TOWN BOARD WORK SESSION
September 22, 2014 – 6:00 P.M.
Town Board Chambers
301 Walnut Street, Windsor, CO 80550

The Town of Windsor will make reasonable accommodations for access to Town services, programs, and activities and will make special communication arrangements for persons with disabilities. Please call (970) 674-2400 by noon on the Thursday prior to the meeting to make arrangements.

GOAL of this Work Session is to have the Town Board receive information on topics of Town business from the Town Manager, Town Attorney and Town staff in order to exchange ideas and opinions regarding these topics.

Members of the public in attendance who have a question related to an agenda item are requested to allow the Town Board to discuss the topic and then be recognized by the Mayor prior to asking their question.

AGENDA

1. Pedestrian Crossing Treatment Guidelines
2. Future meetings agenda

TOWN OF WINDSOR
COLORADO

M E M O R A N D U M

Date: September 18, 2014
To: Mayor and Town Board
Via: Kelly Arnold, Town Manager
From: Dennis Wagner, Director of Engineering
Re: Pedestrian Crossing Treatment Guidelines

Background / Discussion:

The traffic code requires vehicles to yield the right-of-way to crossing pedestrians at any intersection where crossing is not prohibited, regardless of marked crosswalks. At the same time, the code requires pedestrians to wait until it is safe before attempting to cross. Thus, motorists and pedestrians share responsibility for safe street crossings. The main function of a marked crosswalk is to channel pedestrians. Crosswalks also prepare drivers for the likelihood of encountering a pedestrian and create an atmosphere of walkability and accessibility for pedestrians. Marked crossings reinforce the location and legitimacy of a crossing.

I have read the pedestrian crossing policies and guidelines published by these northern Colorado municipalities: Boulder, Fort Collins, Lafayette, Loveland, Greeley and Longmont.

"Pedestrian Crossing Treatment Installation Guidelines" adopted by the City of Boulder in 2011 seem to be the most definitive and logical; a copy of which is included with this memorandum. According to the Executive Summary in the document, "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." … "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."

Guidelines can provide a consistent procedure for considering the installation of crossing treatments where needed on a case-by-case basis. Of course, implementation of crossing treatments requires funds and therefore must be considered carefully in the funding allocation process.

The cost of materials, not including labor, to install one marked crosswalk and accessory signage is approximately $1,000. The cost to add solar-powered rectangular rapid flashing beacons (RRFB) to a crosswalk sign is $9,800, excluding installation. A third, higher level, crossing treatment is called a HAWK beacon. "HAWK" is an acronym for **H**igh-Intensity **A**ctivated cross**W**al**K** beacon. HAWK beacons have two red signals per fixture that are activated by the pedestrian and traffic is expected to stop. I don't have cost data for HAWK beacons.

HAWK beacon

Boulder's guidelines include four steps to evaluate a potential crossing location:

Step 1: Identification and description of crossing location.
Step 2: Physical data collection.
Step 3: Traffic data collection and operation observations.
Step 4: Apply data to Figure 1, Table 1 and Figure 2 to determine appropriate treatments.

As per Section 2.2.2 in Boulder's guidelines, crossing treatments should generally not be installed at locations where the average daily traffic (ADT) is lower than 1,500 vehicles per day. Exceptions can 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).

Actual Windsor case study: The intersection of 7th Street and Garden Drive has a marked crosswalk and signage equivalent to *Treatment A* in Boulder's guidelines (see

Table 1 in the guidelines). However, evaluating the crossing in accordance with Boulder's guidelines, *Treatment C* is indicated because 7th Street is 3-lanes wide. The additional treatment suggested in *Treatment C* is in-roadway bollard or median mounted sign. *Treatment C* also suggests necking the street down or median refuge islands to shorten the pedestrian crossing distance and increase pedestrian visibility to motorists.

A second Windsor case study: The Poudre River Trail crosses WCR 13 south of the Poudre River. The existing crossing includes pavement markings and signage equivalent to Boulder's *Treatment A*. Table 1 in Boulder's guidelines points to *Treatment E* because the posted speed limit on WCR 13 is 45 mph, but *Treatment E* goes on to say that a marked crosswalk should not be located at an uncontrolled intersection unless the effective speed limit can be reduced to 40 mph and a raised refuge median can be installed. If the speed limit can be reduced to 40 mph and a raised median installed, then *Treatment D* (signage and RRFB) is appropriate. If that criterion can't be achieved, then a HAWK beacon, pedestrian traffic signal or grade-separated crossing should be considered.

Recommendation:

I recommend using the City of Boulder's "Pedestrian Crossing Treatment Installation Guidelines" for guidance on evaluating pedestrian crossing treatments in Windsor.

City of Boulder

Pedestrian Crossing Treatment Installation Guidelines

November 2011

Prepared for:
City of Boulder Transportation Division
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FOX TUTTLE

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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

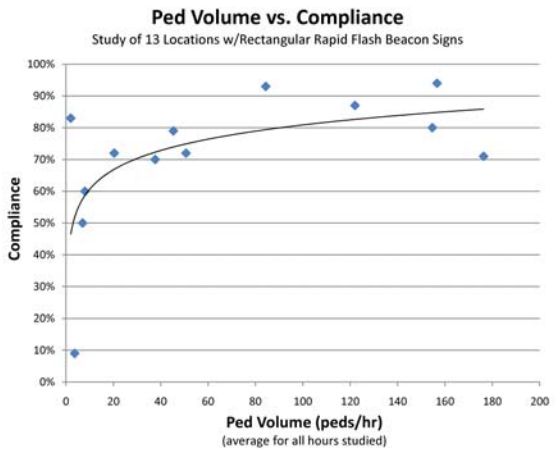
This information does not directly play in to the use of Table 1, but they do provide important context for the user as they help distinguish the crossing types and support the difference in recommended crossing treatments. These topics are discussed in more detail below.

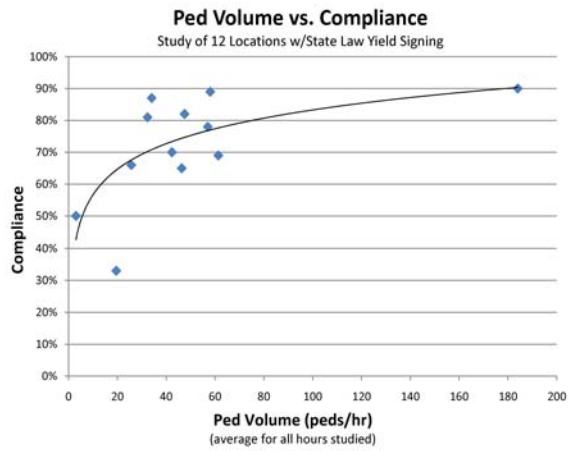
2.2.2 Minimum Vehicle Volume For Treatments

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

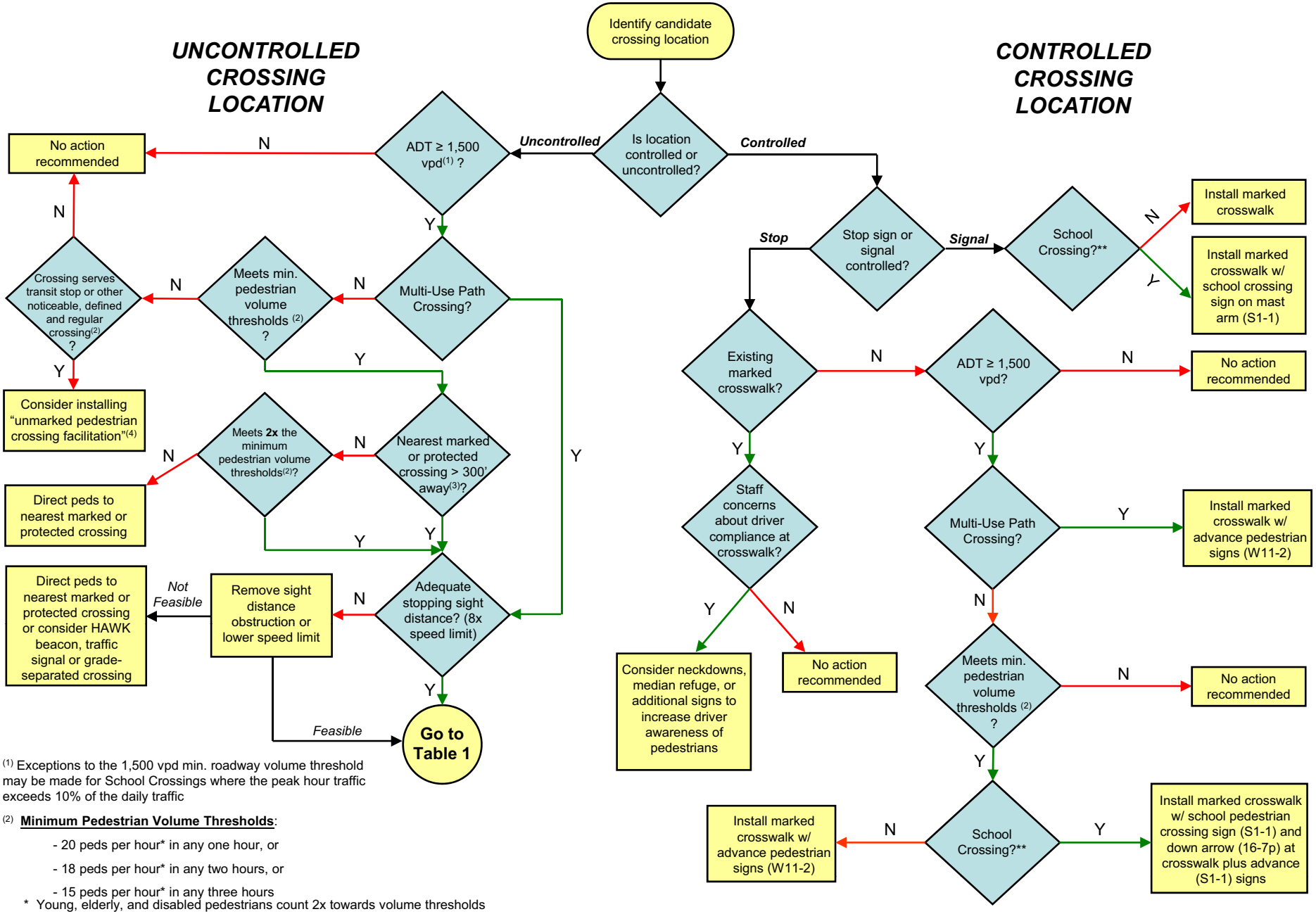
	AM	Mid-Day	PM	Other
How many times per hour did the downstream vehicle queue back up into pedestrian crossing?				
If multiple lanes per direction, are queue lengths approximately equal?	Y N	Y N	Y N	Y N
If NO (above),which lane is longer (inside, outside, middle) and by how much (feet)?				

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.]*

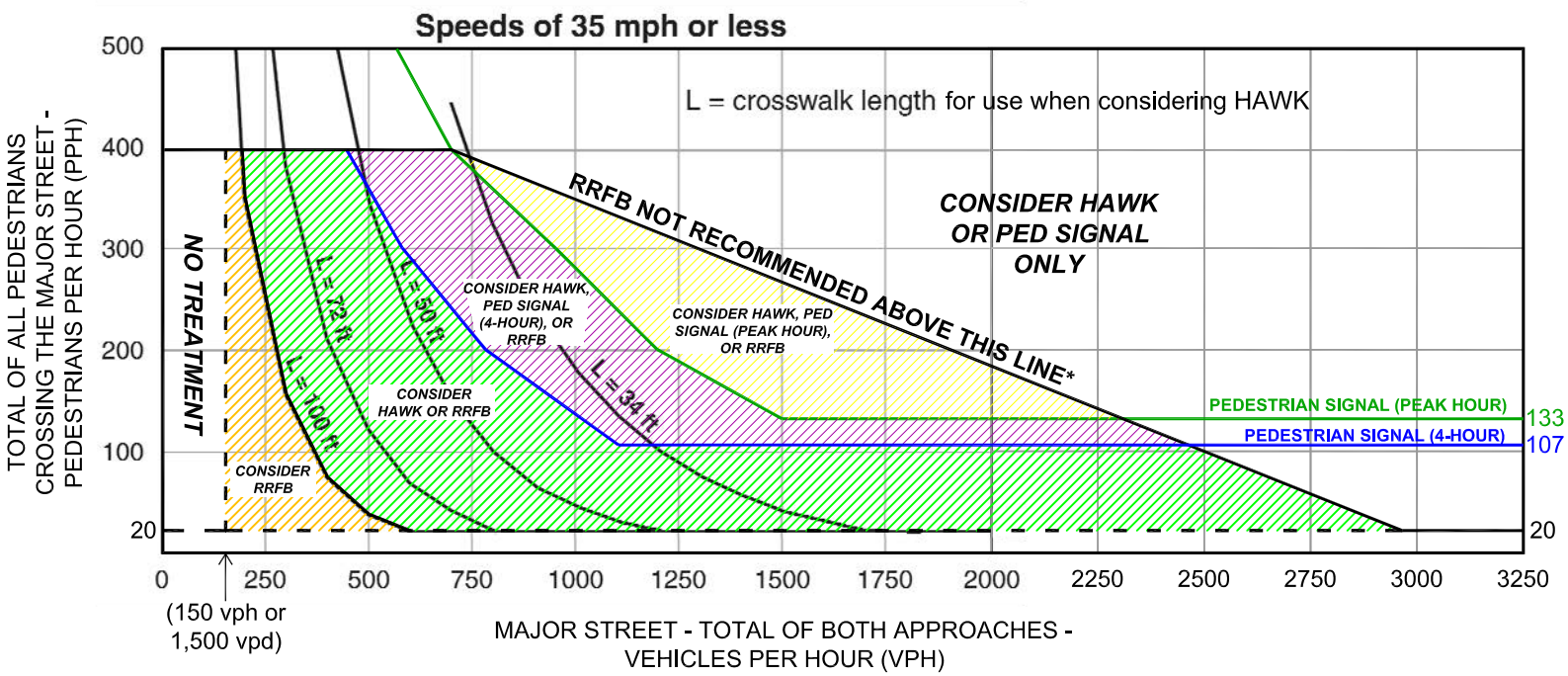
E ***Do not install marked crosswalk at uncontrolled crossing. Determine if the speed limit can be effectively reduced to 40 mph AND a raised refuge median can be installed. If so, utliize Scenario D criteria above. If this is not possible, or if pedestrian volume falls above the RRFB limit line on Figure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

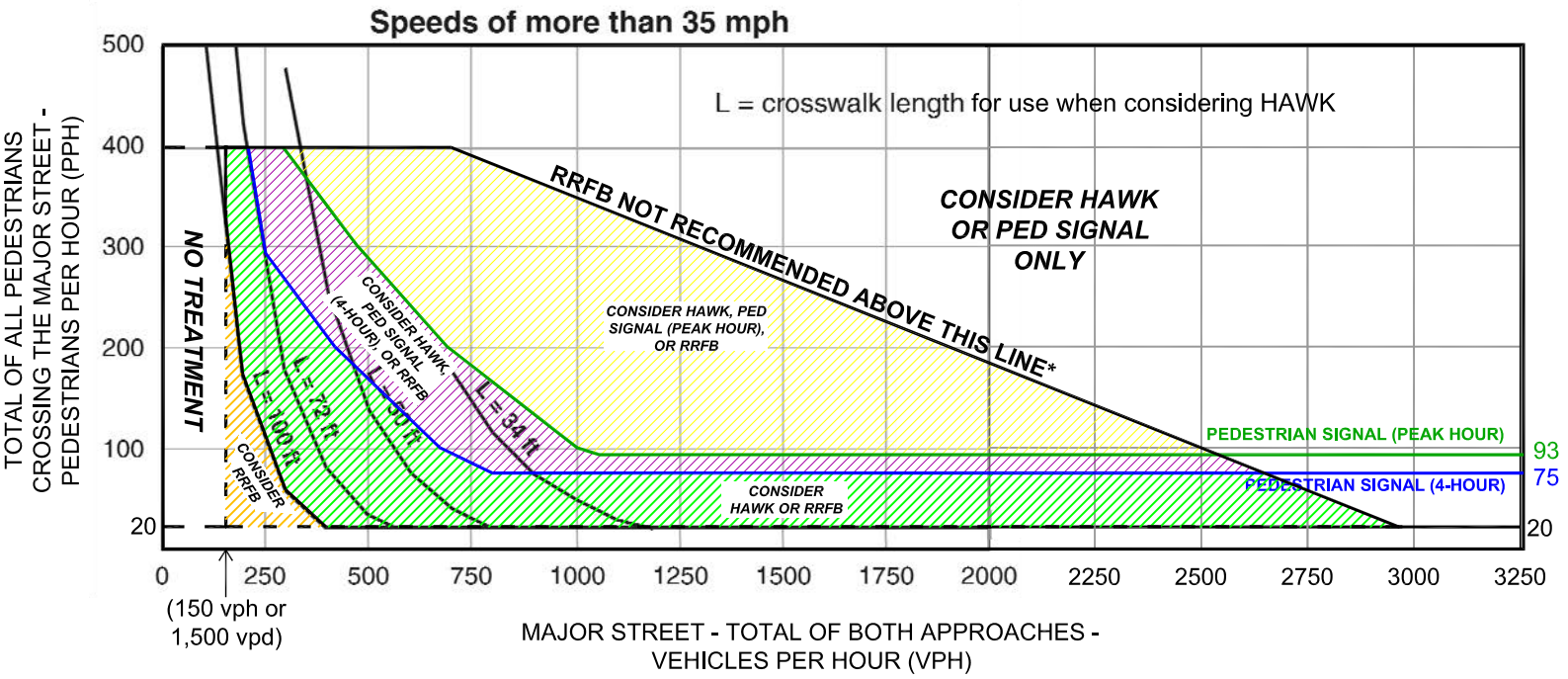
Specific Guidance : Consider HAWK beacon, pedestrian traffic signal or grade-separated crossing; application of these treatments will consider corridor signal progression, existing grades, phyiscal contraints, and other engieering factors

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.

Bibliography

[1] Zegeer, C.V., Stewart, R.J., Huang, H.H., 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., February 2002.

[2] Institute of Transportation Engineers. *Design and Safety of Pedestrian Facilities*. Washington, D.C., March 1998.

[3] Smith, Steven A., Knoblauch, Richard L. *Guidelines for the Installation of Crosswalk Markings*. Transportation Research Record 1141, Transportation Research Board, National Research Council, Washington, D.C., 1987.

[4] Dougald, Lance E. *Development of Guidelines for the Installation of Marked Crosswalks.* Virginia Transportation Research Council, Charlottesville, Virginia. December 2004.

[5] City of San Jose, California, Department of Transportation. *Guidelines for the Installation and Removal of Marked Crosswalks.* April 2005.

[6] Lalani Nazir and the ITE Pedestrian and Bicycle Task Force. Alternative Treatments for At-Grade Pedestrian Crossings. Institute of Transportation Engineers. 2001.

FUTURE TOWN BOARD MEETINGS

Work Sessions & Regular Meetings will be held in the Board Chambers unless otherwise noted.

September 29, 2014	Fifth Monday
October 6, 2014 6:00 p.m.	Town Board Work Session
October 13, 2014 5:30 p.m./1st floor conference room	Board/Manager/Attorney Monthly Meeting
October 13, 2014 7:00 p.m.	Town Board Meeting
October 20, 2014 6:00 p.m.	Town Board Work Session Windsor Housing Authority work session on CDBG-DR grant application Reader board signage discussion Large entertainment establishments discussion
October 27, 2014 6:00 p.m.	Town Board Work Session Discussion of draft 2015 DDA budget
October 27, 2014 7:00 p.m.	Town Board Meeting
November 3, 2014 6:00 p.m.	Town Board Work Session
November 10, 2014 5:30 p.m./1st floor conference room	Board/Manager/Attorney Monthly Meeting
November 10, 2014 7:00 p.m.	Town Board Meeting
November 17, 2014 6:00 p.m.	Town Board Work Session
November 24, 2014 6:00 p.m.	Town Board Work Session
November 24, 2014 7:00 p.m.	Town Board Meeting

Additional Events

October 2, 2014 Estes Park	CML District 2 meeting; attending: Christian Morgan, Ivan Adams
October 11, 2014	Budget work session

Future Work Session Topics

None.