motorists. If the lights flashed continually, a motorist would lose respect and ignore the installation after being "falsely warned" several times. Therefore, when flashing yellow lights are used at crosswalks, they should be activated by pedestrians.

Pedestrian actuated lights flash when a pedestrian pushes a button or passes a sensor. These lights indicate the presence of a pedestrian. The lights can be mounted with the crosswalk signs at the side of the road, over the driving lanes on mast arms, or in the pavement with airport taxiway style lights. For crossing multi-lane same direction traffic, overhead or in pavement lights are recommended.

5. **Pedestrian Warranted Traffic Signals** - Traffic signals can be installed at an intersection or mid-block based on pedestrian volumes if warranted by the Manual on Uniform Traffic Control Devices. (MUTCD) When traffic signals are installed based on pedestrian volumes, pedestrian signals must be used. (WALK, DON'T WALK)

6. **Grade Separation Structure** - Where it is not possible to accommodate pedestrians with at-grade crossings, grade separation may be considered. These facilities are expensive and can add out-of-direction travel. Therefore, grade separation should only be located where their use would be maximized. To ensure proper use, these facilities must be open, with good visibility and easily accessible.

7. **Supplemental Pedestrian Crossing Channelizing Devices (SPCCD) -** SPCCD are portable devices consisting of a standard "yield to pedestrians" sign attached to a light weight frame and stand. These devices are not currently contained in the MUTCD but can be effective for temporary use during peak pedestrian hours. The SPCCD must be manually set up on the street centerline and removed after the peak period. They are most useful at crossings with a crossing guard and typically are used at school crossings, campuses, and special events. The SPCCD should only be used at existing marked crosswalks.



City of Longmont

Pedestrian Crossing Treatment Guidelines

Adopted by City Council
September, 2009

Public Works and Natural Resources
385 Kimbark Street
Longmont, CO 80501

Table of Contents

1.0 Crossing Treatment Policies

Safe and efficient pedestrian travel benefits everyone in our community and has become an increasingly important issue for the City of Longmont. Pedestrian facilities play a major role in promoting walking as a viable mode of travel, reducing our dependency on the automobile, and improving quality of life. Our decision to walk, or to let our children walk, often depends on our ability (and perceived ability) to safely cross streets that act as barriers along the way.

A quality pedestrian environment should have the following characteristics:

- Provide safe and efficient travel along facilities and at crossings
- Meet needs of all pedestrian abilities and age groups
- Reasonable balance of impacts among all modes of travel
- Effective balance between treatment needs and available resources

Until recently there has been little available research and few agencies had developed formal guidelines for pedestrian crossing treatments. National standards continue to provide little guidance for pedestrian crossings, especially at mid-block locations. There has been considerable controversy and disagreement regarding the safety benefits of marking crosswalks. Many believe that marked crosswalks can give pedestrians a "false sense of security" when crossing a roadway and therefore create a hazardous pedestrian environment. Others believe that marked crosswalks help channel pedestrians to a preferred crossing location, alert motorists to the presence of a pedestrian, and therefore create a safer pedestrian environment. With these varying opinions and lack of a national standard, agency staff are often left to use their own judgment (often influenced by public and/or political pressure) in determining where to install crosswalks, resulting in practices that differ considerably from one community to another and even within a community. Inconsistent application in turn can lead to reduced driver and pedestrian compliance, increased public discontent, and reduced safety.

The lack of a national standard and increased emphasis on pedestrian safety has spurred a growing number of guidelines and studies on this topic. In an effort to apply a more systematic approach for Longmont's pedestrian crossings, these guidelines were developed to include:

- Criteria and procedures for evaluating the need for and recommended level of pedestrian devices,
- Identification of appropriate treatments for pedestrian crossings based on pedestrian characteristics, vehicular characteristics, and roadway geometry,
- Review of pedestrian crossing research and evaluation, both nationally and in our region.

This is Longmont's initial attempt to formally establish written guidelines on this topic. In the past, Longmont has often relied upon *Guidelines for the Installation of Crosswalk Markings* (American Automobile Association, 1988) to evaluate the need for marked pedestrian crossings. These AAA guidelines are well established and nationally recognized, but are viewed by many as pedestrian-unfriendly with unreasonably difficult requirements for installing a marked crossing.

Longmont's transportation system should be consistent throughout the community, and relatively consistent with our neighbor communities, so that expectations of all pedestrians and drivers are met and "surprises" are minimized. These guidelines are based on research and best practices in surrounding Front Range communities and around the country, and recommended crossing treatments are consistent with treatments used by CDOT and nearby communities. A separate document, *Support Material for Pedestrian Crossing Treatment Guidelines*, summarizes research and best practices related to these City guidelines.

Following are pedestrian crossing and treatment policies that support Longmont's goal of providing a safe pedestrian environment within a balanced transportation system.

1.1 Avoid overuse of Crossings and Treatments

Following are reasons to avoid the overuse of pedestrian crossings and treatments:

- The MUTCD (2003 edition) recommends against indiscriminate use of crosswalks,
- Research by FHWA and other sources suggests that overuse of crosswalks and treatments can lead to reduced compliance, effectiveness and safety,
- Crosswalks and treatments at locations with low pedestrian levels lose their effectiveness and become less safe, as drivers rarely see pedestrians and ignore the treatments,
- Installation and maintenance of unnecessary crossings and treatments is an inefficient use of limited City resources,
- Inappropriate crossings and treatments may increase the risk of liability.

While crossings and treatments may be effective at many individual crossing locations, their overuse can result in their decreased effectiveness if drivers become desensitized (and disrespectful) to them. Therefore, these minimum pedestrian and vehicle volume criteria should be followed for installation and removal of pedestrian crossing treatments.

1.2 Minimum Pedestrian Volume for Installation of Crossings and Treatments

Marked pedestrian (and school) crossings and treatments should only be installed where the following levels of pedestrian (or bicycle) crossing volumes exist:

1. 20 or more pedestrians per hour during any single hour of an average day, or
2. 18 or more pedestrians during each of any two hours of an average day, or
3. 15 or more pedestrians during each of any three hours of an average day.

Young, elderly and disabled pedestrians count two times (2x) toward these volume thresholds; so that a crossing with 10 students (elementary or middle school) meets the 20 pedestrian volume threshold.

1.3 Minimum Vehicular Volume for Installation of Crossings and Treatments

Pedestrians (and students) can normally cross a street with low traffic volumes safely and quickly

without marked crosswalks and treatments. Therefore, marked pedestrian (and school) crossings and treatments should only be installed at locations where the average daily traffic (ADT) is at least 1,500 vehicles per day (vpd). School crossings and treatments can also be installed if hourly vehicle traffic exceeds 10% of required ADT during a peak hour of student activity when pedestrian volumes also exceed their minimum threshold. School crossing treatments are normally installed where student pedestrian volumes and vehicular volumes exceed these thresholds during peak school times and the crossing is along a school route.

These installation thresholds apply to crossings that are either uncontrolled or controlled by a stop or yield sign. Crossings controlled by a traffic signal are discussed in Section 1.8.

1.4 Removal of Marked Crosswalks and Treatments

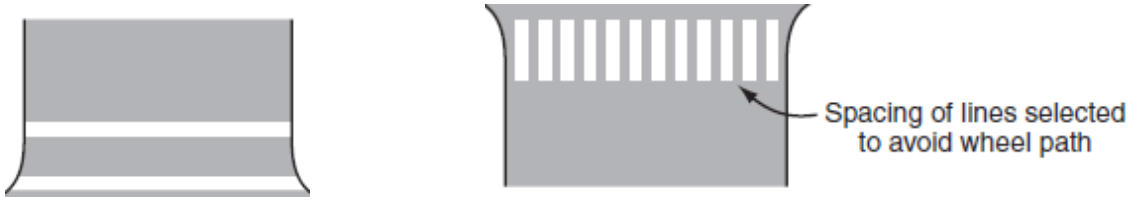
Conditions can change over time so that a crossing and/or specific treatment(s) may no longer be needed. If traffic volumes or pedestrian (or student) volumes drop below 50% of their minimum thresholds for installation, then removal of the marked crosswalk should be considered. If conditions change and some treatments are no longer appropriate or justified, then these treatments may be changed or removed. Existing crossings or treatments may be evaluated when there is a planned roadway rehabilitation or overlay project, change in land use, need for replacement or maintenance of crossing markings and/or treatments, safety or operational issues, installation of alternate pedestrian facility or crossing, or other conditions that bring to question the need for a marked crosswalk or the appropriateness of it's treatments.

1.5 Multi-Use Path Crossings

Our goal is to promote the use of multi-use paths around Longmont, and roadway crossings often create barriers for pedestrians and bicyclists. Therefore, crossing locations connecting a multi-use path on each side of a roadway are not subject to minimum pedestrian volume criteria for installation or removal of markings and treatments. Locations where a multi-use path ends on one side of a roadway crossing and a sidewalk or similar facility exists on the other side of the crossing must meet 50% of the pedestrian volume threshold for installation, and are subject to removal if pedestrian volumes fall below half of this reduced threshold. Minimum vehicular volume criteria still apply for installation (Section 1.3) and possible removal (Section 1.4) of marked crosswalks and treatments at these multi-use paths.

1.6 Crosswalk Markings

Longmont's goal is to provide safe crosswalks for pedestrians in a cost-efficient manner. High visibility markings such as Continental crosswalks are more expensive to install as they typically require 30-75% more pavement marking material than standard (or transverse) crosswalks. Standard crosswalk markings are typically used at crossings controlled by traffic signals, stop signs, or yield signs. Continental markings should be used where their higher visibility can provide additional benefit, such as uncontrolled crossings and school crossings. The following table describes the style of crosswalk markings that will generally be installed under different crossing situations:



Vehicle Control at Crossing	Pedestrian Crossing	School Crossing
Traffic Signal	Standard	Standard or Continental
Stop or Yield	Standard	Continental
Uncontrolled at Intersection	Continental	Continental
Uncontrolled Mid-block	Continental	Continental

Longmont may install continental markings rather than standard markings at locations where they could potentially last longer and be more cost-effective, such as intersection approaches with low turning volumes where markings can be located to avoid wheel paths.

1.7 Geometric Elements

Longmont follows the FHWA recommendation that geometric elements, such as median refuge islands, curb extensions, and raised crosswalks, should be considered and installed based on engineering judgment rather than a warrant. These geometric elements are very effective at minimizing pedestrian exposure as they can improve pedestrian visibility, reduce crossing distance, improve accessibility, allow pedestrians to cross a roadway in two stages, provide increased pedestrian (and bicycle) storage, and moderate vehicle speeds to help make gap selection more predictable and safe. While these geometric elements are typically installed at marked crosswalks, they have also proven effective as traffic calming measures at unmarked crossings where pedestrian volumes did not justify a marked crosswalk. Longmont will continue to evaluate and implement these types of geometric elements on a case by case basis at marked and unmarked pedestrian crossing locations. Longmont will also continue to be guided by AASHTO's Green Book and Pedestrian Guide in the design of these elements.

In order for center median refuge islands to be a viable refuge treatment, it should be able to store a group of pedestrians, provide at least two feet on each side for splash protection, and accommodate a bicycle without overhanging into traffic lanes. At higher speeds, wider medians should be used to increase protection of pedestrians. Therefore, center median islands at pedestrian crossings of roadways with 35 mph speed limits or less must be at least 6 feet wide, and are recommended to be 8 feet wide or more if feasible. Along multi-lane roadways or where speeds are 40 mph or higher, center median islands must be at least 8 feet wide. 10 foot wide center median islands are desirable at multi-use path crossings to better accommodate bicycles with child trailers, tandem bicycles, or groups of bicycles.

Curb extensions improve visibility of pedestrians, shorten the crossing distance, and moderate speeds of vehicular traffic. Longmont has effectively used these in many locations, including

signalized intersections, STOP controlled intersections, and uncontrolled crossings (marked or unmarked).

Raised pedestrian crosswalks improve visibility of pedestrians, improve accessibility, and moderate the speed of vehicular traffic. Raised pedestrian crossings can be particularly effective at right turn bypass islands and school crossings. Installation may not be possible along roadways that serve as a primary access route for emergency vehicles.



1.8 Traffic Signal Enhancements

It is Longmont's goal to provide the following enhancements at signalized intersections:

- Pedestrian signals, pushbuttons and stop bars at all intersection approaches,
- Marked crosswalks on all intersection approaches with pedestrian facilities on both sides,
- Countdown pedestrian heads to better educate everyone on pedestrian signal operation, and inform pedestrians about remaining available crossing time,
- place pedestrian signals on recall so that the "Walk" phase comes up every signal cycle for crosswalks parallel to major roadways with pedestrian activity and sidewalks present, in order to reduce pedestrian delay; this can be provided as long as traffic operations are not significantly impacted.


These improvements will be phased in as resources become available, and will be prioritized for locations with high pedestrian activity, such as near schools and in business and commercial districts.

1.9 Prioritization

When limited resources restrict our ability to evaluate or install pedestrian crossing treatments, Longmont may need to prioritize our crossing evaluations and installations.

Projects - Crossing treatment evaluations within the limits of Street Rehabilitation, Neighborhood Mitigation, or other Projects in the City will occur during the planning phases of the project in order to allow the treatments to be installed with the Project.

Non-Project – Citizen requests will be evaluated by staff in the order that the requests are received. City initiated evaluations will be performed based on the crash rating or # crashes / severity. Locations that meet these Guidelines for installation will be prioritized based on crossing activity, conflicting vehicle activity, and construction cost. Construction will occur as resources are available.

1.10 Pedestrian Abilities

Recognizing that people have very different abilities as pedestrians, Longmont will consider the unique needs of pedestrians at crossing locations. Research has shown that young, elderly and disabled pedestrians are often more challenged when crossing streets, due to factors such as inattention, ability to judge gaps in traffic, and slower walking speeds.

When counting pedestrians for crossing evaluation Longmont will classify young (middle school age children or younger), elderly, and disabled pedestrians separately and multiply them by two (2) when calculating the total number of pedestrians at crossings. For example, where 20 pedestrians in an hour might be required for a crosswalk, only 10 young or elderly pedestrians would be needed. Longmont will consider special treatments for unique needs where there are high concentrations of these users.

Longmont's *School Safety Program* supplements these guidelines on topics specific to schools.

1.11 Crosswalk Lighting

FHWA recommends that adequate lighting be provided at marked crosswalks to enhance the safety of pedestrians crossing at night. Where there is an expectation of frequent night time pedestrian use, adequate lighting shall be provided at all marked crosswalks. Where infrequent pedestrian use is anticipated, it should be Longmont's goal to provide adequate nighttime lighting at unprotected marked crosswalks, and where feasible and practical at protected marked crosswalks.

1.12 Textured and Colored Pavement Treatments

Applications of textured, brick, or otherwise colored pavement treatments alone do not establish a marked crosswalk. Pavement markings as described in the MUTCD are required to mark crosswalks at intersections, or legally establish crosswalks at mid-block locations. Contrasting pavement treatments can supplement these crosswalk lines as long as they do not reduce the visibility of the crosswalk lines.

1.13 Accessible Crosswalks

It is a Longmont's goal that all crosswalks comply with the Americans with Disabilities Act (ADA) in order to provide and enhance mobility for all users.

1.14 The Other "E"s

These guidelines primarily address Engineering aspects of pedestrian crossings, but other "E"s also help provide a safe pedestrian environment.

Education – Research has found that drivers and pedestrians lack an accurate knowledge of right of way laws in crosswalks at unsignalized intersections. Longmont provides route maps with safety tips for elementary and middle school students who walk and bicycle to school. Longmont will expand the use of crosswalk treatments that help educate drivers and pedestrians, such as:

- "State Law" signs for drivers approaching marked crosswalks,
- Informational signs to instruct pedestrians on how to safely cross, especially at more challenging crossings with high vehicular volumes, multiple lanes, and pedestrian activated treatments.

Enforcement – Pedestrian and driver behavior improves when enforcement is provided. The presence of Longmont police at many schools during peak times reminds everyone to drive slowly in school speed zones. Longmont staff regularly provides an annual crash safety report to the police, and coordinates with police on safety issues related to pedestrians.

Encouragement – Emphasizing a safe pedestrian environment and developing (and maintaining) an extensive sidewalk / path network, are key elements that encourage people to walk. The City of Longmont and the St. Vrain Valley School District have been very active in the statewide Safe Routes to School program and have been awarded grants in recent years. The number of students walking to schools has noticeably increased at schools that actively participate in this program.

2.0 Recommended Treatments for Longmont

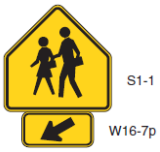
Many treatments are being used in nearby communities with varying degrees of success. The selection of treatments in Longmont will be based on recommendations in recent FHWA and NCHRP reports that include the most thorough research in the United States. Longmont will also try to be reasonably consistent with treatments used in nearby communities. Pedestrian crossing treatments that are traffic control devices will adhere to the current *Manual on Uniform Traffic Control Devices* (MUTCD).

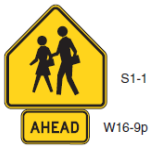
Following are recommended **device categories** and typical treatment options for Longmont:

1. **Unmarked or No Crosswalk** – If criteria are not met to justify a marked crosswalk, then the location will remain an unmarked crossing or will not be established as a mid-block crossing.

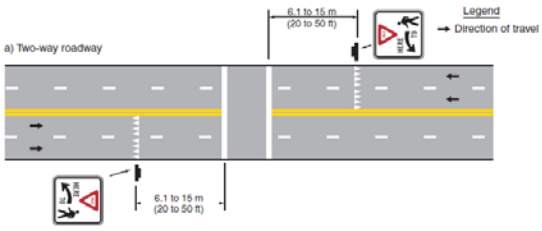
2. **Crosswalk** - Standard or continental crosswalk markings. At uncontrolled crossings install pedestrian crossing sign (W11-2) and diagonal downward pointing arrow plaque (W16-7p)

at the crossing. An additional pedestrian crossing sign (W11-2) in advance is an option at all unsignalized marked crossings. Use school crosswalk warning sign (S1-1) sign for school crossing locations.

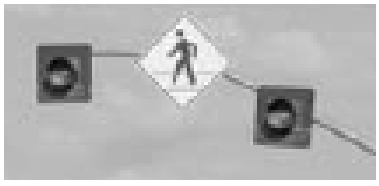




3. **Enhanced** – Supplemental treatments to enhance visibility and increase compliance at crossings without signal or stop sign control:
    a. Roadside Signs - Install "State Law – Yield to Pedestrian" signs at crossing.
    b. In-Street signs – Install "State Law – Yield to Pedestrian within Crosswalk" (R1-6) at the marked crosswalk in the center median island or center of the roadway. Add school plaque (S4-3) for school crossings locations.
    c. Advance Signs and Markings - Install "Yield Here to Pedestrian" (R1-5 or R1-5a) signs in conjunction with yield lines in advance of mid-block marked crosswalks.



4. **Active** – Treatments to display warnings when activated by pedestrians at crossings without signal or stop sign control:
    a. Pedestrian Activated Flashing Signs – Install LED lights on pedestrian crossing sign (W11-2) with nearby pedestrian pushbuttons, which can be activated by a pedestrian with nearby pushbuttons. This treatment is primarily intended for multi-lane crossings, and is not available for use at school crossings.
    b. Overhead Flashing Amber Beacons – Install LED lights on pedestrian crossing sign (W11-2), or beacons next to pedestrian crossing sign (W11-2), on mast arms that extend over the roadway at or in advance of the crossing. These beacons can be activated by pedestrians with nearby pushbuttons, and are normally intended for mid-block crosswalks



5. **Red** – These devices display a circular red signal indication to motorists at the crossing location after pedestrian activation. These signal devices do not service side street motor vehicle traffic.
    a. Pedestrian Crosswalk Signal – Install three section traffic signal head (red, yellow, green) with pushbuttons at mid-block crossing that is activated by a pedestrian. This signal is subject to MUTCD requirements.
    b. Half Signal, HAWK Beacon Signal, or Pedestrian Beacon Signal – These devices are experimental or proposed in 2003 MUTCD, and may be included in future MUTCD revisions. The Half Signal is standard three section head, while the others use "Mickey Mouse Ears" signal heads with two red lenses above a yellow lens.

6. **Signal** – These are standard traffic control signals that serve side street vehicular traffic as well as pedestrians attempting to cross.

These criteria will first determine the appropriate device category, after which the crossing location will be evaluated to select the appropriate treatment within that device category. Specific treatment options and traffic control devices will be selected based on current MUTCD standards, national guidelines and best practices.

Following are some recommendations and restrictions:

- Geometric elements such as center median islands and curb extensions may be considered to enhance pedestrian safety at Marked or Unmarked crossing.
- Some geometric elements are more appropriate when used with other specific treatments; for example, a raised crosswalk are intended for marked crosswalks.
- Significant treatments and possibly geometric elements are needed at uncontrolled marked crosswalks when vehicle speeds are 40 mph or 45 mph, or when crossing 4 lanes or more.
- Traffic control signal or grade separated crossing is needed when crossing 6 lanes or more, or when major roadway speeds are 50 mph or higher.
- Active devices are intended for multi-lane crossings.
- Active devices are not intended for school crossings or crossing locations where vehicular speeds are 45 mph or higher.

3.0 Crossing Evaluation Procedures

This section describes the procedures that should be followed when evaluating a potential new crossing, changes to an existing crossing, or possible removal of an existing marked crosswalk.

3.1 Identify and Describe Crossing Location and Issues

- Identify street, crossing location, and whether it connects to a multi-use path on one or both sides (intersection leg, street address, sidewalks, intersecting path or trail, etc.).
- Document specific issues (citizen request, roadway project, safety history, etc.).
- Identify nearby pedestrian generators (schools, parks, community centers, retirement centers, commercial uses, etc.).

3.2 Physical Data Collection

- Existing roadway configuration and geometric elements (crossing distance, lane configuration, center medians, curb extensions, curb ramps, bike lanes, etc.).
- Posted speed limit along major street at crossing location.
- Existing traffic control and other crossing treatments (lighting, signs, markings, etc.).
- Stopping sight distance (SSD) on all vehicular approaches to the crossing; if SSD does not meet AASHTO Green Book criteria, determine if mitigation is feasible to achieve adequate SSD.

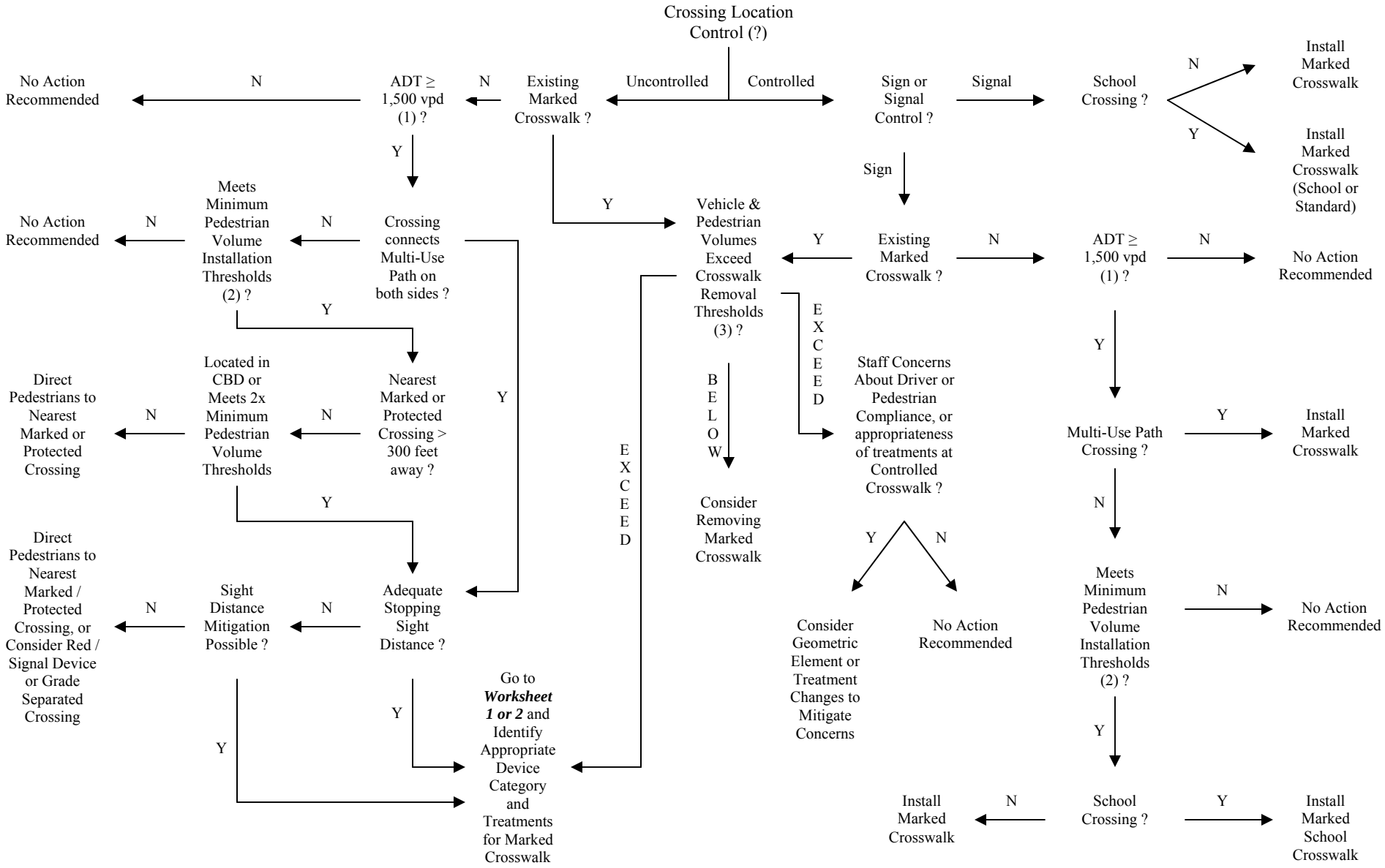
3.3 Vehicular and Pedestrian Data Collection

- Perform pedestrian and bicycle crossing counts during peak hours of pedestrian activity, normally during AM, mid-day and PM peak hours. Young, elderly and disabled pedestrians should be noted. Near elementary and middle schools, students on their way to/from school should be noted, and data collection times should include the 30 minute periods before school opens and after school closes.
- Compile or collect average daily traffic volumes for vehicular traffic along the major roadway at the crossing location, and peak hour volumes at proposed school crossings.
- Compile available crash data (normally during the most recent 3-5 years) near the crossing location, noting crashes involving pedestrians and bicycles attempting to cross the road.

3.4 Evaluation to Determine Appropriate Treatments

Based on data described above, perform the following evaluation:

1. Use ***Figure 1–Pedestrian Crossing Treatment Flowchart*** to evaluate whether a marked crosswalk is needed, and at controlled crosswalks help identify the appropriate treatment.
2. At uncontrolled crossing locations where a crosswalk is needed, use the correct Pedestrian Crossing Evaluation Worksheet (see *Support Material for Pedestrian Crossing Treatment Guidelines*) to determine the appropriate device category (crosswalk, enhanced, active, red, or signal).
3. Evaluate conditions, and select specific treatments and geometric elements.
4. Document the evaluation and treatment selection process.



Notes:

(1) Or ≥ 150 vph at School Crossing during peak school period

(2) **Minimum Pedestrian Volume Installation Thresholds:**
- 20+ pedestrians per hour during any single hour, or
- 18+ pedestrians per hour during each of any two hours, or
- 15+ pedestrians per hour during each of any three hours

[Apply 50% of above thresholds if crossing connects end of Multi-Use Path and sidewalk, Young, elderly and disabled pedestrians count 2x toward volume thresholds]

(3) **Crosswalk Removal Thresholds:**
- pedestrian or vehicular volumes fall below 50% of Installation Thresholds

Figure 1
Pedestrian Crossing Evaluation Flowchart

CITY OF SAN DIEGO, CALIFORNIA

COUNCIL POLICY

CURRENT

SUBJECT: MARKED CROSSWALK CRITERIA AT UNCONTROLLED LOCATIONS

POLICY NO.: 200-07

EFFECTIVE DATE: June 11, 2015

1.0 INTRODUCTION

1.1 Background

Marked crosswalks are an important tool that can enhance pedestrian safety with proper traffic controls on public streets. There have been many changes in technology and practice related to pedestrian safety since Council Policy 200-07 was adopted in 1990. This council policy incorporates those changes and supersedes that policy based on the 2015 City of San Diego Pedestrian Crosswalk Guidelines.

1.2 Purpose

The main function of marked crosswalks is to channelize pedestrians to desirable paths of travel across streets at intersections or mid-block locations. Crosswalks alone at uncontrolled locations do not guarantee the safety protection of pedestrians, therefore careful consideration of their location and warning devices is essential. This Council Policy provides standards for when to install crosswalks at uncontrolled locations, and for when they must be accompanied by other traffic control devices.

Council Policy 200-07 consists of:

- Basic Warrants
- Point Warrants
- Crossing treatments to supplement marked crosswalks
- Requirements for the removal of marked crosswalks

1.3 Summary

Council Policy 200-07 provides the requirements uncontrolled pedestrian crossings must meet in order to be considered for a marked crosswalk, how a crosswalk must be marked, and the process of removal, if necessary.

If a location meets each of the Basic Warrants and scores a minimum of 16 points in the Point Warrants, it qualifies for a marked crosswalk. Point Warrants are indicated in Table 1. In addition, crossing treatments and/or warning devices must accompany the crosswalk. Table 2 identifies categories for crossing treatments that are needed based on thresholds of vehicle volumes and crossing distances. Table 3 lists the crossing treatments for each category.

For unusual conditions not identified in this policy, engineering judgment should be used to apply these guidelines or adjust them to fit individual field site conditions. These guidelines are not intended to be a substitute for engineering knowledge, experience or judgment.

In addition, any removal of a marked crosswalk must follow the procedure outlined in the California Vehicle Code.

2.0 POLICY

2.1 Basic Warrants

Each of the following warrants must be satisfied in order for an uncontrolled location to be considered for a marked crosswalk.

2.1.1. Pedestrian Volume Warrant
The pedestrian volumes must be equal to or greater than ten (10) pedestrians per hour during the peak pedestrian hour. Children under 13, elderly over 64 years and/or disabled persons count as 1.5 pedestrians. Alternatively, this warrant can be satisfied using Latent Pedestrian Demand if conditions (a), (b), or (c) under Table 1, T1.1b are met.

2.1.2. Approach Speed Warrant
The 85th percentile approach speed must be equal to or lower than 40 MPH. This warrant does not apply when a pedestrian hybrid beacon or a pedestrian traffic signal will be installed.

2.1.3. Nearest Controlled Crossing
The proposed location must be farther than 250 feet from the nearest controlled pedestrian crossing (measured from the nearest edge of the proposed marked crosswalk to the closest edge of the controlled crossing).

2.1.4. Visibility Warrant
The motorist must have an unrestricted view of all pedestrians at the proposed location for a distance required by the following table (stopping sight distance is to be interpolated when 85th percentile speed is between 5 mph increments):

85th Percentile Speed (MPH)	Stopping Sight Distance (feet)
25	150
30	200
35	250
40	300

2.1.5. Illumination Warrant
The proposed location must have existing lighting.

2.1.6. Accessibility Warrant
The proposed location must have existing accessibility to disabled pedestrians or have accessibility improvements programmed.

2.2 Point Warrants

Point warrants are the number of points a location is required to meet (in with the Basic Warrants above) to qualify for a marked crosswalk. Sixteen points are required and can be achieved through pedestrian volumes or latent pedestrian demand, general conditions, and/or the average gaps in traffic. A summary of each Point Warrant and the allocation of points are presented in Table 1. A discussion of each Point Warrant variable follows the table.

Table 1: Point Warrants

T1.1a Pedestrian Volume Warrant		
Number of Pedestrians (Peak Hour)	**Points**	**Total Available Points**
10 – 25	4	10
26 – 50	8	
51+	10	
T1.1b Latent Pedestrian Demand Warrant (in lieu of Pedestrian Volume Warrant)		
Condition	**Points**	**Total Available Points**
(a) The proposed crosswalk is in a commercial, mixed land use, or high density residential area.	3	10
(b) A pedestrian or shared use path is interrupted by a restricted crossing.	3	
(c) A pedestrian attractor/generator is directly adjacent to the proposed crosswalk as defined in the explanatory notes below.	4	
T1.2 General Condition Warrant		
Condition	**Points**	**Total Available Points**
(a) The nearest controlled crossing is greater than 300 feet from the proposed crosswalk.	3	18
(b) The proposed crosswalk will position pedestrians to be better seen by motorists.	3	
(c) The proposed crosswalk will establish a mid-block crossing between adjacent signalized intersections or it will connect an existing pedestrian path.	3	
(d) The proposed crosswalk is located within ¼ mile of pedestrian attractors/generators as defined in the explanatory notes below.	3	
(e) An existing bus stop is located within 100 feet of the proposed crosswalk.	3	
(f) Other factors.	3	

Table 1: Point Warrants (continued)

T1.3 Gap Time Warrant		
Average Number of Vehicular Gaps per Five-Minute Period	**Points**	**Total Available Points**
0 – 0.99	0	10
1 – 1.99	1	
2 – 2.99	8	
3 – 3.99	10	
4 – 4.99	8	
5 – 5.99	1	
6 or over	0	
Total Available Points		**38**

Table 1, Explanatory Notes:

T1.1a Pedestrian Volume Warrant

The Pedestrian Volume Warrant assigns point values based on pedestrian crossing volumes at the proposed location. Children under 13, elderly over 64 years and/or disabled persons count as 1.5 pedestrians.

T1.1b Latent Pedestrian Demand Warrant (in lieu of Pedestrian Volume Warrant)

The Latent Pedestrian Demand Warrant may be used in lieu of the Pedestrian Volume Warrant.

T1.2 General Condition Warrant

The General Condition Warrant presents six (6) unique categories. A location can score either zero (0) or three (3) points for each unique category, making a total of 18 points possible. The general conditions include the following:

(a) *The nearest controlled crossing is greater than 300 feet from the proposed crosswalk.*
The distance should be measured from the proposed location of the crosswalk to the nearest controlled intersection, i.e. stop sign, traffic signal, etc.

(b) *The proposed crosswalk will position pedestrians to be better seen by motorists.*
This condition should be considered at locations where one leg of the intersection provides better sight distance than the other legs or midblock location with better sight distance.

(c) *The proposed crosswalk will establish a mid-block crossing between adjacent signalized intersections.*
This warrant refers to a condition where there is a major pedestrian attractor/generator nearby, and an adequate crossing can be provided that could help channelize a heavy flow of mid-block pedestrians.

Table 1: Point Warrants (continued)

(d) *The proposed crosswalk is located within ¼ mile of a pedestrian attractor/generator as defined below:*
- International Border Crossing
- Major Multi-Modal Transit Centers
- Transit Stops
- Elementary/Middle/High Schools
- Universities and Colleges
- Neighborhood Civic Facilities (Libraries, Post Office & Religious Facilities)
- Neighborhood and Community Retail
- Pedestrian Intensive Beaches
- Parks & Recreation (excludes non-useable open space)
- Mixed Land Uses (housing near employment and/or commercial)

(e) *A bus stop is located within 100 feet of the proposed location.*
This warrant applies if there is a bus stop within 100 feet of the proposed crosswalk.

(f) *Other factors.*
Other factors allow for extenuating circumstances not covered in the proposed warrants. These are to be evaluated using engineering judgment.

T1.3 Gap Time Warrant

Gap time is the time needed for a pedestrian to cross the travelled lanes of a roadway at an average walking speed without the need for a driver to yield. The number of usable gaps (or gaps that exceed the minimum time needed to cross) are counted during the peak vehicular hour and averaged per five-minute period.

2.3 Crossing Treatments

2.3.1 Crossing Treatment Thresholds

If the proposed crossing location meets the criteria set by both the Basic and Point warrants, the next step is to evaluate the most appropriate crossing treatment(s) to be installed with the marked crosswalk. Marked crosswalks at streets that have less than 1,500 ADT can be installed with signs and markings alone. Table 2 provides thresholds for determining whether additional treatments are required prior to installing a marked crosswalk. The thresholds are based on vehicle volumes, vehicle speeds, and pedestrian crossing distance at the proposed location. Location types are divided into categories A, B, C, and D, and are used to determine the appropriate treatment for the proposed marked crosswalk location.

Table 2: Crossing Treatment Thresholds for Uncontrolled Marked Crosswalks if Warrants are Met

Crossing Distance[2]	Roadway ADT (vehicles per day)									
	< 1,500	1,501 – 5,000		5,001 – 12,000		12,001 – 15,000		> 15,000	
< 40’	A	B		B		C		C	D[1]
40’ to 52’	A	B		C		C	D[1]	D	
> 52’	A	B	C[1]	C	D[1]	D		D	

1. For streets with more than one lane at an approach or posted speed limit 30 mph or greater.
2. Crossing distance can be measured to a pedestrian refuge island if one is present.

2.3.2 Crossing Treatments

Table 3 presents treatment requirements for the categories shown in Table 2. As new devices or treatments are proven, they may be considered in lieu of these treatments, with the City Engineer’s approval.

Table 3: Crossing Treatments for Uncontrolled Marked Crosswalks if Warrants are Met

Category	*Crossing Treatments*
A	**The following is required:** • **(W11-2) Pedestrian Warning Signage with the corresponding (W16-7P) arrow plaque as shown in CA MUTCD Section 2C.50**
B	**At least one of the following is required:** • **(R1-6) State Law – Yield to Pedestrian sign if median is present** • **Rectangular Rapid Flashing Beacons (RRFBs)** • **Raised crosswalk or other traffic calming treatments if the City of San Diego’s Traffic Calming Guidelines are met**
C	**At least two of the following are required:** • **Radar Speed Feedback Signs** • **Striping changes such as narrower lanes, painted medians, road diets, or other speed reducing treatments.** • **RRFBs** • **Staggered crosswalks and pedestrian refuge island** • **Horizontal deflection traffic calming treatments[1] if the City of San Diego’s Traffic Calming Guidelines are met**
D	**A Traffic Signal is required if the CA MUTCD warrants are met and it is recommended by a traffic engineering study. Otherwise at least one of the following is required:** • **Pedestrian Hybrid Beacon if the CA MUTCD warrants are met** • **Horizontal deflection traffic calming treatment[1] with RRFBs if the City of San Diego’s Traffic Calming Guidelines are met**

1. Horizontal deflection treatments include, but are not limited to: roundabouts, pedestrian refuge islands, and pedestrian pop-outs.

2.4 Stop Controlled Crosswalks

At stop controlled intersection approaches, stop signs are the major factor controlling both the motorist's and pedestrian's behavior, rather than crosswalk markings. The warrants reflected in this policy do not apply at stop controlled intersection approaches. At such approaches stop bars are intended to define pedestrian paths. A marked crosswalk may be installed at a stop controlled intersection on a case by case basis if a clear benefit to pedestrians is demonstrated. Examples of such demonstrated benefits are:

- An all-way stop controlled intersection where at least one street is a one-way street with more than one lane, and marking the far side crossing will highlight pedestrian crossing (all approaches that pedestrians are allowed to cross should be marked in this case).

- An all-way stop controlled intersection where pedestrians are restricted on one or more legs and marking the alternate crossing routes will highlight where pedestrians are allowed to cross.

2.5 Removal of Crosswalks

It shall be the Policy of the City of San Diego to follow the California Vehicle Code requirements when a crosswalk is considered for removal.

The California Vehicle Code, Section 21950.5, states the following:

(a) An existing marked crosswalk may not be removed unless notice and opportunity to be heard is provided to the public not less than 30 days prior to the scheduled date of removal. In addition to any other public notice requirements, the notice of proposed removal shall be posted at the crosswalk identified for removal.

(b) The notice required by subdivision (a) shall include, but is not limited to, notification to the public of both of the following:

(1) That the public may provide input relating to the scheduled removal.

(2) The form and method of providing the input authorized by paragraph (1).

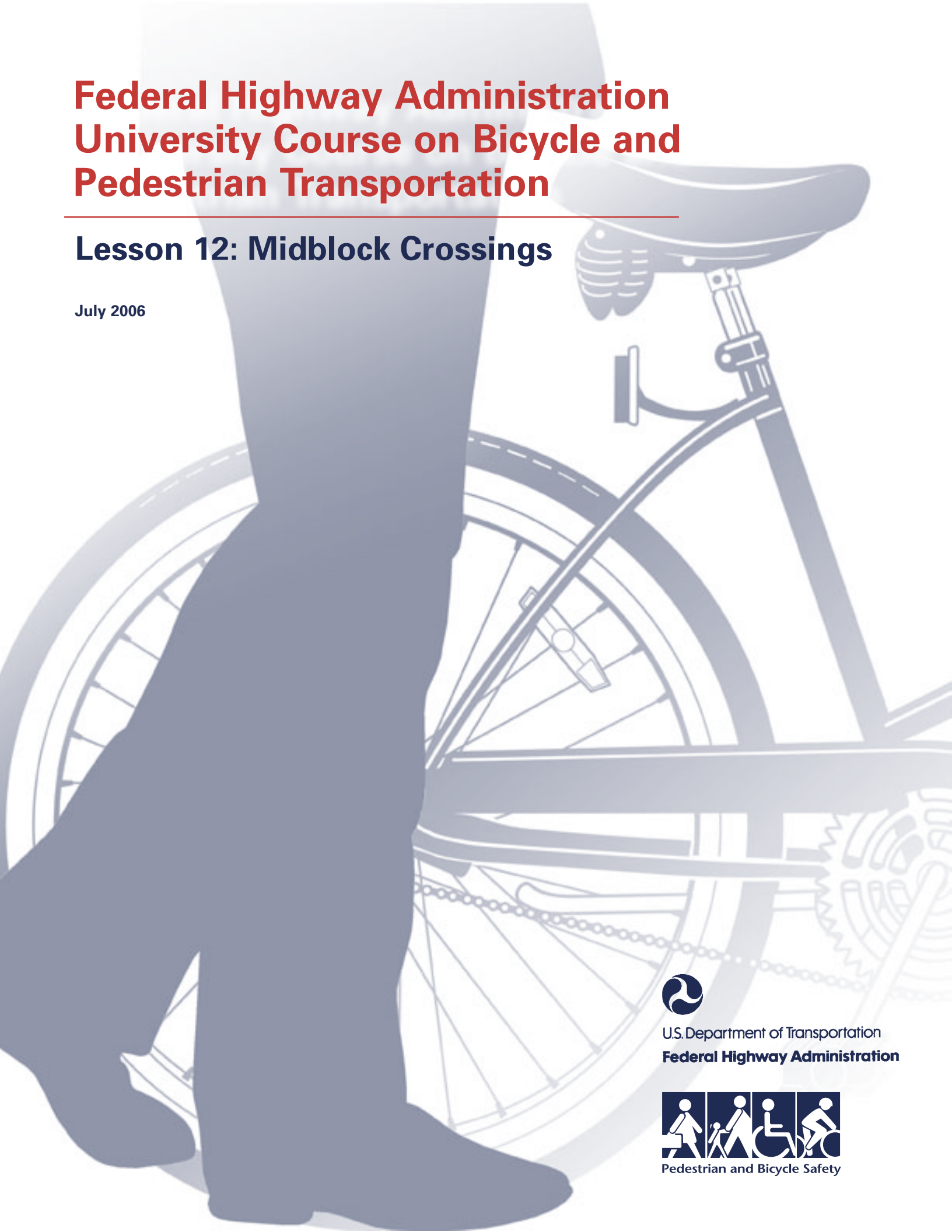
3.0 HISTORY:

"Installation of Parking Facility Guide Signs"
Adopted by Resolution R-171103 - 05/31/1962
Repealed by Resolution R-212199 - 12/12/1974
"Comprehensive Pedestrian Crossing Policy"
Adopted by Resolution R-275560 - 04/23/1990
"Marked Crosswalk Criteria at Uncontrolled Locations"
Amended by Resolution R-309772 - 06/11/2015

Federal Highway Administration University Course on Bicycle and Pedestrian Transportation

Lesson 12: Midblock Crossings

July 2006



U.S. Department of Transportation
Federal Highway Administration

Pedestrian and Bicycle Safety

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

Table of Contents

List of Figures

LESSON 12

MIDBLOCK CROSSINGS

12.1 Introduction

Designers often assume that pedestrians will cross roadways at established intersections. However, observation of pedestrian behavior clearly indicates that people routinely cross at midblock locations. Pedestrians will rarely go out of their way to cross at an intersection unless they are rewarded with a much improved crossing—most will take the most direct route possible to get to their destination, even if this means crossing several lanes of high-speed traffic.

Well-designed midblock crossings can actually provide many safety benefits to pedestrians when placed in proper locations. This chapter discusses those benefits and explains several basic design principles for midblock crossings. The major sections of this lesson are as follows:

12.2 Background

For most of this century—since pedestrians and motorists began competing for space—safety campaigns have directed pedestrians to walk to intersections to cross roadways. This is helpful advice, especially in downtown locations where signalization is frequent, where cycle lengths are short, where blocks are short, and where intersections are small and compact. But with the advent of the modern suburb, blocks are much longer, signalization is less frequent, some intersections are very wide, and vehicle speeds are much higher than in downtown areas. Under these conditions, crossing at intersections becomes less practical and often more dangerous.

Today's designer is challenged to find workable crossing points to move pedestrians across high-speed roadways. When convenient and manageable crossing points are not identified, most pedestrians cross at random, unpredictable locations. In making random crossings, they create confusion and add risk to themselves and drivers.

This chapter addresses several ways to facilitate nonintersection crossings: medians and refuge islands, midblock crossings, and grade-separated crossings. By placing medians along multilane roadways, the designer helps channel pedestrians to the best locations: where gaps are more frequent; where lighting is improved; and where motorists have the best chance to search, detect, recognize, and respond to the presence of pedestrians (see figure 12-1). Where there are medians, the pedestrian still may cross at random locations, but because of the increased frequency of acceptable gaps and greatly reduced conflicts, the pedestrian is more likely to find a longer gap and then walk (not rush) across the roadway.

Midblock crossings are an essential design tool. All designers must learn the best placement, geometrics, and operations of midblock crossings.

Figure 12-1. Photo. Midblock crossings are easily located on low-volume, low-speed roadways such as short collectors through neighborhoods.

12.3 Medians and Refuge Islands—Powerful Safety Tools

A median or refuge island is a raised longitudinal space separating the two main directions of traffic. Median islands, by definition, run one or many blocks. Refuge islands are much shorter than medians, with a length of 30.5–76.2 meters (m) (100–250 feet (ft)). Medians and refuge islands can be designed to block side-street or driveway crossings of the main road, as well as block left-turning movements. Because medians reduce turning movements, they can increase the flow rate (capacity) and safety of a roadway.

Medians have become an essential tool in minimizing the friction of turning and slowing vehicles. Medians maximize the safety of the motorist and pedestrian. Medians have been extensively studied by the Georgia and Florida Departments of Transportation (DOTs). Based on more than 1609.3 centerline kilometers (km) (1,000 centerline miles (mi)) of conversion from two-way left-turn lanes (TWLTLs) to raised medians, motorist crashes were reduced dramatically. Florida DOT (FDOT) research has shown that pedestrians are at high risk while standing in TWLTLs.[(1)]

Midblock crossings can be kept simple and are easily located on low-volume, low-speed (40.2–48.3 kilometers per hour (km/h) (25–30 miles per hour (mi/h)) roadways such as short collectors through neighborhoods. When collectors are longer and handle more traffic and higher speeds, medians or refuge islands are helpful and sometimes essential (see figure 12-2). On multilane minor and major arterials, refuge islands or raised medians are essential. However, when used, crosswalks must be placed with great care in these locations, especially once travel speeds exceed 64.4 km/h (40 mi/h).

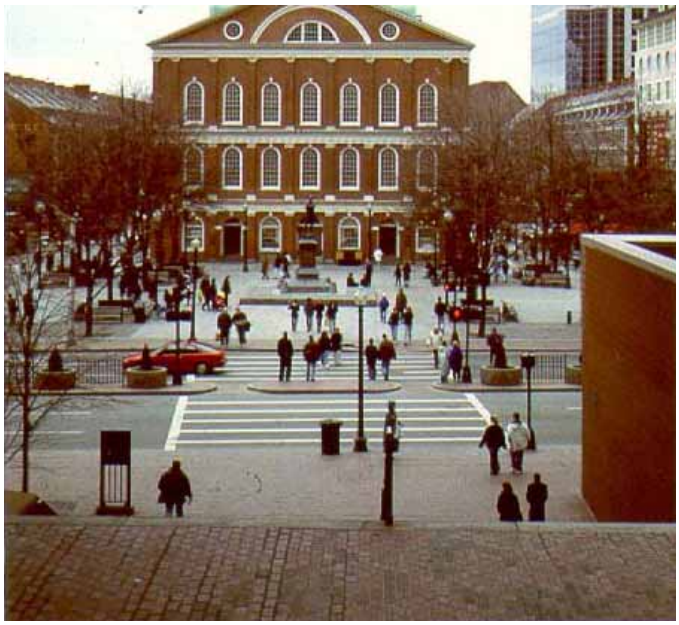


Figure 12-2. Photo. Refuge islands and visible crosswalks are essential on major arterials with higher traffic speeds.

12.4 Advantages of Medians

Medians separate conflicts in time and place. The pedestrian faced with one or more lanes of traffic in each direction must determine a safe gap in two, four, or even six lanes at a time. This is a complex task requiring accurate decisions. Younger and older pedestrians have reduced gap acceptance skills compared with pedestrians in other age groups. Pedestrians also typically have poor gap assessment skills at night. Many may predict that a car is 61.0 m (200 ft) off when, in fact, it is only 30.5 m (100 ft) away, far too close to attempt a crossing.

Medians Allow More Frequent Gaps

Not only do medians separate conflicts, but they also create the potential for acceptable gaps. On a standard-width, four-lane roadway with a center left-turn lane (19.5 m (64 ft) wide, with five 3.7-m (12-ft) lanes plus two 61.0-centimeter (cm) (24-inch) gutter pans), it takes an average pedestrian traveling 1.2 m/second (s) (4 ft/s) nearly 16 s to cross. Finding a safe 16-second gap in four moving lanes of traffic may be difficult or impossible. In any event, an attempt to cross may require a wait of 3–5 minutes (min). Faced with such a substantial delay, many pedestrians select a less adequate gap, run across the roadway, or stand in the center left-turn lane in hope of an additional gap. If a raised median is placed in the center, the pedestrian now crosses 7.9 m (26 ft) instead. This requires two 8-second gaps (see figures 12-3 and 12-4). These shorter gaps come more frequently. Based on traffic volume and the platooning effects from downstream signalization, the pedestrian may be able to find an acceptable gap in a minute or less.

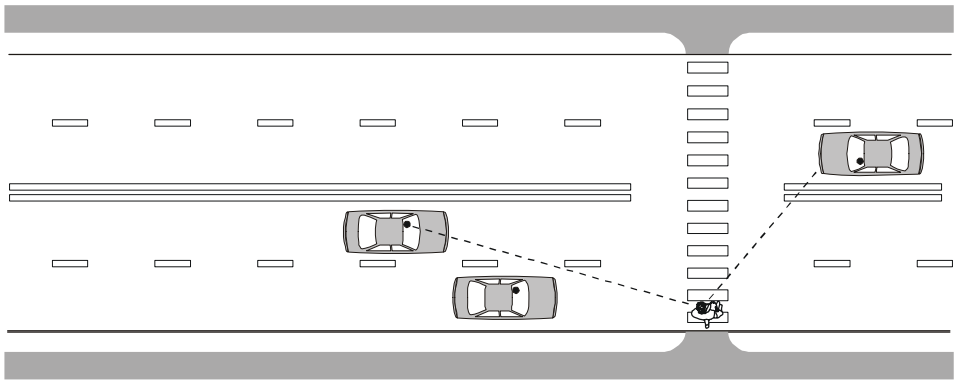


Figure 12-3. Photo. A midblock crossing without median refuge requires the pedestrian to look for gaps in both directions at once.

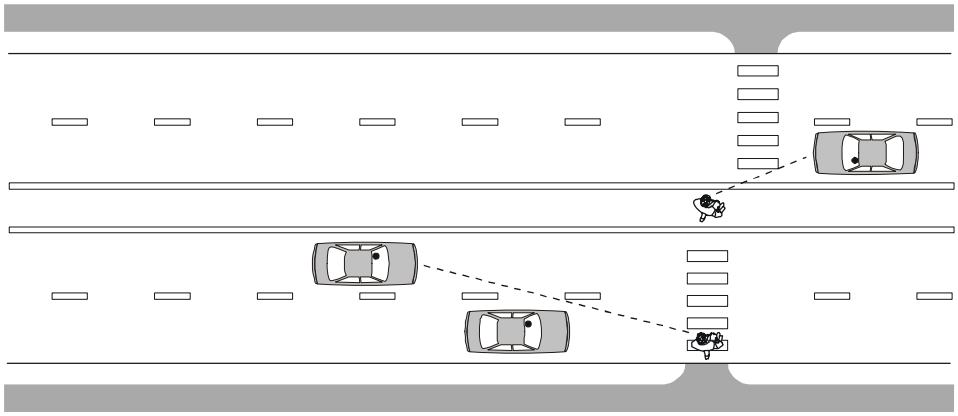


Figure 12-4. Photo. A midblock crossing with a median refuge allows the pedestrian to look for gaps in only one direction at a time.

Medians Are Less Expensive To Build

The reduced construction cost of a median versus a center left-turn lane comes as a surprise to many designers. Grass medians allow natural percolation of water, thus reducing drainage and water treatment costs. Medians do not require a base or asphalt. Curbing is essential in urban sections where medians are typically raised above the level of the street. In general, however, medians average a 5- to 10-percent reduction in materials and labor costs compared to a center left-turn lane.

Medians Are Less Expensive To Maintain

While there is only a slight savings in cost to build a raised median versus a center left-turn lane, there is a substantial savings in maintenance. An FDOT study compared 6.4 km (4 mi) of median versus center left-turn lane maintenance costs and found that medians save an average of 40 percent on maintenance costs based on a 20-year roadway life. More frequent resurfacing, such as every 7 to 9 years, would show much greater savings. This, too, surprises many designers. During the full life of the roadway asphalt, a raised median saves costs associated with sweeping accumulated debris, repainting lines, replacing raised pavement markers, and resurfacing lanes.

12.5 Design Considerations for Medians

Ideally, a median should be at least 2.4 m (8 ft) wide to allow the pedestrian to wait comfortably in the center, 1.2 m (4 ft) from moving traffic. A wider median is necessary if it must also serve the purpose of providing a left-turn bay for motor vehicle traffic at intersections. If the desired 2.4 m (8 ft) cannot be achieved, a width of 1.8 m (6 ft), or 1.2 m (4 ft) will be sufficient. To find the needed width, especially in a downtown or other commercial environment, consider narrowing travel lanes to an appropriate width. In most locations, this reduction in travel lanes can only be made to 3.4 m (11 ft), but in many other locations, where speeds are in the 32.2–48.3-km/h (20–30-mi/h) range, the reduction to 3.0 m (10 ft) or even 2.7 m (9 ft) is possible, and may even be desirable.

Medians typically have an open, flat cut and do not ramp up and down due to the short width. If the island is sufficiently large, then ramps approved by the Americans with Disabilities Act (ADA) (1:12 grade) can be used. It is best to provide a slight grade (2 percent or less) to permit water and silt to drain from the area. Median cuts work best at midblock crossings.

12.6 Midblock Crossings by Roadway Classification

Midblock crossings are located and placed according to a number of factors, including roadway width, traffic volume, traffic speed and type, desired lines for pedestrian movement (see figure 12-5), and adjacent land use. Guidance for median placement on various types of roadways appears below.

Figure 12-5. Photo. Landscaping a median can block midblock access and divert pedestrians to adjacent intersections.

Local Roads

Due to their low traffic speed and volume, local roadways rarely have median treatments. Some exceptions may apply, especially around schools and hospitals, where traffic calming is desired, and in other unique locations.

Collector Roads

Two-lane collector roads occasionally have medians or refuge islands to channel pedestrians to preferred crossing locations. Used in a series, these refuge islands have a strong visual presence and act as significant devices to slow motorist travel through the corridor. A 16.1-km/h (10-mi/h) speed reduction (from to 64.4 to 48.3 km/h (40 mi/h to 30 mi/h)) has been achieved. Pedestrians crossing at these midblock refuge islands with marked crosswalks (who also make their intent to cross known) achieve a nearly 100-percent favorable response from motorists.

When collector roads are widened to four lanes (not recommended), raised medians may be essential. A boulevard-style street with tree canopies is recommended. This canopy effect helps reduce travel speeds.

Multilane Arterial Highways with Four Lanes

Suburban crossings of four-lane roadways are greatly improved when medians and midblock crossings are used. On lower-volume roadways, it is best not to use signalization.

Signalization may be helpful or even essential under the following conditions:

- On higher volume roadways.
- Where gaps are infrequent.
- In school zones.
- Where elderly or disabled pedestrians cross.
- Where speeds are high.
- When a number of other factors are present.

Multilane Arterial Highways with Six or More Lanes

On multilane arterials with six or more lanes, merging is occurring, lane changing increases, and there is a greater tendency for motorists to speed and slow. This creates highly complex conditions that must be interpreted by the pedestrian.

At midblock locations, where vehicle speeds are high, signalization may be the only practical means of helping pedestrians to cross unless as part of a signal coordination scheme. At high speeds and with infrequent signal calls, high numbers of rear-end crashes can be anticipated. It is best not to allow urban area roadways to achieve high corridor speeds. This is especially true in areas where land use supports higher densities. The higher the speed, the greater the engineering challenge to cross pedestrians safely.

If a pedestrian crossing is needed in such a location, the designer must increase the devices used to alert the motorist. The standard pedestrian crossing and advanced crossing symbols with signs measuring 91 by 66 cm (36 by 26 inches) are an absolute minimum for speeds of 64.4 km/h (40 mi/h) or greater. Pavement word symbols can be used as further enhancements. An enhanced crosswalk marking such as a zebra- or ladder-style crossing should be considered. Large overhead signs, flashing beacons, bulb-outs (see figure 12-6), and even flashing overhead signs have been successfully used in some locations.

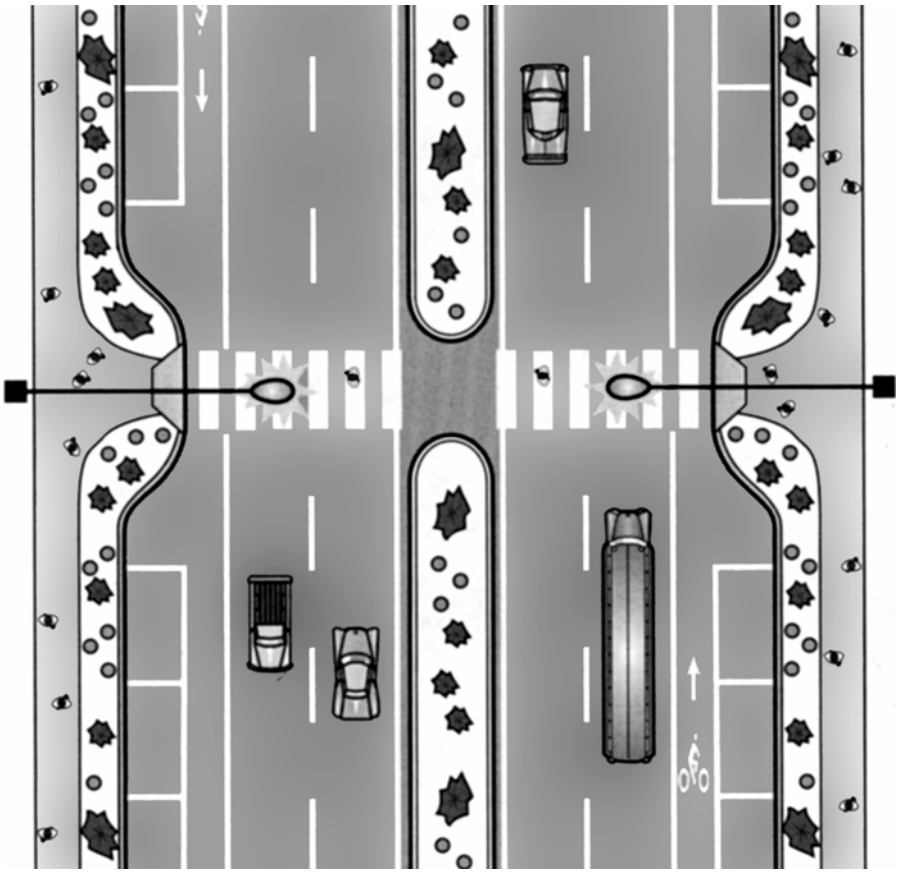


Figure 12-6. Illustration. Midblock crossing curb extensions provide better visibility for motorists and pedestrians.

12.7 Midblock Crossing Design

The design of midblock crossings makes use of warrants similar to those used for standard intersections. Stopping sight distances, effects of grade, cross slope, the need for lighting, and other factors all apply. The design considerations for medians are covered earlier in this lesson. However, there are a number of added guidelines that must be followed.

Connect Desire Lines

All other factors considered, pedestrians and bicyclists have a strong desire to continue their intended path of travel. Look for natural or existing patterns. Use of a high-angle, time-lapse video camera to map pedestrian crossings quickly paints this location, if it is not already well known.

Lighting

Motorists need to see both the pedestrians who stand waiting to cross and those who are already crossing. Either direct or back lighting is effective. Some overhead signs such as in Portland, OR, and Seattle, WA, use overhead lights that identify the pedestrian crossing and also shine down on the actual crosswalk.

Grade-separated crossings at midblock or intersection locations are effective in a few isolated circumstances (see section 12.11 for a further discussion of grade-separated crossings). However, because

of their cost and their potentially low use, engineering studies should be conducted by experienced designers. If given a choice, on most roadways, pedestrians generally prefer to cross at grade.

12.8 Staggered Midblock Crosswalks

Staggered crosswalks (or Z-crossings) are treatments in which the crosswalk is split by a median and is offset on either side of the median. This configuration forces pedestrians to turn in the median and face oncoming traffic before turning again to cross the second half of the crosswalk. Notice in figure 12-7 how, in either walking direction, the pedestrian must turn slightly toward traffic before crossing. In order to curtail shortcutting and force pedestrians to follow the intended path, some medians may also have attractive fencing to corral pedestrians in the correct direction (see figure 12-8). One problem with staggered crosswalks is that they may present a challenge for visually impaired pedestrians who are thrown off course by changes in the direction of the walkway leading to the road. A solution is to provide detectable warnings and/or railings to help realign the pedestrian perpendicularly to the roadway just before the crossing.

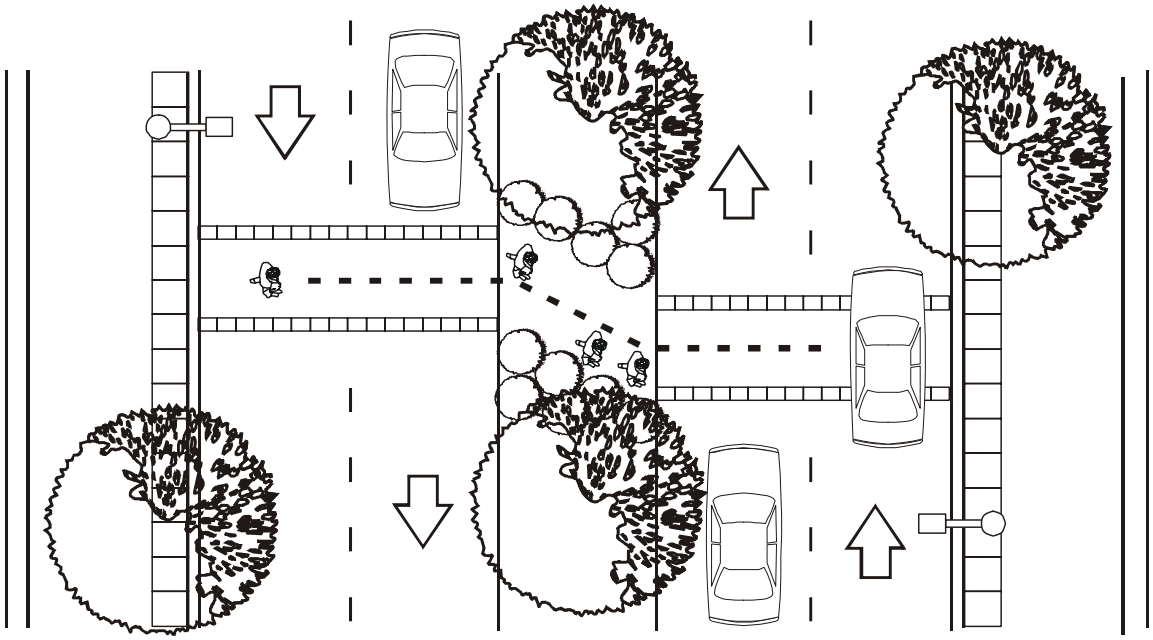


Figure 12-7. Illustration. Diagram of a staggered crossing configuration.

Source: *Southeast Neighborhood Traffic Management Plan*[(2)]

Figure 12-8. Photo. Staggered crosswalk with fencing.

Source: Pedestrian and Bicycle Information Center (PBIC)
Image Library, http://www.pedbikeimages.org[3]

12.9 Midblock Crossing and Detection Technology

Midblock crossings can be enhanced and made safer by the installation of some of the same crossing and detection technology found at intersections and other walkway locations. Refer to these previous sections for a discussion of these technologies:

- Pavement markings and signing (lessons 10.4–10.8).
- In-pavement flashers (lesson 10.9, "Intelligent Transportation Systems Technology").
- Automated detection devices (lesson 10.9, "Intelligent Transportation Systems Technology").
- Street lighting (lesson 9.5, "Ambience, Shade, and Other Sidewalk Enhancements").
- Pavement surfaces and detectable warning (lesson 9.3, "Basic Sidewalk Elements").
- Other crossing technologies (lesson 11.5, "Crossing and Detection Technology").

12.10 Midblock Signals

The placement of midblock signals is called for in some locations. The warrants provided in the *Manual on Uniform Traffic Control Devices* (MUTCD) should be followed. But even more caution must be provided for signalized midblock locations. Pedestrians feel frustrated if a signal is holding them back from crossing when there is an ample gap. Many will choose to cross away from the crossing, while others will dutifully push the activator button, not get an immediate response, and cross when there is a sufficient gap. A few seconds later, the approaching motorists must stop at a red signal for no reason, which can encourage motorist disrespect for the signal in the future.

Thus, the best signal setup for a midblock crossing is a hot (nearly immediate) response. As soon as the pedestrian call actuator button is pushed, the clearance interval should be activated. This minimal wait

time is a strong inducement for pedestrians to walk out of their way to use the crossing. Hot responses can often be used if the nearby signals are not on progression, or else a hot response may be permitted in off-peak hours. Midblock signals should be part of a coordinated system to reduce the likelihood of rear-end crashes and double cycles (i.e., two pedestrian cycles per one vehicle cycle at intersections to reduce pedestrian delay).

If a midblock signal system is used, it is important to place pedestrian pushbuttons in the median. There will be times when some pedestrians start too late or when older pedestrians lack time to cross, even at 0.9 m/s (3 ft/s). In these rare instances, the pedestrian needs to reactivate the signal.

12.11 Grade-Separated Crossings

According to the North Carolina DOT (NCDOT) *Bicycle Facilities Guide*, a grade-separated crossing "provides continuity of a bicycle/pedestrian facility over or under a barrier."[4]

A grade-separated crossing such as a bridge/overpass or a culvert/underpass should be considered when a pedestrian facility meets a barrier like an active multitrack railroad, stream, or freeway (see figure 12-9).

Figure 12-9. Photo. An underpass continues this shared-use bicycle path beneath a four-lane highway with high traffic volume.

Source: *Bicycle Facilities Guide: Types of Bicycle Accommodations*[4]

Some principal planning concerns with grade-separated crossings are:

- This type of facility can be expensive and difficult to implement. For these reasons, advance planning, identification of a source of funds, and a compelling purpose and need are primary factors in obtaining approval for construction of bicycle/pedestrian bridges or underpasses.
- Bicycle/pedestrian grade separations to be included in State highway construction projects should already be identified in locally adopted bicycle or greenway master plans by the time a proposed highway improvement is in the early stages of development.
- Many bicyclists and pedestrians will not use an overpass that is inconvenient. Instead, pedestrians may choose a time-saving and sometimes more hazardous crossing. Fencing or other controls may be required to reinforce the safe crossing point.
- Grade crossings must be accessible; ramps, handrails, landings, etc., must be provided so the facility is accessible to all.

For a grade-separated crossing to be warranted, some of the following circumstances should be present:

- High pedestrian volumes at the location and a high demand to cross.
- A large number of young children who must regularly cross (particularly at locations near schools).
- High volumes of motor vehicles traveling at high speeds along the roadway.
- No convenient alternative crossing places nearby.
- Funding and a specific need for the overpass/underpass.
- An extreme hazard for pedestrians.

Section 7F.02 of the MUTCD states that "experience has shown that overpasses are more satisfactory than underpasses for pedestrian crossings, as overpasses are easier to maintain and supervise."[5] When deciding on the use of an overpass or underpass, be aware of the need to provide artificial lighting to reduce potential crime. Also, pay attention to the existing topography of the proposed site to "minimize changes in elevation for users of overpasses and underpasses and to help insure construction costs are not excessive."[6]

12.12 Student Exercise

Choose an urban site that would be a good candidate for a midblock crossing with a pedestrian refuge island. Document the reasons that people often cross at this site (or would cross, given the opportunity). Photograph the site and prepare a sketch design solution.

12.13 References and Additional Resources

The references for this lesson are:

1. *Florida Pedestrian Planning and Design Guidelines*, Florida Department of Transportation, Tallahassee, FL, 1996, available online at http://www.dot.state.fl.us/Safety/ped_bike/handbooks_and_research/PEDHBTOC.PDF.

2. "Chapter 5: Neighborhood Street Design Guidelines," *Southeast Neighborhood Traffic Management Plan* (*NTMP*), City of Vancouver, WA, 2003, available online at http://www.ci.vancouver.wa.us/transportation/ntmp/NTMTools/TOOL%2012%20-%20Mid-Block%20Crossing%20for%20Arterial%20Streets.pdf, accessed May 18, 2004.

3. Image Library, Pedestrian and Bicycle Information Center (PBIC), available online at http://www.pedbikeimages.org, accessed May 6, 2004.

4. *Bicycle Facilities Guide: Types of Bicycle Accommodations*, North Carolina Department of Transportation, Raleigh, NC, June 2003, available online at http://www.ncdot.org/transit/bicycle/projects/project_types/Grade_Separated_Crossing.pdf, accessed April 21, 2004.

5. *Manual on Uniform Traffic Control Devices*, Federal Highway Administration, Washington, DC, 2003, available online at http://mutcd.fhwa.dot.gov, accessed April 22, 2004.

6. "Grade Separation Worksheet," *Kane County Bicycle and Pedestrian Plan: Appendix J*, Kane County Division of Transportation, Geneva, IL, January 2003, available online at http://www.co.kane.il.us/DOT/COM/Bicycle/outline.asp, accessed April 21, 2004.

Additional resources for this lesson include:

- *Design and Safety of Pedestrian Facilities—A Recommended Practice of ITE*, Institute of Transportation Engineers (ITE), Washington, DC1998.
- *Oregon Bicycle and Pedestrian Plan*, Oregon Department of Transportation, Salem, OR, 1995.

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GUIDELINES FOR THE INSTALLATION OF MARKED CROSSWALKS

Virginia Department of Transportation
Traffic Engineering Division

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The *Manual on Uniform Traffic Control Devices* (MUTCD) Section 3B.17 gives little guidance regarding when and where to mark crossing locations.

The Virginia Department of Transportation's (VDOT) *Policy for Integrating Bicycle and Pedestrian Accommodations* states that VDOT will accommodate bicyclists and pedestrians, including pedestrians with disabilities, along with motorized transportation modes in the planning, funding, design, construction, operation, and maintenance of Virginia's transportation network to achieve a safe, effective, and balanced multimodal transportation system.[2]

The following guidelines for the installation of marked crosswalks are intended to serve engineers and planners responsible for planning and designing pedestrian facilities in Virginia. These guidelines are not to be used as warrants, as circumstances can vary depending on location and no set of guidelines can cover every condition or guarantee improved safety.

Designers, engineers, and planners all share a responsibility to find ways for vehicles, pedestrians, and bicyclists to coexist conveniently and safely. Accommodating pedestrians with disabilities is required in the design and planning of pedestrian facilities, and compliance with the Americans with Disabilities Act (ADA) is a federal law. This law is designed to ensure that all Americans have the same access to services and facilities. The ADA requires pedestrian facilities used by the general public to be planned, designed, constructed, and maintained with the understanding that a wide range of people, including people with disabilities, will be using them and relying on them for their daily travel. By providing pedestrian facilities that are fully accessible, people with various degrees of mobility and disability may be as self-sufficient and independent as possible.[3] The ADA applies to all new construction and improvements to existing facilities.

The purpose of this document is to give more guidance than what is offered in the MUTCD for determining the best engineering solutions to pedestrian safety concerns, particularly with regard to the location of marked crosswalks. Specifically, this document describes guidelines relating to the marking of crosswalks at controlled locations (those controlled by signals, stop signs, and yield signs), uncontrolled locations (intersections and mid-block), and unconventional intersections and locations. It describes various crosswalk treatments and guidance as to when to use them. This document should also serve as guidance for retrofit crosswalk marking installations and installations at new and future construction projects.

BACKGROUND

A *crosswalk* is generally defined as the portion of roadway designated for pedestrians to use in crossing the street. Crosswalks may be marked or unmarked. At intersections, a sidewalk or pedestrian walkway extension across a street defines a crosswalk (refer to the *Code of Virginia*, Section 46.2-100 for a complete definition of *crosswalk*).[4] There is no legal difference between marked or unmarked intersection crosswalks; however, at times, markings can be used to designate a wider crosswalk or a mid-block crosswalk.

Marking crosswalks serve two purposes: (1) they tell the pedestrian the best place to cross; and (2) they clarify that a legal crosswalk exists at a particular location. Marked crosswalks may be used to delineate preferred pedestrian paths across roadways under the following conditions:

- *At locations with stop signs or traffic signals.* Vehicular traffic might block pedestrian traffic when stopping for a stop sign or red light; marking crosswalks may help to reduce this occurrence.

- *At non-signalized street crossing locations where an engineering study dictates that the number of motor vehicle lanes, pedestrian exposure, average daily traffic (ADT), posted speed limit, and geometry of the location would make the use of specially designated crosswalks desirable for traffic/pedestrian safety and mobility.*[5]

- *At approved school crossings or for crossings on recommended school routes.*

Further, a marked crosswalk helps to create reasonable expectations for motorists with regard to where pedestrians may cross a roadway and the predictability of pedestrian actions and movement.

There are both advantages and disadvantages of marking crosswalks. Advantages include:

- helping pedestrians find their way across complex intersections
- designating the shortest path
- directing pedestrians to location of best sight distance.

Disadvantages include:

- possibly creating a "false sense of security" for pedestrians
- generating a greater number of pedestrian collisions at uncontrolled locations on multi-lane streets with high traffic volumes
- higher maintenance costs.[6]

GENERAL GUIDANCE

As with any installation of traffic control devices, the most essential tool for crosswalk installation is the use of engineering judgment. Engineering judgment should be used and, if applicable, an engineering study performed when considering the marking of crosswalks. Section 1A-13 of the MUTCD describes *engineering judgment* and *engineering study.*

Crosswalk markings should not be used at all intersections. If used extensively, many marked crosswalks would be underused and motorists would tend to be desensitized to their presence. This could lead to problems at heavily used crosswalks and detract from potential safety value at these locations. Crosswalks should be used, in general, only at locations where

pedestrian activity is significant. This will ensure that motorists come to associate crosswalks and pedestrian activity.[7]

Intersection design is also extremely important for the safety of pedestrians. However, no single feature creates a safe intersection for pedestrians.[8] The first step in identifying candidate marked crosswalk locations is to identify the places people would like to walk (pedestrian desire lines) that are affected by local land uses (homes, schools, parks, commercial establishments, etc.) and the location of transit stops. This information forms a basis for identifying pedestrian crossing improvement areas and prioritizing such improvements, thereby creating a convenient, connective, and continuous walking environment.

The second step is identifying where it is safest for people to cross. Of all road users, pedestrians have the highest risk accidents because they are the least protected. National statistics indicate that pedestrians represent 14 percent of all traffic incident fatalities, whereas walking accounts for only 3 percent of total trips. Vehicle-pedestrian collisions occur most often when a pedestrian is attempting to cross the street at an intersection or mid-block location.[6]

APPLICABLE SECTIONS OF THE *CODE OF VIRGINIA*

The following excerpts from the *Code of Virginia* should be referenced when defining a crosswalk or a crossing location and when determining pedestrian and vehicular right of way.

Definition of a Crosswalk[4]

Section §46.2-100 defines a crosswalk as "that part of a roadway at an intersection included within the connections of the lateral lines of the sidewalks on opposite sides of the highway measured from the curbs or, in the absence of curbs, from the edges of the traversable roadway; or any portion of a roadway at an intersection or elsewhere distinctly indicated for pedestrian crossing by lines or other markings on the surface."

How and Where Pedestrian Are to Cross Highways[9]

Section §46.2-923 states: "When crossing highways, pedestrians shall not carelessly or maliciously interfere with the orderly passage of vehicles. They shall cross, wherever possible, only at intersections or marked crosswalks. Where intersections contain no marked crosswalks, pedestrians shall not be guilty of negligence as a matter of law for crossing at any such intersection or between intersections when crossing by the most direct route."

Pedestrian and Vehicular Right of Way[10]

Section §46.2-924.A states that the driver of any vehicle on a highway shall yield the right-of-way to any pedestrian crossing such highway:

1. At any clearly marked crosswalk, whether at mid-block or at the end of any block.

2. At any regular pedestrian crossing included in the prolongation of the lateral boundary lines of the adjacent sidewalk at the end of the block.

3. At any intersection when the driver is approaching on a highway or street where the legal maximum speed does not exceed 35 miles per hour.

Section §46.2-924B states: "No pedestrian shall enter or cross an intersection in disregard of approaching traffic. The drivers of vehicles entering, crossing, or turning at intersections shall change their course, slow down, or stop if necessary to permit pedestrians to cross such intersections safely and expeditiously. Pedestrians crossing highways at intersections shall at all times have the right-of-way over vehicles making turns into the highways being crossed by the pedestrians."

GUIDELINES FOR MARKING CROSSWALKS AT CONTROLLED LOCATIONS

The following should be considered when determining the need to mark crosswalks at signalized intersections, approaches controlled by stop signs, and approaches controlled by yield signs. Engineering judgment should be used when considering the installation of marked crosswalks at controlled locations.

Basic Justification for Marking a Crosswalk

- *Marked crosswalks should be considered on all approaches*[6] *near pedestrian generators.* This should be done using standard crosswalk markings (Figure 1) or high-visibility markings (see types of high-visibility crosswalks in the *Guidelines for Marking Crosswalks at Uncontrolled Locations* of these guidelines). Markings must be white and retroreflective (visible at night). For further guidance on crosswalk markings, refer to Section 3B.17 of the MUTCD.[1]

  The installation of stop lines at crosswalk locations controlled by traffic signals or stop signs is recommended as an effective measure in reducing vehicle encroachments on the

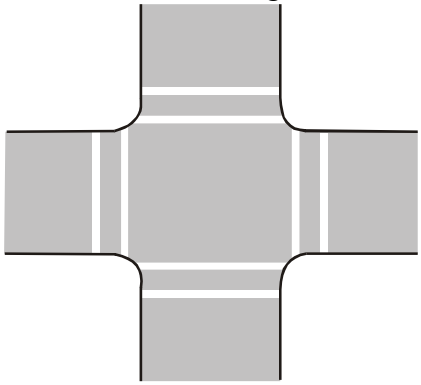

Figure 1. Standard Crosswalk Markings on All Approaches of an Intersection

  crosswalk. Where the crash data or observations of conflicts identify a crosswalk of particular concern, consider special treatments (refer to *Special Treatments* in this section)

and warning signs (Figure 2). Refer to Section 2C.41 of the MUTCD for further guidance on warning signs.[1]

Figure 2. Pedestrian Crossing Warning Sign. Source: MUTCD, Section 2C.41.

- *The following is an exception for considering marking crosswalks on all approaches:*

  Where crossing locations have conflicting heavy right- or left-turn traffic volumes.[6] There are dilemmas with regard to pedestrian crossings on multi-lane, high-speed, high-volume suburban arterials. The introduction of marked crosswalks alone would essentially communicate to the pedestrian that it is reasonably safe to attempt a crossing. Typically, under these conditions, marked crosswalks alone are not sufficient to facilitate safe crossings at complex, multi-phase intersections.

  In order to make at-grade pedestrian crossings as safe as they need to be at signal-controlled intersections on wide, high-volume, high-speed roadways, the incorporation of pedestrian signals, refuge medians, slip lane refuge islands, and fully protected pedestrian phasing may be considered.

  Where other solutions are infeasible, an alternative pedestrian crossing should be identified. It may be necessary to install barrier treatments to reinforce that pedestrians should not cross at the location without a marked crosswalk. Prohibiting crossing should be considered only in very limited circumstances, for example:

  — where it would be very dangerous for pedestrians to cross, as where visibility (for pedestrians and motorists) is obstructed and the obstruction cannot be reasonably removed

  — where so many legal crosswalks exist that they begin to conflict with other modes, as on an arterial street with multiple offset or T intersections.

  — where there are unique considerations at a particular intersection and pedestrian mobility is not disproportionately affected by the closure.[11]

Special Treatments

There are a number of innovative treatments for pedestrians at controlled intersections, mostly related to pedestrian signals. At locations with a high number of pedestrian-vehicle conflicts, the following measures are means to enhance the safety of pedestrian crossings.

- At locations where there are high numbers of turning vehicles, special treatments that may be considered include[6]:

  — installing animated eye light emitting diode (LED) signals
  — equipping signals with early release or pedestrian lead time
  — installing special pavement stencils onto the pavement such as "Pedestrians Look Left" and "Watch for Turning Vehicles"
  — designing or retrofitting intersections with reduced corner radii.

- At locations where there are high numbers of pedestrians around or near an intersection, special treatments that may be considered include[6]:

  — equipping signals with pedestrian "scramble" phases
  — implementing "No Right Turn on Red" restrictions
  — installing STOP lines or YIELD lines in advance of crosswalks.

- At locations where there are wide intersections, special treatments that may be considered include[6]:

  — installing additional pedestrian signal heads in a median (if possible), if the width of the crossing is greater than 60 feet
  — installing countdown signals
  — installing pedestrian refuge islands and medians
  — installing bulbouts or curb extensions.

GUIDELINES FOR MARKING CROSSWALKS AT UNCONTROLLED LOCATIONS

This section describes guidance for the installation of marked crosswalks at uncontrolled approaches of intersections and mid-block locations. Crosswalk lines should not be used indiscriminately. An engineering study should be performed before crosswalk markings are installed at uncontrolled locations.

Pedestrian crossing warning signs should always be installed in advance of mid-block crossings. Placement of advance warning signs depends on the speed of motor vehicle traffic and other conditions, such as available sight distance. If yield lines are used in advance of a mid-block crosswalk, "Yield Here to Pedestrians" signs shall be placed 20 to 50 feet in advance of the crosswalk.[1] Refer to Sections 3B.17 and 2B.11 of the MUTCD for further guidance.[1] In-street pedestrian crossing signs can also be used at crosswalk locations to remind road users of laws

regarding right of way at an unsignalized pedestrian crossing.[1] Refer to Section 2B.12 of the MUTCD for further guidance on in-street pedestrian crossing signs.[1]

Basic Justification for Marking a Crosswalk

Crossings should be marked where *all* of the following are the case[6]:

- Sufficient demand exists to justify the installation of a crosswalk. Uncontrolled crossings should be identified as a candidate for marking if there is a demonstrated need for a marked crosswalk. Need can be demonstrated by either of the following:

  — The crosswalk would serve 20 pedestrians per hour during the peak hour, 15 elderly and/or children per hour, or 60 pedestrians total for the highest consecutive 4-hour period; or

  — The crossing is on a direct route to or from a pedestrian generator, such as a school (refer to section 7C.03 of the MUTCD)[1], library, hospital, senior center, shopping center, park, employment center, and transit center or service.

- The location is 300 feet or more from another crossing location or a controlled crossing location.

- The location has sufficient sight distance (sight distance in feet should be greater than 10 times the speed limit) and/or sight distance will be improved prior to crosswalk marking.

- Safety considerations do not preclude a crosswalk.

Figure 3 and Table 1 should be used to determine if special treatments are needed to ensure safe crossing at uncontrolled locations.

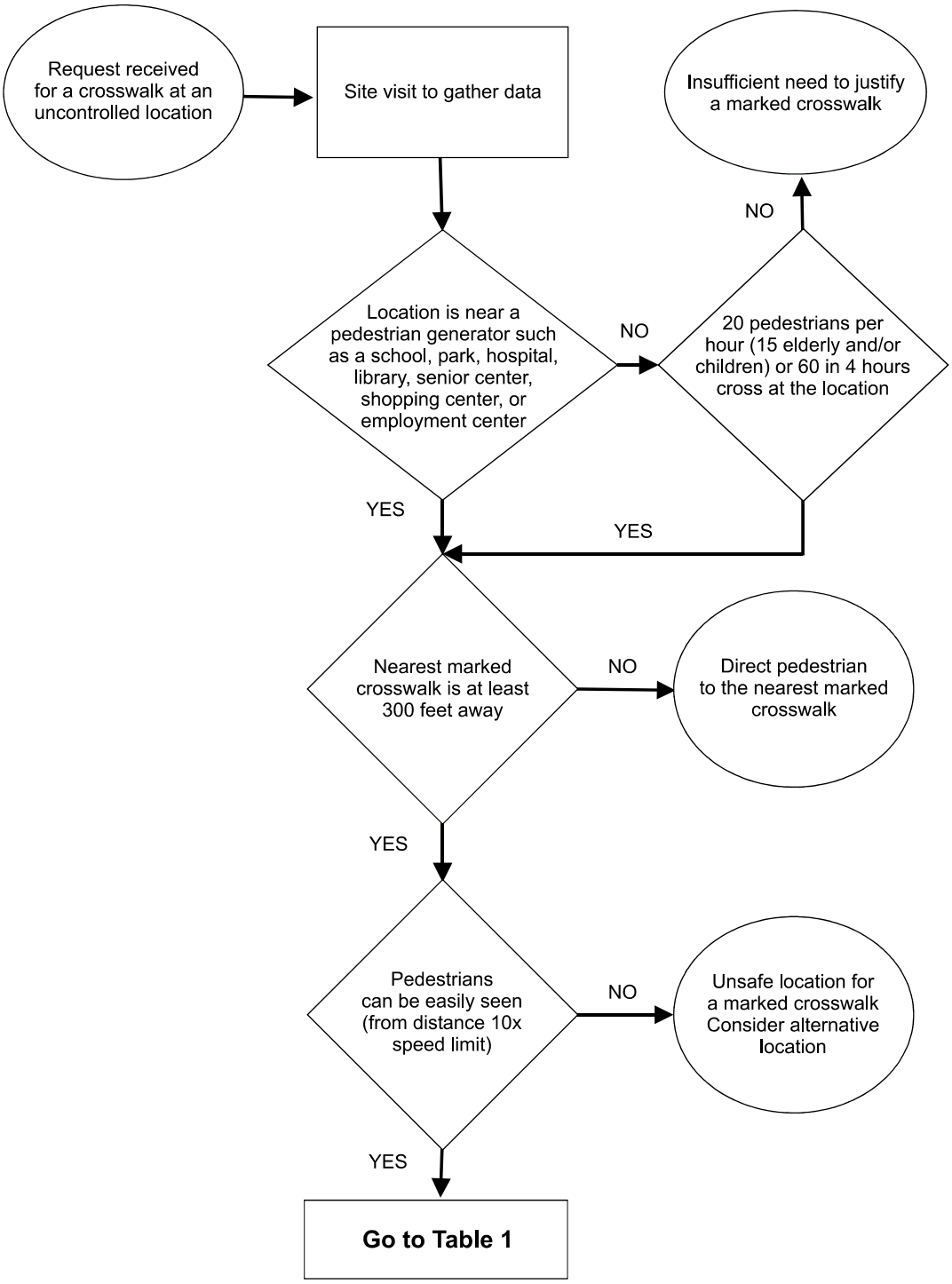

Figure 3. Flowchart for Justifying Installation of Marked Crosswalks at Uncontrolled Intersections. Adapted from City of Stockton Public Works Department, *Pedestrian Safety and Crosswalk Installation Guidelines*. Stockton, California, 2003.

Table 1. Recommendations for Considering Marked Crosswalks and Other Needed Pedestrian Improvements at Uncontrolled Locations[a]

	≤ 9,000 ADT			> 9,000 ADT to ≤ 12,000 ADT			> 12,000 ADT to ≤ 15,000 ADT			> 15,000 ADT		
	≤ 30 mph	35 mph	≥ 40 mph	≤ 30 mph	35 mph	≥ 40 mph	≤ 30 mph	35 mph	≥ 40 mph	≤ 30 mph	35 mph	≥ 40 mph[b]
2 lanes												
3 lanes												
++4 lanes, raised median[c]												
++4 lanes, no median												

Candidate sites for marked crosswalks. Marked crosswalks must be installed carefully and selectively. First, an engineering study is needed to determine whether the location is suitable for a marked crosswalk. For an engineering study, a site review may be sufficient at some locations, but a more in-depth study of pedestrian volume, vehicle speed, sight distance, vehicle mix, etc., may be needed at other sites. If the speed limit is less than or equal to 30 mph, use **Level 1** or **Level 2** devices. If the speed limit exceeds 30 mph, use **Level 2** devices. *Refer to Level 1 and Level 2 devices in the Special Treatments section*.

Probable candidate sites for marked crosswalks. Pedestrian crash risk may increase if marked crosswalks are added without other pedestrian facility enhancements. Add **Level 3** or **Level 4** devices if feasible. *Refer to Level 3 and Level 4 devices in the Special Treatments section*.

Marked crosswalks alone are insufficient, since pedestrian crash risk may increase if only marked crosswalks are provided. Consider using **Level 5** devices if feasible. If not feasible, use multiple treatments from **Level 2, Level 3,** or **Level 4** devices. *Refer to Level 5 devices in the Special Treatments section*.

[a]These guidelines include intersection and mid-block locations with no traffic signal or stop sign on the approach to the crossing. They do not apply to school crossings. A two -way center turn lane is not considered a median. Crosswalks should not be installed at locations that could pr esent an increased safety risk to pedestrians, such as where there is poor site distance, complex or confusing designs, substantial volumes of heavy trucks, or other dangers, without first providing adequate design features and/or traffic control devices. Adding crosswalks alone will not make a crossing safer or necessarily result in more drivers stopping for pedestrians. Whenever marked crosswalks are installed, it is important to consider other pedestrian facility enhancements, as needed, to improve the safety of the crossing (for example, raised median, traffic signal, roadway narrowing, enhanced overhead lighting, traffic calming measures, curb extensions). **These are general recommendations; an engineering study should be performed to determine where to install marked crosswalks.**

[b]Where the posted speed limit or 85th percentile speed exceeds 40 mph, marked crosswalks alone should not be used at uncontrolled intersections with an ADT greater than 15,000.

[c]The raised median or refuge island must be at least 4 feet (1.2 meters) wide and 6 feet (1.8 meters) long to adequately serve as a refuge area for pedestrians.

Adapted from Zegeer, C.V., Stewart, R.J., Huang, H.H., and Lagerwey, P.A. *Safety Effects of Marked Vs. Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines*. FHWA-RD-01-075. Federal Highway Administration, Washington, D.C., 2002.

Special Treatments

There are a number of innovative treatments for pedestrians at uncontrolled crossing locations. Level 1 devices are typically less costly to install and are found at locations with potentially lower levels of vehicle/pedestrian conflict. Level 2 through 5 devices can be more costly to install and are used at locations with an ascending order of potential vehicle/pedestrian conflicts.

Level 1 Devices

Standard Crosswalk

Standard crosswalks (Figure 4) consist of two parallel lines and can be used at uncontrolled intersections. They are not to be used at mid-block crossings. Refer to section 3B.17 of the MUTCD for further guidance on standard crosswalks[1].

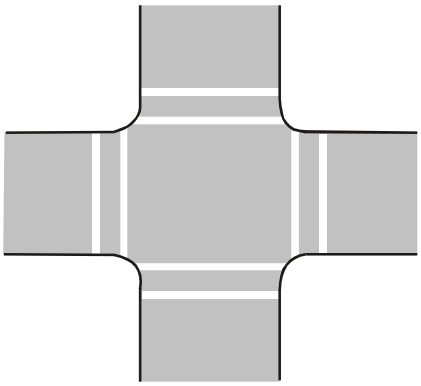

Figure 4. Standard Crosswalk

Raised Mid-Block Crosswalk

Raised mid-block crossings (Figure 5) are sometimes constructed to provide a well-defined pedestrian crossing and to calm traffic. This type of crossing is suitable for only low-speed, low-volume local streets, since the raised crossing is essentially functioning as a speed table or hump.

Raised crossings enhance pedestrian safety by creating a vertical pavement undulation that forces motorists to slow down when approaching. They can function as an extension of the sidewalk and allow pedestrians to cross at a constant grade without the need for curb ramps or median cut-throughs. Raised crossings should have a 6-foot (1.8-meter) parabolic approach transition, raising the vehicle to 3 to 4 inches (7.6 to 10.2 centimeters) above the nominal pavement grade. The flat section of the crossing table should be 10 to 12 feet (3.0 to 3.7 meters) wide. Raised crossings need to be highly visible, either striped as a mid-block crossing or constructed of a contrasting pavement design. Raised crossings should be signed with advance warning signs and pedestrian crossing signs in the same manner as other mid-block crossings.[12]

Figure 5. Raised Mid-block Crossing. From http://pedbikeimages.org / Portland Office of Transportation. Reprinted with permission.

Rumble Strips

Rumble strips are series of intermittent, narrow, transverse areas of a rough-textured, slightly raised, or depressed road surface that are installed to alert road users to unusual traffic conditions.[1] They can be used as a temporary traffic control device in areas of temporary, unexpected crosswalks. Rumble strips should be placed in advance of a crosswalk. Because of maintenance issues, rumble strips should be used only in special circumstances.

Level 2 Devices[6]

High-Visibility Crosswalks

High-visibility crosswalks should be white and retroreflective (visible at night). They include the textured pavement crosswalks (Figure 6), "zebra" and "continental" crosswalks (Figure 7), and "triple-four" crosswalks (Figure 8). Textured pavement crosswalks are composed of stamped concrete or asphalt or brick pavers placed in a pattern and are outlined with white, retroreflective markings. These types of crosswalks can increase driver awareness of pedestrian activity by improving visibility and creating a different audible tone. The treatment can also improve the aesthetics of crosswalk installations. Disadvantages include higher construction and maintenance costs and the lack of smooth, accessible surfaces for pedestrians.[13]

Figure 6. Example of a Textured Pavement Crosswalk. From www.pedbikeimages.org / Dan Burden. Reprinted with permission.

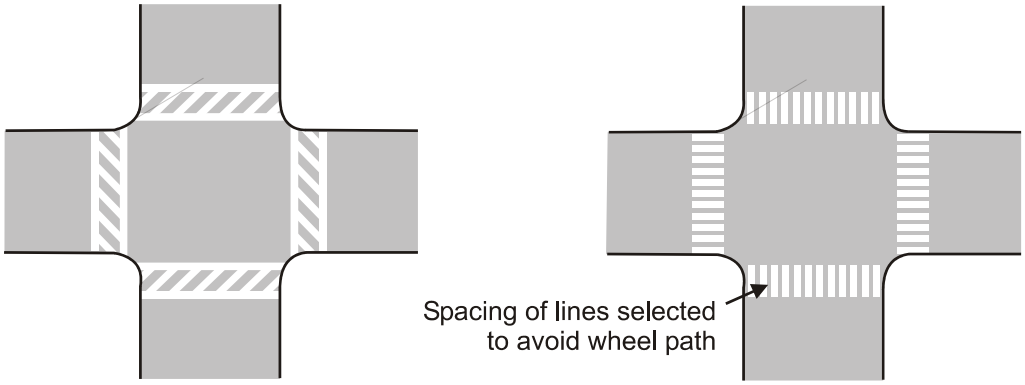

Figure 7. "Zebra" Crosswalk (Left) and "Continental" Crosswalk (Right).

Figure 8. "Triple-Four" Crosswalk. From www.pedbikeimages.org / Dan Burden. Reprinted with permission.

Level 3 Devices[6]

Refuge Islands

Refuge islands (Figures 9 and 10) allow pedestrians to cross one segment of the street to a relatively safe location out of the travel lanes and then continue across the next segment in a separate gap. At unsignalized crosswalks on a two-way street, a median refuge island allows the crossing pedestrian to tackle each direction of traffic separately. This can significantly reduce the time a pedestrian must wait for an adequate gap in the traffic stream.[11] A pedestrian pushbutton should be placed in the median of signalized mid-block crossings where the crossing distance exceeds 60 feet (18.2 meters). Curb ramps or cut-throughs should be provided for accessibility.[14] Refer to VDOT's *Guidelines for the Placement of Curb Ramps for Accessible Routes and Continuous Passages* on when and how to use curb ramps.[15]

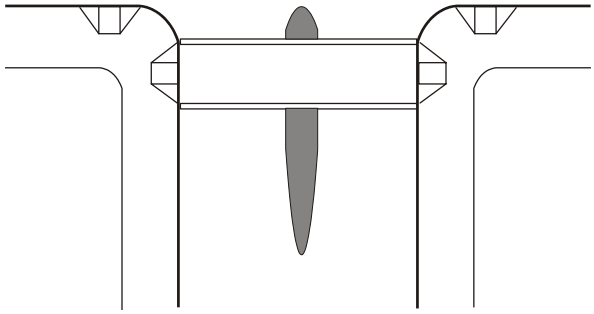

Figure 9. Typical Median Refuge Island at an Intersection, with Median Nose and At-Grade Passage for a Crosswalk.

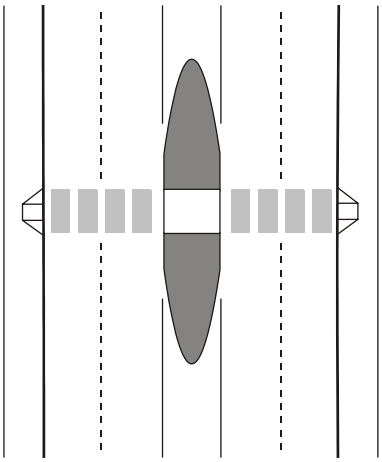

Figure 10. Typical Median Refuge Island at Mid-Block, with At-Grade Passage for Crosswalk.

Split Pedestrian Crossover (SPXO)

The SPXO (Figure 11) is a pedestrian refuge that channels pedestrians to cross one half of the street; enter the island at one end; walk toward the flow of traffic; and exit at the other end to cross the second half of the street. This special treatment is primarily used at mid-block locations and is especially beneficial at or near transit connections.

Figure 11. Example of a Split Pedestrian Crossover. From www.pedbikeimages.org / Dan Burden. Reprinted with permission.

Bulbouts

Intersections

At an intersection, each corner of the bulbout (Figure 12) is extended into the intersection by approximately 7 to 8 feet to shorten the crossing distance for pedestrians and raise their visibility to motorists.

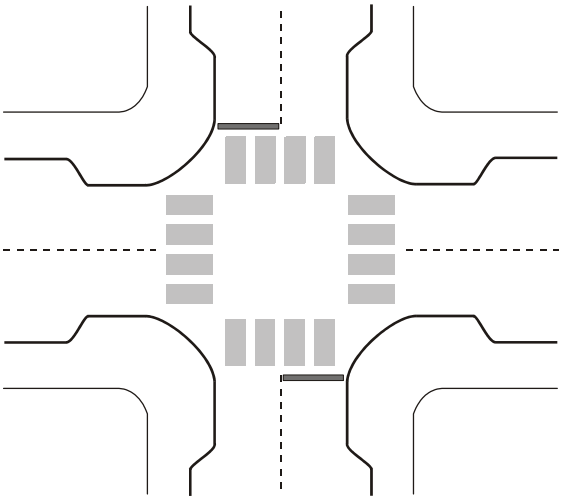

Figure 12. Bulbouts at an Intersection.

Mid-Block Locations

At mid-block locations, bulbouts (Figure 13) are extended into the street by approximately 7 to 8 feet to shorten the crossing distance for pedestrians and raise their visibility to motorists.

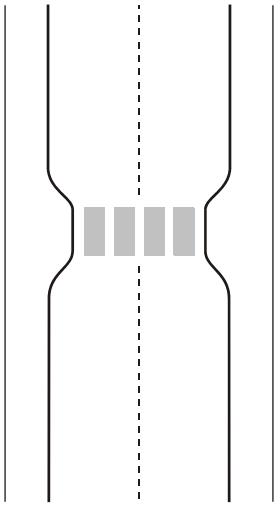

Figure 13. Bulbouts at a Mid-Block Location.

Level 4 Devices[6]

Overhead Signs and Flashing Beacons

Overhead signs can be various signs showing the universal pedestrian symbol, including standard yellow, fluorescent yellow, and LED displays that hang from a mast arm and extend over the street. Flashing beacons should accompany the overhead signs (Figure 14). A flashing beacon provides a relatively low-cost treatment for mid-block pedestrian crossings. The flashing light alerts drivers in advance of potential pedestrians without forcing them to stop unless there is actually a pedestrian in the crosswalk. This sort of device can be used on roadways with higher vehicular volumes without causing undue delay to drivers. Flashing beacons are most effective if they are operating only during times when there is a clear need to alert motorists, such as when pedestrians are actually present (rather than constantly flashing).[3] This can be done by using pedestrian pushbuttons (Figure 15) or passive activation. Refer to Section 4K.03 in the MUTCD for further guidance on flashing beacons.[1]

Figure 14. Overhead Sign with Flashing Beacons. From www.pedbikeimages.org / ITE Pedestrian Bicycle Council. Reprinted with permission.

Figure 15. Pedestrian Pushbutton for Flashing Beacon Operation. From www.pedbikeimages.org / Dan Burden. Reprinted with permission.

In-Roadway Warning Lights (IRWLs)

IRWLs (Figure 16) should be installed with a flashing sign at the crosswalk and an advanced flashing sign ahead of the crosswalk. They should also be installed with advance audible warning devices for motorists, such as rumble strips. Refer to VDOT's *Guidelines for the Installation of In-Roadway Warning Lights* for further guidance.[16]

Figure 16. In-Roadway Warning Lights at a Mid-block Crosswalk. From www.pedbikeimages.org / ITE Pedestrian Bicycle Council. Reprinted with permission.

Level 5 Devices[6]

Pedestrian-Actuated Signals

Pedestrian-actuated signals (Figure 17) should be placed at mid-block locations where vehicle and pedestrian volumes warrant a signal. Refer to Section 4C.05 Warrant 4, Pedestrian Volume of the MUTCD for further guidance on mid-block pedestrian-actuated signals.[1]

Figure 17. Pedestrian-Actuated Mid-block Signal. From www.pedbikeimages.org / ITE Pedestrian Bicycle Council. Reprinted with permission.

Grade-Separated Crossings

The purpose of grade-separated crossings is to separate pedestrian travel from vehicular travel completely. These crossing facilities should be used only where it is not possible to provide an at-grade facility. Examples are crossing a freeway or major highway (Figures 18 and 19), a rail yard, or a waterway. Grade-separated crossings should:

- be accessible.
- have minimal grade changes
- have a clear passage width of at least 3.7 meters (12 feet).[11]

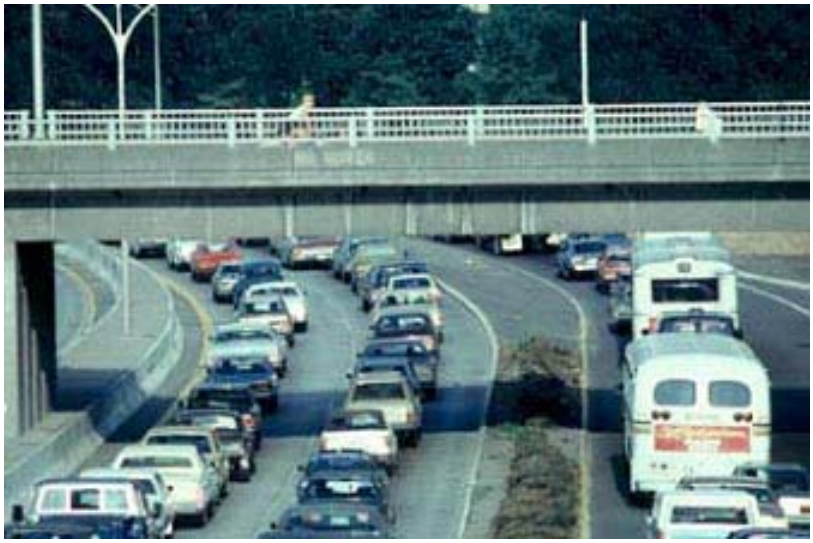

Figure 18. Grade-Separated Crossing (Bridge) Over a Major Highway. From www.pedbikeimages.org / Dan Burden. Reprinted with permission.

Figure 19. Grade-Separated Crossing (Tunnel) Under a Roadway. From www.pedbikeimages.org / Dan Burden. Reprinted with permission.

GUIDELINES FOR MARKING CROSSWALKS AT UNCONVENTIONAL INTERSECTIONS AND LOCATIONS

The geometric characteristics of an intersection are very important to the safe movement of pedestrian and vehicular traffic. There are many instances where the geometries of an intersection are not conventional, i.e., in the form of two intersecting perpendicular lines. The following guidelines describe additional treatments and/or practices for crosswalk markings at T, offset, and skewed intersections at controlled and uncontrolled approaches of an intersection. Guidance is also provided for the placement of crosswalks on hills and curves.

T and Offset Intersections

At closely spaced T and offset intersections, overall pedestrian safety and convenience may be increased by selectively enhancing some crosswalks while eliminating others. The offset intersection on the left of Figure 20 shows a typical offset intersection with all legal crosswalks marked. The offset intersection on the right of Figure 20 shows a more practical and effective application of marked crosswalks at offset intersections. In general, enhancement of the outer crosswalks and elimination of the inner crosswalks would be the preferred design at most offset intersections. However, other configurations may be chosen based on the particular site.[11]

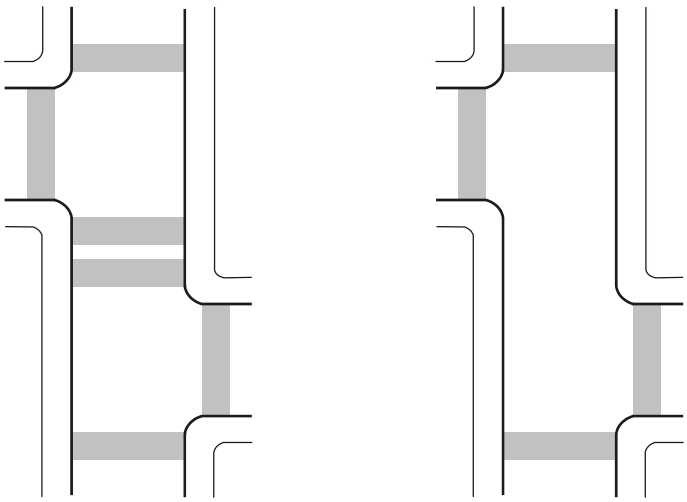

Figure 20. Typical Offset Intersection Showing All Legal Crosswalks (left) and a More Practical and Effective Crosswalk Application (right).

Figure 21 shows all legal crosswalks at a T intersection. This crosswalk design is useful in highly urbanized areas with heavy pedestrian volumes and heavy right turns from the eastbound leg of the T. In rural areas or in situations where vehicular and pedestrian volumes are low, it may be appropriate to mark only the right portion of the upper leg of the T and across the lower portion of the T.

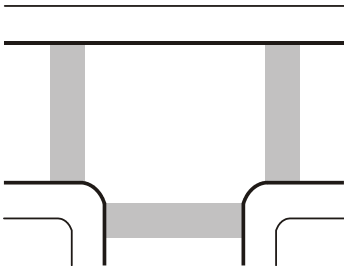

Figure 21. All Legal Crosswalks at a T Intersection.

Skewed Intersections

At skewed intersections, crosswalks should, whenever possible, be installed so that they form 90-degree angles with the curb. Perpendicular (90 degree) crosswalks minimize the walking distance and, therefore, the pedestrian exposure to vehicle conflicts. They also better accommodate the needs of pedestrians with visual disabilities who are usually accustomed to perpendicular crossings.[17]

On highly skewed roadways, there is a trade-off between making a 90-degree crossing of a roadway and matching the junction of the roads. This skew adds another 10 to 30 feet (3.1 to 9.2 meters) to the crossing width. By dropping back to a 90-degree crossing, the crosswalk may end up 10 feet (3.1 meters) or even 30 feet (9.2 meters) from the intersection. This creates one of two problems. Either the motorist tends to move closer to the intersection, thus blocking the intersection, or he or she picks up high speed that endangers the pedestrian on the right-turn leg of the intersection. Therefore, crosswalks need to be kept close to the turning traffic so that pedestrians stay within the driver's line of sight. If this cannot be achieved, it is essential to stay as close as practicable.[14]

Hills and Curves

If at all possible, crosswalks should not be placed on hills where vertical stopping sight distances are restricted. Motorists need at least 4 seconds to detect, react, and slow down for a pedestrian in a crosswalk. At locations where crosswalks are needed, placement at the top of a hill is much better than just below the crest.

Likewise, if at all possible, crosswalks should not be placed on curves where horizontal stopping sight distances are restricted. Placement where the motorists have been slowed by a curve and are therefore able to view the pedestrian is desirable. However, there will be locations where crosswalks are needed along a corridor with curves. In these instances, installation of a refuge or median island will help slow the motorist and provide a low conflict crossing for pedestrians. The refuge or median island should begin before the curve. If inadequate vertical or horizontal stopping sight distances exist, the use of traffic calming measures (such as the refuge or median island) to reduce a vehicles speed or special signing, beacons, and signalization should be considered.[14]

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