

Standards for Traffic Calming and Crosswalks



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777 Lynn Street
Herndon, VA, 20170

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1 INTRODUCTION

Per Herndon’s 2030 Comprehensive Plan, the Town of Herndon (hereafter referred to as the “Town”) seeks to provide a transportation system that safely accommodates local traffic, facilitates alternative modes of transportation within the town, and provides safe streets that are friendly to pedestrians and bicyclists. The Town’s Department of Public Works (DPW) is responsible for the maintenance of streets within the Town boundary, except those which are privately maintained; however, private street owners are encouraged to reference this document and apply elements found herein for consistency across the Town’s transportation network. The Town, through the Traffic Engineering Improvement Committee (TEIC) and the departments of Public Works, Community Development, and Police, are responsible for processing resident concerns related to transportation safety and connectivity on Town-maintained streets.

This document standardizes the process by which community concerns are reviewed, the criteria utilized to determine if modifications or treatments are warranted, and the criteria utilized to select appropriate treatments. For the purposes of this document, traffic calming measures are defined as either physical features or policy measures designed to improve non-motorist safety, mobility, and comfort through the reduction of vehicle speeds. However, some traffic calming elements may also be used to improve roadway safety or operations as necessitated by deficient transportation network conditions. Crosswalk treatments include the provision of new marked crosswalks in locations where they currently do not exist, or the addition of features to an existing crosswalk intended to enhance non-motorist safety, mobility, and comfort. This document replaces the *Neighborhood Traffic Calming Guide*, approved by the Herndon Town Council in August 2011.¹ Other transportation measures which fall outside of these definitions, such as traffic control devices (e.g. stop signs), cut-through traffic restrictions, sidewalk improvements, or new transportation network connections are considered outside of the scope of this document.

1.1 Document Overview

This document is organized into the following chapters:

- **Chapter 1: Introduction**
- **Chapter 2: Process Overview** – Reviews the overall process for receiving and reviewing transportation-related concerns in the Town of Herndon.
- **Chapter 3: Basic Eligibility Requirements and Engineering Study Requirements** – Provides guidance on what locations are eligible for traffic calming measures and/or crosswalk treatments, and the information that should be collected as part of an engineering study if the location is deemed eligible.
- **Chapter 4: Evaluation Criteria** – Details the evaluation process to be utilized in the selection of appropriate traffic calming measures and/or crosswalk treatments.
- **Appendices** – Provides a toolbox of traffic calming measures and crosswalk treatments.
 - **Appendix A: Traffic Calming Measures** – Defines potential traffic calming measures and documents their advantages, disadvantages, effectiveness, and other considerations.
 - **Appendix B: Crosswalk Treatments** – Defines potential crosswalk treatments and documents their advantages, disadvantages, effectiveness, and other considerations.

1.2 How to Read this Document

Town of Herndon staff utilize this guidance to classify concerns, determine the extent of the concern, determine eligibility of mitigations related to the concern, determine appropriate traffic calming measures or crosswalk treatments for the location of concern (if applicable), and inform the selection of potential improvements. Town staff also utilize this document to consider improvements throughout the Town as part of typical safety audits, public works maintenance activities, and during planning activities.

Residents can utilize this guide to understand the process by which the Town intakes and evaluates transportation-related concerns such as traffic calming measures and crosswalk treatments. All readers can utilize this guidance to understand potential traffic calming measures or crosswalk treatments, their advantages and disadvantages, and the contexts in which each measure is appropriate.

1.3 Town Standards

The Town is subject to Federal requirements and State code, which cover topics such as accessibility and connections to State Highways. This includes the Final Ruling of the Pedestrian Right-of-Way Accessibility Guidelines (PROWAG), which is published in the Federal Register. The Town of Herndon owns and maintains all public roadways within its physical municipal limits. As such, the following documents have been adopted as the Town’s standards for roadway design and markings within the public right-of-way:

- The *Manual on Uniform Traffic Control Devices* (MUTCD), published by the United States Department of Transportation Federal Highway Administration.²
- *A Policy on the Geometric Design of Highways and Streets* (the “Green Book”), published by the American Association of State Highway and Transportation Officials.³
- The *Town of Herndon Public Facilities Manual*, as described in Town of Herndon Code Section 1-15.

Where the above standards and guides lack detailed information, the Town will opt to follow the most current and applicable Virginia Department of Transportation (VDOT) standard or reference applicable industry guidance from the sources including, but not limited to the following:

- The Institute of Transportation Engineers
- The Transportation Research Board
- The National Association of City Transportation Officials

2 PROCESS OVERVIEW

This chapter describes the process through which a transportation concern is reviewed and addressed. Figure 1 provides a step-by-step diagram illustrating this process. At various steps in the process, the diagram references additional requirements or criteria documented in later chapters of this document. Following this process diagram is a narrative describing each individual step. Note that while the source of a transportation concern may vary (e.g. residents, business owners, or elected officials), Town staff will follow the same general intake and evaluation process. However, the approval and stakeholder engagement may vary based on the appropriate forum for communication.

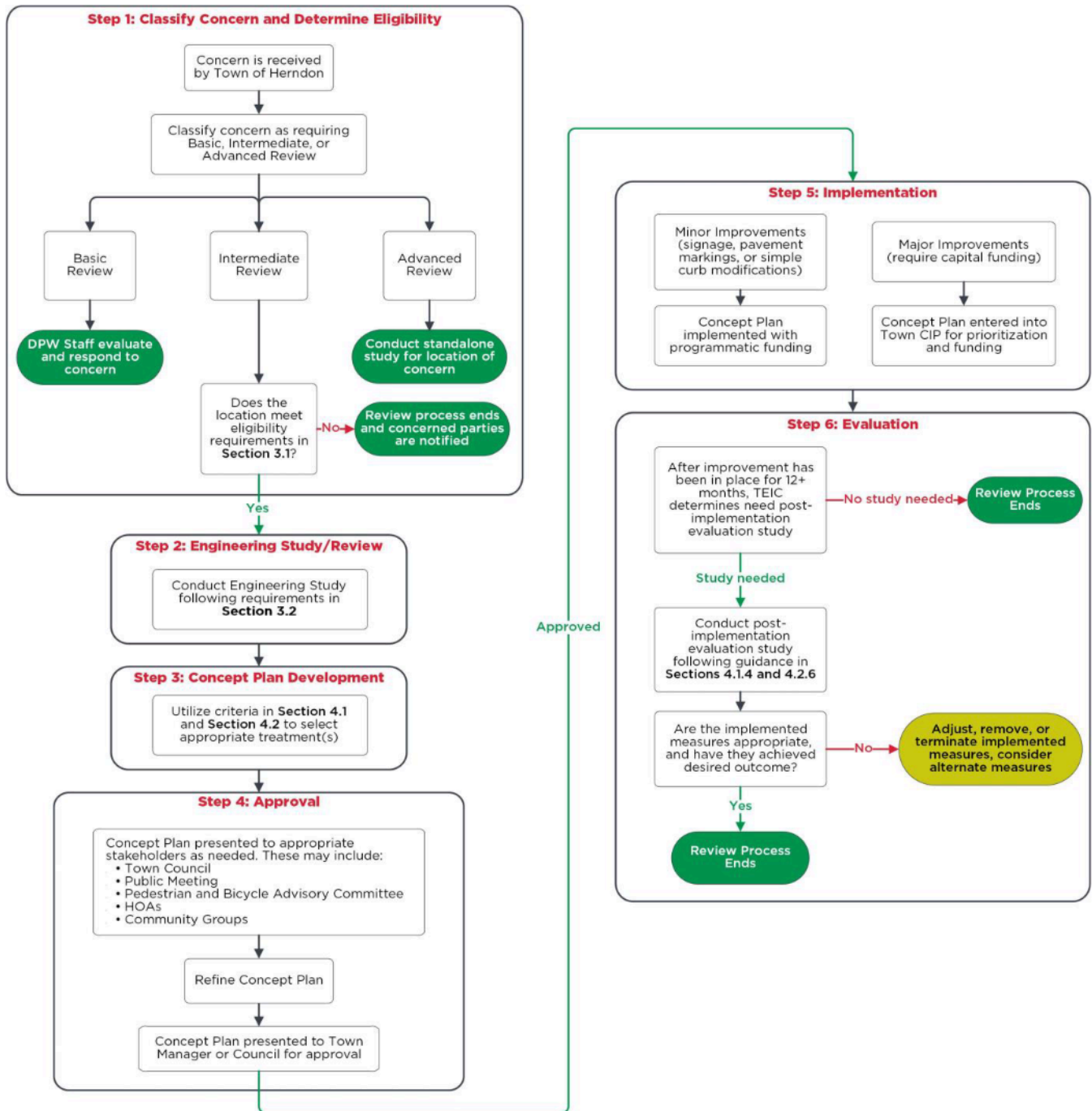


Figure 1: Process Flow Chart

2.1 Step 1 – Classify Concern and Determine Eligibility

Residents, community groups, or organizations may submit a transportation-related concern via e-mail, phone call, in-person meetings, or the Herndon on the Go App; however, staff will enter and track all concerns through the Town’s internal CityWorks system throughout the remainder of the process. Concerns may also be raised by staff as part of Town transportation planning efforts. Upon receipt of this submission, Town staff will conduct a preliminary review to classify the concern, define the issue or problem in the concern, determine eligibility, identify the study area, and determine the proper action. This may include a site visit to the location of concern. Staff may also contact the submitting party to clarify the concern and/or collect additional details.

Concerns will be classified under one of the following categories, based on the complexity of the identified concern:

- **Basic Review** – DPW staff evaluate the concern and take action based on the discretion of the Director of Public Works. Concerns that undergo a Basic Review can typically be addressed at the staff level without consultation with the TEIC.
- **Intermediate Review** – The identified concern is progressed through subsequent steps of the review process described in this guide, including conducting preliminary work and presenting findings to the TEIC, conducting an engineering study, and development of a concept plan.
- **Advanced Review** – The concern requires a level of review more detailed than what could be provided in the review process described in this guide. If an Advanced Review is required to address the identified concern, the TEIC would proceed with conducting a standalone Town study to address the identified concern. The study may consider the evaluation criteria in this guidance document to determine appropriate improvements, but shall use engineering judgement to determine which improvements are appropriate. Recommended measures may be implemented as part of the Town Capital Improvement Program (CIP). Improvements would undergo an interdepartmental review and would be presented to the Town Manager or Town Council for approval.

Concerns categorized as requiring a Basic Review will be addressed at the staff level and will not progress through the subsequent review steps described in this guide. Examples of concerns that would fall under the Basic Review category include those that could be addressed through minor staff-level actions, such as improvements to sight distances (e.g. tree pruning or sign sizes), warning signs, or changes to parking restrictions. Concerns categorized as requiring Advanced Review will require a standalone Town study to properly review and address the identified concerns. Examples of concerns that may require Advanced Review include (but are not limited to) corridor-wide speeding concerns (i.e. requiring consideration of countermeasures along an extended stretch of road) or pedestrian crossing concerns within school zones or near pedestrian generators. Once a concern is categorized as requiring Basic or Advanced Review, the review process is considered outside of the scope of this guide, but staff may utilize this document to consider potential improvements.

Based on the nature of the concern, staff will then identify a study area:

- **Traffic Calming** – Study area is likely to include the street segment identified in the initial communication, but may be expanded at the discretion of the Town engineer.
- **Crosswalk Treatments** – Study area is likely to focus on the intersection identified in the community concern. If the location is mid-block, the study area will include the entire street segment between the two nearest crosswalks. Adjacent or nearby intersections or street segments may be included if beneficial to the comprehensive review of the crossing concern.

Upon review and classification of the concern, staff will determine if traffic calming or crosswalk treatment criteria are specifically applicable to the location in question. Eligibility requirements will reference the following:

- **Traffic Calming** – Follow eligibility criteria outlined in Section 3.1.1.
- **Crosswalk Treatments** – Follow eligibility criteria outlined in Section 3.1.2.

If the location is deemed not eligible for traffic calming or crosswalk treatments, the review process ends and any parties who submitted the concern to the Town will be notified.

2.2 Step 2 – Engineering Study/Review

The TEIC will conduct an engineering study to collect relevant traffic data and inform the selection of appropriate traffic calming or crosswalk treatments. The study will include collection of traffic data and a field review at the location of concern; the data collection and field review will be conducted based on the nature of the concern:

- **Traffic Calming** – Follow engineering study guidelines outlined in Section 3.2.1
- **Crosswalk Treatments** – Follow engineering study guidelines outlined in Section 3.2.2

For studies that include multiple locations or encompass potential issues other than those noted above, the TEIC will evaluate what the appropriate scope of study is to study and address the concern(s).

2.3 Step 3 – Concept Plan Development

Under this step, the TEIC will review the results of the engineering study to identify the appropriate treatments for the study location and propose a plan to address concerns (if warranted and applicable).

For traffic calming concerns, the TEIC will use the evaluation criteria outlined in Section 4.1 to select the appropriate traffic calming treatment(s). The specific context of the location and engineering judgment shall then be used to select a specific measure or set of measures.

For crosswalk treatment concerns, the TEIC will use the evaluation criteria outlined in Section 4.2 to select the appropriate crosswalk treatment(s). The specific context of the location and engineering judgment shall then be used to select a specific treatment or set of treatments.

During this step, it may be determined that no treatments are appropriate or justified, at which point the review process ends. For example, if the engineering study for a traffic calming concern does not show speeding in excess of established thresholds, the TEIC may determine that no treatment is justified at the study location.

2.4 Step 4 – Approval

Upon selection of a concept plan for the study location, staff will present the plan to the appropriate body for review and approval. For plans that require significant adjustments to public infrastructure (such as parking restrictions, curb modifications, or signal adjustments), a public meeting will be held during concept development to solicit community input. Following this input and refinement of the concept, the plan will move to the appropriate approval level (Town Manager or Town Council).

2.5 Step 5 – Implementation

After approval of the concept plan, DPW will oversee the implementation of the proposed improvement measures based on funding and contractor availability. For minor improvements consisting primarily of signage, pavement markings, or simple modifications to curb such as curb ramps, staff will advance the plan through programmatic funding. For larger improvements where capital funding is required, staff will enter the project into the Town’s Capital Improvement Program (CIP) for prioritization and funding.

2.6 Step 6 – Evaluation

After an improvement has been in place for more than one month, but less than six months, Town staff may conduct a post-implementation evaluation study depending on the extent of the problem identified at the location of concern. Whether a post-implementation evaluation study is conducted will be determined by the Town's TEIC. Guidance on evaluation studies is provided in Sections 4.1.4 and 4.2.6. If a study is conducted, staff will record the results of the post-implementation evaluation and summarize them in a report to the Town Manager. If it is determined that the implemented measures are not appropriate or have not achieved the desired outcome, Town staff may adjust, remove, or terminate such measures or consider alternate measures. If Town staff identifies a new safety concern due to an implemented measure, they may unilaterally make the decision to remove the measure.

3 BASIC ELIGIBILITY AND ENGINEERING STUDY REQUIREMENTS

3.1 Basic Eligibility Requirements

3.1.1 Traffic Calming

To be considered for traffic calming measures, the study location should meet the following conditions:

- Be a roadway maintained by the Town of Herndon
- Have a posted speed limit of 25 mph or less
- Have a maximum of 2 lanes of vehicular traffic
- Be classified as a local or collector road by the Town of Herndon
- Traffic calming measures have not been previously requested and studied in the past two (2) years at the study location

If a roadway does not meet these requirements, the structured review process ends. The Town's TEIC may consider an alternate process outside of the scope of this guidance document to address community concerns at the location of concern.

3.1.2 Crosswalk Treatments

To be considered for crosswalk treatments, the proposed crossing location should meet the following eligibility criteria:

- Be a roadway maintained by the Town of Herndon
- Crosswalk treatments have not been previously requested and studied in the past two (2) years at the study location
- An existing crosswalk is already provided at the location of concern (i.e. additional treatments are being considered to improve the existing crosswalk); OR
- A crosswalk has already been determined to be warranted through an outside process (i.e. additional treatments are being considered in addition to the provision of a crosswalk); OR
- If an existing crosswalk is not already provided at the location of concern, determine eligibility as follows:
 - If the location is at a signalized intersection, it is considered eligible.
 - If the location of concern is unsignalized, the location should:
 - Be at least 300 feet or more to nearest controlled crosswalk
 - Have adequate stopping sight distance of the entire crosswalk (or potential crosswalk) and its entry points, based on the most recent methodology for stopping sight distance calculations in the AASHTO Policy on Geometric Design of Highways and Streets; refer to Table 1 for stopping sight distances on level ground.
 - If the location does not have adequate stopping sight distance, crosswalk treatments may still be considered; however, any proposed treatments for the location should include mitigation measures to address the inadequate stopping sight distance.

Table 1: Stopping Sight Distance

Design Speed	Minimum Stopping Sight Distance*
25 mph	155 feet
30 mph	200 feet
35 mph	250 feet
40 mph	305 feet

* The minimum distance needed by drivers to see pedestrians and other potential obstacles on the road in time to come to a safe stop. In simpler terms, it is the distance required for a driver to see a hazard, such as a pedestrian in a crosswalk, and then have enough space to stop before reaching that point. This table is provided as a quick reference; distances shown are based on the AASHTO *Policy on Geometric Design of Highways and Streets*, 7th Edition and are for level roadways only.

Note that a crosswalk is not always marked with pavement markings, particularly on local and neighborhood streets; however, Town staff will still treat these locations as having existing crosswalks. If the location fails to meet eligibility requirements, the structured review process ends. However, Town staff may consider the subject location in a comprehensive planning process, development review process, or other planning activity if pedestrian safety and connectivity concerns are noted at the study location. Additionally, locations within school zones (within an a quarter mile of schools, or up to industry standard based on staff discretion), near pedestrian generators, or requiring consideration of new traffic control devices (such as traffic signals or stop signs) may require an Advanced Review or other separate study.

3.2 Engineering Study Data Collection Requirements

3.2.1 Traffic Calming Study Requirements

For an engineering study conducted in response to a traffic calming concern, the following data should be collected as it pertains to the specific need:

- Traffic volumes and speed data, typically collected over a 48-hour period on Tuesdays, Wednesdays, or Thursdays, during a week when public schools are in session, no holidays occur, and weather does not impact typical travel patterns
- Crash history of the study location for the most recently available 5-year period
- A site visit should be conducted to gather additional information specific to the study location, including:
 - Grade
 - Designation of the study location as an emergency, truck, or bus route
 - Sight distances and sight line issues
 - Roadway geometry, including widths
 - Posted speed limit
 - Observation of abnormal or undesirable driver behaviors or site conditions
 - Notable land uses such as schools, parks and recreation facilities, or commercial shopping centers

3.2.2 Crosswalk Treatment Study Requirements

For an engineering study conducted in response to a crosswalk treatment concern, the following data should be collected:

- Traffic volumes, collected over a 48-hour period on Tuesdays, Wednesdays, or Thursdays, during a week when public schools are in session, no holidays occur, and weather does not impact typical travel patterns
- Pedestrian volumes, collected over a 48-hour period on Tuesdays, Wednesdays, or Thursdays, during a week when public schools are in session, no holidays occur, and weather does not impact typical travel patterns. If the study location does not have an existing crosswalk, volumes should observe any crossings that occur within 300 feet in either direction from the location of concern. If the study location is near a bicycle facility, such as a trail or bike lane, and potential treatments may involve provision of bicycle crossing facilities, bicycle volumes should be collected in the same period.
- (Optional) Driver yield rates during peak hours, collected only for locations with an existing crosswalk and where driver yielding behavior has been identified as a concern
- Crash history of the study location for the most recently available 5-year period
- A site visit should be conducted to gather additional information specific to the study location, including:
 - Nearby pedestrian generators such as schools, hospitals, senior centers, shopping centers, parks, bus stops, or recreation centers
 - Distance to the nearest controlled crosswalk
 - Stopping sight distance
 - Presence of street lighting adjacent to the proposed crossing location
 - Roadway geometry, including number of lanes and presence of a raised median
 - Posted speed limit

4 EVALUATION CRITERIA

4.1 Traffic Calming

Once a study location is considered eligible for potential traffic calming measures based on the criteria outlined in Section 3.1.1, and an engineering study has been conducted in accordance with Section 3.2.1, the evaluation criteria discussed in this section will be used to identify appropriate traffic calming measures and inform the development of a concept plan for the study location. The decision tree in Figure 2 describes this evaluation process.

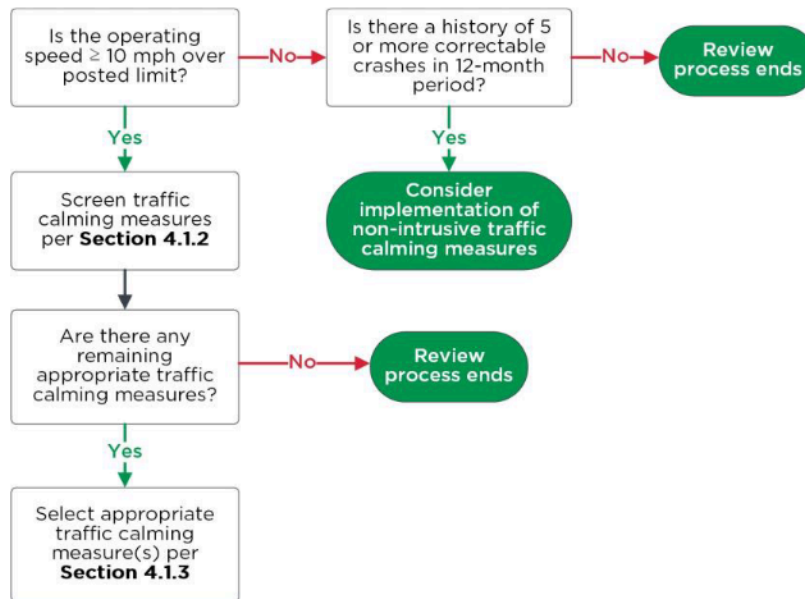


Figure 2: Traffic Calming Process Decision Tree

4.1.1 Potential Traffic Calming Measures

Potential traffic calming measures that could be utilized at the study location include the following, with detailed definitions provided in [Appendix A](#):

- Non-Intrusive Measures
 - Education
 - Enforcement
 - Pavement Markings
 - Warning Signs
 - Radar Speed Feedback Sign
 - Additional \$200 Fine Sign
- Vertical Measures
 - Speed Hump
 - Speed Cushion
 - Speed Table
 - Raised Intersection

- Horizontal and Narrowing Measures
 - Chicane
 - Median Island
 - Choker
 - Curb Extension
 - Traffic Circle

Detailed information on traffic calming measures, including descriptions, pictures, advantages/disadvantages, and effectiveness is provided in [Appendix A](#).

The following are **not** intended for and will not be used as traffic calming measures:

- Stop Signs – The placement of stop signs shall be determined in accordance with the Manual on Uniform Traffic Control Devices (MUTCD). The MUTCD indicates that stop signs shall not be used for speed control and, when used for purposes other than traffic control, they may cause more harm than good. As such, they are not included as a traffic calming measure in this guidance.
- Traffic Restrictions – Traffic restriction is the use of various methods to restrict vehicle travel through specific locations. This could include the placement of signage to restrict undesired movements (such as one-way such restricted turn movements), or placement of physical barriers to block undesired travel (such as half- or full-street closures). These measures are more appropriate for the restriction of cut-through traffic, which is not an objective of this guidance.
- Roundabouts – While roundabouts have documented traffic calming effects, the cost and scope of implementing a roundabout generally does not fit within the scope of improvements considered in this *Transportation Guidance*. If a roundabout is desired, a full intersection redesign and traffic study should be conducted. Mini-roundabouts (also called traffic circles) are included in this guidance as they provide a traffic calming effect but have a scope more appropriate and similar to the other measures discussed.

The elements above are intended to regulate traffic flow and provide guidance where motorist right-of-way must be controlled. The need for and use of these elements will be assessed in a separate study by the Town’s TEIC using criteria detailed in the MUTCD.

Note that the above lists are not exhaustive, and the final selection of appropriate traffic calming measures will be at the professional judgement of the Town’s engineer.

4.1.2 Initial Screening

The intent of this section is to describe the initial screening process to be used to remove from consideration any traffic calming measures that are not appropriate for the study location. The appropriateness of a particular measure depends on several factors, including the function of the street, operating speeds, volumes, and other context-specific characteristics of the study location.

The first step of the screening process is to identify and determine the extent of the problem to be addressed. For traffic calming measures, this includes determining the 85th percentile speed of vehicles on this segment, also referred to as the operating speed. The 85th percentile speed is the speed at which 85% of drivers drive at or below and 15% of drivers drive faster than. If the operating speed is less than 10 mph over the posted speed limit, then traffic calming measures are generally considered to not be justified and the review process ends. If otherwise justified, non-intrusive traffic calming measures may be considered at excepted locations where there is a history of crashes (guidance: 5 or more correctable crashes in a 12-month period), or repeated, observed, unsafe behaviors.

If the operating speed is 10 mph or more than the posted speed limit, Table 2 and Table 3 are used as initial screening tools to determine whether a particular traffic calming measure may be appropriate for the study location.

Table 2 is used as a screening tool to determine whether a particular traffic calming measure is considered appropriate for the study location given its classification, function, and daily vehicle volume. Certain traffic calming measures may be considered not appropriate for streets of a certain classification, or streets considered emergency routes, transit routes, or truck routes. For example, because speed humps can cause delay for emergency vehicles, they are generally not considered appropriate for routes frequently utilized by emergency vehicles, such as streets that provide access to a hospital or other emergency service locations. Guidelines were developed based on the results of studies listed in the FHWA Traffic Calming E-Primer⁴ as well as the guidance of other jurisdictions such as VDOT. Traffic calming measures are listed in Table 2 as one of three levels of appropriateness:

- May be appropriate
- Caution; could be inappropriate
- Likely inappropriate

Table 3 is used to screen traffic calming measures based on additional constraining factors, including:

- Grades – Certain traffic calming measures are not considered appropriate on steep grades or may limit the ability to drain stormwater on the roadway.
- Operating speeds – If the operating speed (the observed 85th percentile speed of vehicles at the study location) is over 45 mph, vertical measures such as speed humps or speed tables are not considered appropriate.
- Available curb-to-curb width – Some measures require a minimum amount of curb-to-curb width to be implemented while still being effective and leaving room for emergency vehicles.
- Measure location – Certain measures are appropriate for implementation only at intersections, a certain distance from an intersection, or along street segments.

Table 2: Traffic Calming Screening – Roadway Classification and Function

Roadway Classification and Function		Vehicles Per Day								
		≤500			500 - 4,000			≥4000		
Local	Standard	1	2	3	①	②	③	①		
		4	5	6	④	⑤	⑥			
		7	8	9	⑦	⑧	⑨	⑦	⑧	
	Emergency Access*	1		3	①		③	①		
			5	6		⑤	⑥			
		7	8		⑦	8		⑦	8	
	Bus Route*	1	2	3	①	②	③	①		
		4	5	6	④	⑤	⑥			
		7	8	9	⑦	8	9	⑦	8	
	Truck Access*	1	2	3	①		③	①		
		7	8		⑦	8		⑦	8	
	Collector	Standard	1		3	①		③	①	
4			5	6	④	⑤	⑥			
7			8		⑦	⑧		⑦	⑧	
Emergency Access*		1		3	①		③	①		
			5	6		⑤	⑥			
		7	8		⑦	8		⑦	8	
Bus Route*		1		3	①		③	①		
		4	5	6	④	⑤	⑥			
		7	8		⑦	8		⑦	8	
Truck Access*		1		3	①		③	①		
		7	8		⑦	8		⑦	8	

* If a roadway has multiple functions, screen measures based on all applicable functions.

- 1 Non-Intrusive Measures (Education, Enforcement, Pavement Markings, Signage)
- 2 Speed Hump
- 3 Speed Cushion
- 4 Speed Table
- 5 Raised Intersection
- 6 Chicane
- 7 Median Island or Choker
- 8 Curb Extension
- 9 Traffic Circle

In each combination of roadway classification, function, and vehicle volumes:

- Circled Number Signifies that the measure may be appropriate
- # Uncircled Number Signifies that the measure could be inappropriate and to use caution when considering
- Missing Number Signifies that the measure is likely inappropriate

Source: [FHWA - Traffic Calming ePrimer](#); [VDOT - Traffic Calming Guide for Neighborhood Streets](#)

Table 3: Traffic Calming Screening – Additional Considerations

Traffic Calming Measure	Grade	Operating Speed	Consideration		Other Considerations
			Curb-to-Curb Width	Location (Segment vs. Intersection)	
Education				Segment	
Enforcement				Segment or Intersection	N/A
Pavement Marking			Can be utilized to narrow travelway on wider roadways	Segment or Intersection	
Radar Feedback Sign	N/A			Segment	
Additional \$200 Fine Sign				Segment	Use as a targeted measure for school zones, locations near senior living centers, and pedestrian activity centers
Speed Hump				Segment	Place at a midblock location at least 150 feet from an unsignalized intersection and 250 feet from a signalized intersection. Must review impact on road drainage and may increase noise.
Speed Cushion	Not appropriate for steep grades (>8%)	Not appropriate if operating speed is ≥45 mph		Segment	
Speed Table				Segment	
Raised Intersection	N/A			Intersection	N/A
Chicane	Not appropriate for steep grades (>8%)		Requires enough curb-to-curb width to install an effective chicane	Segment	Must review impact on road drainage; potential to add greenery/landscaping; impact to on-street parking
Median Island (Crosswalk Refuge)			Requires enough curb-to-curb width to install a median	Segment or Intersection (Can be utilized as a crosswalk refuge)	
Choker (Mid-Block Crossing)	N/A		Requires enough curb-to-curb width to install a choker	Segment; can be utilized to implement a mid-block crossing	
Curb Extension			Requires enough curb-to-curb width to install curb extensions	Segment or Intersection	Must review impact on road drainage; potential to add greenery/landscaping; check curb-radius if on an access route; impact to on-street parking
Traffic Circle	N/A			Intersection	Must review impact on road drainage; potential to add greenery/landscaping; affects left turns on transit routes

Source: FHWA - [Traffic Calming ePrimer](#)

4.1.3 Measure Selection

After the initial screening of potential traffic calming measures for the location of concern has been completed, Town staff will select the most appropriate measure(s) for that location. Selection of appropriate measures will require consideration of several factors, including but not limited to:

- Cost of the measure(s)
- Effectiveness of the measure(s)
- Timeline to implement the measure(s)
- Operating speed
- Drainage impacts
- Sight lines
- Existing traffic calming measures already in place
- Snow removal and snow emergency routes
- Noise concerns
- Utility conflicts
- Other nearby or ongoing projects in the area

The Town will work amongst the Departments of Public Works, Community Development, Police, and with Fairfax County emergency services to identify the most appropriate measure based on the factors present at the study location. Information on the advantages, disadvantages, effectiveness, and special considerations for traffic calming measures is provided in [Appendix A](#).

4.1.4 Post-Implementation Evaluation

Town staff may elect to conduct a post-implementation evaluation study depending on the extent of the problem identified at the location of concern. Whether a post-evaluation study is conducted will be determined by the Town's TEIC; this document recommends that at minimum if the operating speed determined in the engineering study was 10 mph or more over the speed limit, or there is a history of speed related crashes in the study area, a post-evaluation study should be heavily considered.

In this study, Town staff may do the following:

- Conduct a site visit to the location of concern to observe road user behavior.
- Conduct a speed study, with data collected at times in which driver behavior is considered typical.
- Assess the measure's impact on emergency, transit, or public works maintenance vehicles.

If the study determines that the desired outcome has not been achieved or that the negative impacts outweigh the desired impacts, the TEIC may consider additional action at the subject location, such as implementation of additional or alternative traffic calming measures.

4.2 Crosswalk Treatments

Once a study location is considered eligible for potential crosswalk treatments based on the criteria outlined in Section 3.1.2, and an engineering study has been conducted in accordance with Section 3.2.2, the evaluation criteria discussed in this section will be used to identify appropriate crosswalk treatments and inform the development of a concept plan for the location of concern.

The crosswalk treatment evaluation is a three-step decision process that guides the consideration and selection of crosswalk treatment:

- **Safety Issue Identification:** This step involves recognizing and assessing safety issues associated with pedestrian crossings, laying the groundwork for targeted solutions to enhance pedestrian safety (Section 4.2.1).
- **Crosswalk Treatment Decision Tree:** This decision tree assists in determining the potential need for crosswalk treatments at an existing or a proposed crosswalk location based on a series of criteria (Section 4.2.2).
- **Crosswalk Treatment Screening and Selection:** If a marked crosswalk is justified, appropriate crosswalk treatments are screened and selected based on the safety issues identified and characteristics of the location of concern, among other considerations (Sections 4.2.3-4.2.5).

4.2.1 Safety Issue Identification

Prior to selection of crosswalk treatments, the specific safety issues at the location of concern should be identified. The following five (5) safety issues are crucial to identify and understand when selecting and implementing crosswalk treatments:

- **Conflicts at crossing locations** – Situations where pedestrians face challenges navigating roadways due to conflicts with vehicular traffic or other factors. These conflicts can arise from complex intersections, unclear right of way, or other designed-related issues that hinder the smooth and safe passage of pedestrians across roadways.
- **Excessive vehicle speed** – Vehicles traveling at speeds that exceed safe limits for pedestrian crossing, increasing the risk of accidents and reducing reaction time for both drivers and pedestrians.
- **Inadequate conspicuity/visibility** – Insufficient visibility for pedestrians and crosswalks, making it challenging for drivers to easily recognize and respond to the presence of pedestrians.
- **Drivers not yielding to pedestrian in crosswalks** – Situations when drivers fail to yield the right of way to pedestrians already in a crosswalk, posing a direct threat to pedestrian safety.
- **Insufficient separation from traffic** – A lack of physical or visual separation between pedestrians and vehicular traffic, increasing the likelihood of conflicts.

4.2.2 Crosswalk Treatment Decision Tree

The decision tree shown in Figure 3 serves as a tool in guiding the determination of whether a marked crosswalk is justified at the location of concern. This flowchart outlines a comprehensive decision-making process, directing users through various considerations to reach an informed conclusion. In some cases, a marked crosswalk may not be justified.

Various factors and criteria are taken into account at different crossing locations, including signal-controlled intersections, stop-controlled intersections, and mid-block locations. Each situation necessitates a tailored approach to ensure pedestrian safety.

- **Signal Controlled Intersections** – At intersections and mid-block crossings controlled by traffic signals or flashing beacons, marked crosswalks are recommended. These markings enhance visibility and safety for pedestrians. Generally, crosswalks should be marked across each intersection approach unless specific instances prohibit pedestrian travel.
 - In unique cases, such as T-intersections, engineering judgement may lead to the provision of one crosswalk instead of the typical two, aiming to minimize potential conflicts with left-turning vehicles.

- **Stop Controlled and Uncontrolled Intersections** – The decision to mark crosswalks is determined through Figure 3.
- **Mid-Block Locations** – The decision to mark crosswalks is determined through Figure 3.

Where a crosswalk is justified at an unsignalized or mid-block location, the decision tree leads users to subsequent sections of this guidance for screening and selection of potential crosswalk treatments. Prior to crosswalk treatment screening and selection, staff will determine if any of the safety issues listed above are applicable to the location of concern, as they will inform the ultimate selection of crosswalk treatments.

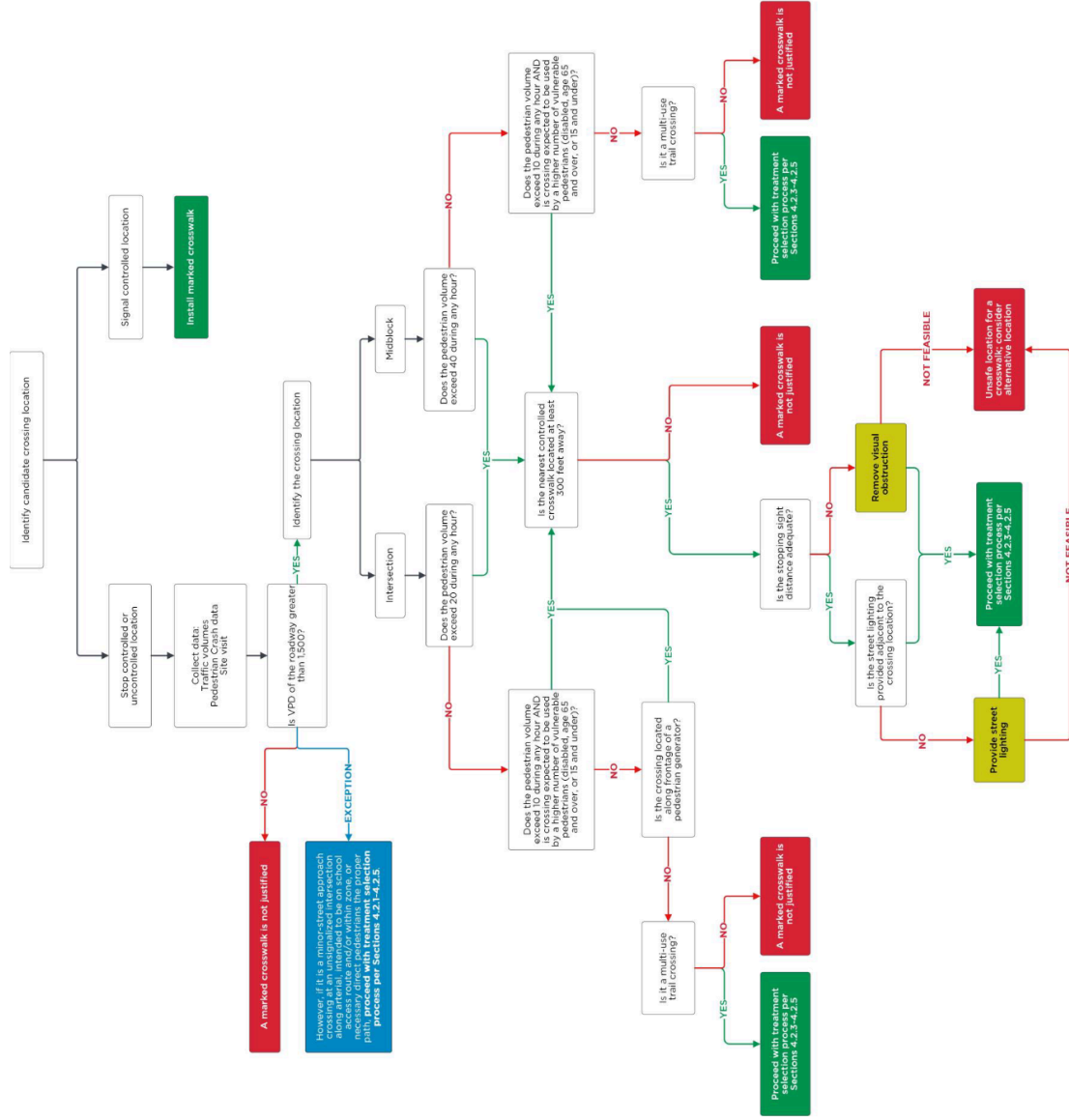


Figure 3: Crosswalk Treatment Decision Tree

4.2.3 Potential Crosswalk Treatments

Potential crosswalk treatments that could be utilized at the location of concern include the following, with detailed definitions provided in [Appendix B](#):

- Crosswalk visibility enhancements, including high-visibility crosswalk markings, adequate nighttime lighting levels, and crosswalk warning signs
- Raised Crosswalk
- Advance Stop Here For Pedestrian Sign and Stop Line
- In-Street Pedestrian Crossing Sign
- Curb Extension
- Pedestrian Refuge Island (Median Island)
- Pedestrian Hybrid Beacon (PHB)
- Road Diet
- Rectangular Rapid-Flashing Beacon (RRFB)

4.2.4 Crosswalk Treatment Screening

The intent of this section is to describe the screening process to remove from consideration any crosswalk treatments that are not appropriate for the location of concern. Table 4 and Table 5 are used as screening tools to determine whether a particular crosswalk treatment is appropriate. Table 5 identifies treatments that would be considered appropriate based on roadway configuration, posted speed limits, and vehicles per day (VPD).

Table 4, which is derived from Table 2 of the FHWA’s *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations* (hereafter referred to as the “FHWA Guide”), identifies appropriate crosswalk treatments to address the safety issues identified in Section 4.2.1.

4.2.5 Crosswalk Treatment Selection

After the initial screening of potential crosswalk treatments, the TEIC will select the most appropriate crosswalk treatments for the location of concern. [Appendix B](#) provides comprehensive details on the description, advantages, disadvantages, safety benefits, and relative costs associated with each crosswalk treatment. Selection of appropriate treatments will require careful assessment of this information, as well as engineering judgment, funding availability, and construction feasibility. If traffic calming concerns have also been identified at the study location, the TEIC may elect to prioritize crosswalk treatments that also serve as traffic calming measures. Table 4 can be used to identify crosswalk treatments that would be considered appropriate for addressing traffic calming concerns, such as excessive vehicles speeds.

4.2.6 Post-Implementation Evaluation

It is at the discretion of the TEIC to determine whether a post-implementation evaluation is necessary based on the severity of the safety issues identified and the selected treatment(s). Depending on the extent and nature of the safety issues identified at the location of concern per Section 4.2.1, the following post-implementation studies should be conducted:

- **Conflicts at crossing locations** – Monitor the occurrence of conflicts at crossing locations by conducting field observations and reviewing incident reports. If conflicts persist or escalate, the TEIC may consider adjustments to the crosswalk design or traffic control measures.

- **Excessive vehicle speeds** – Conduct a speed study, with data collected at times in which driver behavior is considered typical. If speeds remain consistently high, the TEIC may choose to enhance crosswalk treatments (e.g., upgrading high-visibility crosswalk to RRFB, or RRFB to PHB, where appropriate) or implement additional traffic calming measures.
- **Inadequate conspicuity/visibility** – Evaluate the visibility of crosswalk markings and signage, especially during low-light conditions. If conspicuity issues persist, the TEIC may explore enhancement such as high-visibility striping, improved lighting, or additional signage.
- **Drivers not yielding to pedestrians in crosswalks** – Collect driver yield rates during peak hours on Tuesdays, Wednesdays, or Thursdays at any point in the year where no holidays occur, and weather does not impact typical travel patterns. If the driver yielding rate is not improved or is still consistently below the established threshold, HPD may consider implementing educational campaigns, enforcement measures, or alterations to the crosswalk design to encourage proper yielding.
- **Insufficient separation from traffic** – Assess the physical and visual separation between pedestrians and traffic. If insufficient separation persist, consider changes to crosswalk infrastructure such as curb extensions, refuge islands, or raised crosswalks, to enhance safety.

Table 4: Safety Issues Addressed by Crosswalk Treatments

Crosswalk Treatment	Safety Issue				
	<i>Conflicts at crossing locations</i>	<i>Excessive vehicle speed</i>	<i>Inadequate conspicuity/visibility</i>	<i>Drivers not yielding to pedestrians in crosswalks</i>	<i>Insufficient separation from traffic</i>
Crosswalk visibility enhancements	✓	✓	✓	✓	✓
High-visibility crosswalk markings	✓		✓	✓	
Improved nighttime lighting	✓		✓		
Advance Stop Here For Pedestrians sign and stop line	✓		✓	✓	✓
In-street Pedestrian Crossing sign	✓	✓	✓	✓	
Curb extension	✓	✓	✓		✓
Raised crosswalk	✓	✓	✓	✓	
Pedestrian refuge island	✓	✓	✓		✓
Pedestrian hybrid beacon (PHB)	✓	✓	✓	✓	
Road diet	✓	✓	✓		✓
Rectangular rapid-flashing beacon (RRFB)	✓		✓	✓	✓

Source: [FHWA – Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations](#)

Table 5: Crosswalk Treatment Selection Table

Roadway Configuration	Vehicle Per Day (VPD) and Posted Speed Limit											
	1,500 to 9,000 VPD			9,000 to 12,000 VPD			12,000 to 15,000 VPD			≥15,000 VPD		
	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph
2 lanes with raised median	① 2 4 ③ 5 6	① 5 6 ⑦ 9	① 5 6 ⑦ 9	① 4 5 6 ⑦ 9	① 5 6 ⑦ 9	① 5 6 ⑦ 9	① 4 5 6 ⑦ 9	① 5 6 ⑦ 9	① 5 6 ⑦ 9	① 4 5 6 ⑦ 9	① 5 6 ⑦ 9	① 5 6 ⑦ 9
2 lanes w/o raised median	① 2 4 ③ 5 6	① 5 6 ⑦ 9	① 5 6 ⑦ 9	① 4 5 6 ⑦ 9	① 5 6 ⑦ 9	① 5 6 ⑦ 9	① 4 5 6 ⑦ 9	① 5 6 ⑦ 9	① 5 6 ⑦ 9	① 4 5 6 ⑦ 9	① 5 6 ⑦ 9	① 5 6 ⑦ 9
3 lanes with raised median	① 2 3 4 ⑤	① 3 5 6 ⑦ 9	① 3 5 6 ⑦ 9	① 3 4 5 6 ⑦ 9	① 3 5 6 ⑦ 9	① 3 5 6 ⑦ 9	① 3 4 5 6 ⑦ 9	① 3 5 6 ⑦ 9	① 3 5 6 ⑦ 9	① 3 4 5 6 ⑦ 9	① 3 5 6 ⑦ 9	① 3 5 6 ⑦ 9
3 lanes w/o raised median	① 2 3 4 ⑤ 6	① 3 5 6 ⑦ 9	① 3 5 6 ⑦ 9	① 3 4 5 6 ⑦ 9	① 3 5 6 ⑦ 9	① 3 5 6 ⑦ 9	① 3 4 5 6 ⑦ 9	① 3 5 6 ⑦ 9	① 3 5 6 ⑦ 9	① 3 4 5 6 ⑦ 9	① 3 5 6 ⑦ 9	① 3 5 6 ⑦ 9
4+ lanes with raised median	① 3 5 7 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9
4+ lanes w/o raised median	① 3 5 6 7 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9	① 3 5 6 ⑦ 8 9

Note:

Each matrix cell indicates possibilities that may be appropriate for designated pedestrian crossings. Not all of the countermeasures listed in the matrix cell should necessarily be installed at a crossing location.

Given the set of conditions in a cell,

- # Signifies that the countermeasure is a candidate treatment at a crossing location.
- Signifies that the countermeasure should always be considered, but not mandated or required, based on engineering judgement of a crossing location.
- Signifies that the identified countermeasure should always occur in conjunction with crosswalk visibility enhancements.

The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgement.

1. High-visibility crosswalk markings, adequate nighttime lighting levels, and crossing warning signs
2. Raised crosswalk
3. Advance Stop Here For Pedestrian sign and stop line
4. In-street Pedestrian Crossing sign
5. Curb extension
6. Pedestrian refuge island
7. Rectangular rapid-flashing beacon (RRFB)
8. Road diet
9. Pedestrian hybrid beacon (PHB)

Source: FHWA – Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations; VDOT – Pedestrian Crossing Accommodations at Unsignalized Approaches

A APPENDIX A – TRAFFIC CALMING MEASURES

A description, picture examples, advantages, disadvantages, effectiveness, and relative costs of each individual treatment are shown in this appendix. The advantages and disadvantages and costs are based on information from FHWA and VDOT. Cost estimates from these sources were adjusted for inflation to current-year (2024) dollars using the Bureau of Labor Statistics' Consumer Price Index (CPI). An additional 30% contingency was applied to the high end of these cost estimates to account for other potential uncertainties in the design and installation process. Costs for any individual improvement can vary depending on the size of the improvement, materials used, utility needs, and drainage, among other factors.

Traffic Calming Measures included in this Appendix:

- Non-Intrusive Measures
- Education
- Enforcement
- Pavement Markings
- Radar Speed Feedback Sign
- Additional \$200 Fine Sign
- Vertical Measures
- Speed Hump
- Speed Cushion
- Speed Table
- Raised Intersection
- Horizontal and Narrowing Measures
- Chicane
- Median Island
- Choker
- Curb Extension
- Traffic Circle

A.1 Education

Description

Education consists of raising motorists' awareness about traffic safety concerns. Options for education include, but are not limited to, the following:

- Literature distribution – The Town can provide flyers or other educational literature to HOAs, businesses, or other community groups.
- Radar speed feedback sign – Raises awareness of speeding to drivers. See radar speed feedback sign for more information.

Depending on the distribution strategy, the Town's TEIC may partner with HPD, the Town's Pedestrian and Bicycle Advisory Committee, Fairfax County Public Schools, or other community organizations.

Advantages

- Does not physically restrict driver maneuvers and thus does not impose speed reductions on emergency and transit vehicles.
- Does not affect drainage or sight distance and is not affected by excessive grading.
- Can be used with other forms of traffic calming.
- If the program uses the police or a radar speed feedback sign, then the advantages and disadvantages of using those apply here as well.

Disadvantages

- Effectiveness varies depending on the duration and extent of the education program. Even long and extensive programs are found to have limited effectiveness without the use of other traffic calming measures.
- Long term effects are not as well studied, but it is likely to lose its effect over time.⁵
- If the program uses the police or a radar speed feedback sign, then the advantages and disadvantages of using those apply here as well.

Effectiveness

- A reduction of approximately 1-1.5 mph in vehicle speeds.⁵

Approximate Cost

- Costs vary depending on the extent and duration of the program.

A.2 Enforcement

Description

Enforcement involves coordination with the Herndon Police Department to monitor traffic safety concerns and enforce as appropriate.

Advantages

- Does not require any change to the roadway or engineering design and thus can be implemented without imposing speed reductions on emergency and transit vehicles, affecting traffic flow, drainage, or sight distance.
- Can be temporarily placed.
- Limited capital cost to the Town.

Disadvantages

- Monitoring and enforcing speed limits on low-volume residential streets will be a lower priority for Herndon Police Department compared to arterial and collector roadways.
- Cannot be always in effect, only during times when a police officer is on duty.
- Require HPD staff time.

Effectiveness

- While police are actively on location, this method has traditionally been effective at keeping speeds at or below the speed limit. Studies have found that while speeds are low upstream of the police vehicle, after motorists pass the police vehicle, they quickly return to the measured operating speeds.⁶

Approximate Cost

- No capital cost to the Town, but uses police time and resources on this activity versus other priorities.

A.3 Pavement Markings

Description

Pavement markings use paint to visually change the look of the roadway without adapting any physical elements. This can include striping the shoulder or centerline to narrow the roadway. This can also include street marking installed on the pavement to supplement signage. Pavement marking treatments can be utilized anywhere along a roadway segment, or at intersections.



Source: [City of Alexandria](#) (left), Town of Herndon (right)

Advantages

- Does not physically restrict driver maneuvers and thus does not impose speed reductions on emergency and transit vehicles.
- Less costly than other methods and can be done with a repaving project.
- Involves measures that are easily recognizable by motorists.
- Can be easily removed if placed with temporary marking tape.
- Does not affect drainage or sight distance and is not affected by excessive grading. Depending on the implementation, it can be flexible in use.
- Lower maintenance costs when compared to other solutions.

Disadvantages

- New pavement markings are more expensive when eradication of previous pavement marking is required. Thus, it is recommended to pair this with a repaving project.
- Adds to maintenance costs for pavement markings.
- Visibility of markings may be reduced over time, particularly in locations where vehicle tires travel.

Effectiveness

- A reduction in vehicular speeds by 0.5 mph where shoulder markings are used to narrow the travel lane.⁷
- A reduction in vehicular speeds by 1-5 mph when parallel parking is added, and the vehicle travel lanes are narrowed.⁷

Approximate Cost

- Capital cost: approximately \$1.50-\$18 per linear foot of pavement marking/striping and \$140-\$2,200 per pavement marking symbol.⁸
- Cost of ongoing maintenance of pavement markings.

A.4 Radar Speed Feedback Sign

Description

A radar speed feedback sign combines a regulatory speed limit sign with a radar speed display sign that displays the real-time speed of an approaching vehicle. These signs can be portable and temporarily placed in a location. These are placed midblock.



Source: Town of Herndon

Advantages

- Does not physically restrict driver maneuvers and thus does not impose speed reductions on emergency and transit vehicles.
- Is somewhat easily removed and can be temporarily placed. Can be placed at alternate locations.
- Does not affect drainage and is not affected by excessive grading.
- Minimal maintenance costs and can be powered with a solar panel.

Disadvantages

- Residual effects are negligible when removed.
- Placement may be limited by availability of a power source in shaded areas.

Effectiveness

- A reduction of approximately 4 mph in vehicle speeds.⁹

Approximate Cost

- Capital cost: approximately \$9,500-\$12,000 per installation, depending on the power source.¹⁰
- Cost of ongoing maintenance of installed signage.

A.5 Additional \$200 Fine Sign

Description

An Additional \$200 Fine sign combines a regulatory speed limit sign with a sign that displays “\$200 Fine for Speeding.” The segment following this is subject to higher speeding fines. These are placed midblock and must be approved by the Town Manager. These signs should be used as a targeted measures in areas with vulnerable users such as school zones, locations near senior living centers, and pedestrian activity centers.



Source: [VDOT - Traffic Calming Guide for Neighborhood Streets](#)

Advantages

- Does not physically restrict driver maneuvers and thus does not impose speed reductions on emergency and transit vehicles.
- Does not affect drainage or sight distance and is not affected by excessive grading.
- Negligible maintenance costs.

Disadvantages

- Has negligible effects.

Effectiveness

- The effectiveness of this measure is unknown.

Approximate Cost

- Capital cost: approximately \$1,000 per sign. Typically at least four (4) signs per segment are needed, for a total cost of approximately \$4,000. This includes two (2) per direction, indicating the beginning and ending of the higher fine zone.¹⁰
- Cost of ongoing maintenance of installed signage.

A.6 Speed Hump

Description

A speed hump is a vertical deflection measure consisting of an elongated mound in the roadway pavement surface (or a removable installation) extending across the travel lane perpendicular to traffic flow. This is typically 3 inches in height and 12 feet in length. These are placed midblock at least 150 feet from an unsignalized intersection or 250 feet from a signalized intersection. Signage should accompany this measure to improve visibility during snow removal operations.



Sources: [FHWA – Traffic Calming ePrimer](#)

Advantages

- Self-enforcing.
- Involves measures that are easily recognizable by motorists.
- Can spread them out to have a lower impact on the roadway.

Disadvantages

- Impacts travel times of emergency and transit vehicles.
- Can increase noise as vehicles pass over the measure.
- Can affect drainage and should avoid placing on steep grades (>8%).
- If located in locations with limited sight distance, require additional warning signage.
- Can damage vehicles if they pass over it too fast. Should not be installed if operating speeds are over 45 mph.

Effectiveness

- A reduction of approximately 6-8 mph in vehicle speeds.¹¹
- Can result in volume reductions of 20-43% as a result of vehicle trips rerouting to other streets.¹² It should be noted that the Town does not install traffic calming measures to lower traffic volumes, but these are a noted side effect of this form of traffic calming.

Approximate Cost

- Capital cost: approximately \$2,500-\$6,500 per installation.¹³
- Cost of ongoing maintenance of the installed measure and any associated signage and striping.

A.7 Speed Cushion

Description

A speed cushion is a vertical deflection measure; it is a modified speed hump where openings are added to accommodate emergency or transit vehicles to cross the measure without experiencing vertical deflection and slowing down. These are placed midblock at least 150 feet from an unsignalized intersection or 250 feet from a signalized intersection.



Source:

[FHWA - Traffic Calming ePrimer](#) (left); [VDOT - Traffic Calming Guide for Neighborhood Streets](#) (right)

Advantages

- Self-enforcing.
- Does not impose speed reductions on emergency and transit vehicles.
- Produces less noise than speed humps from emergency and transit vehicles.
- Certain designs can be installed temporarily to reduce impact on roadway pavement structure.

Disadvantages

- Can increase noise as vehicles pass over the measure.
- May encourage passenger vehicles to cross into the opposing lane in an attempt to straddle the humps. A centerline strip may help discourage this.
- Depending on placement, may impact bicycle lanes.
- Should avoid placing on steep grades (>8%).
- If located in locations with limited sight distance, place warning signage. Can affect drainage, check design.

Effectiveness

- A reduction of approximately 5-7 mph in vehicle speeds.¹¹

Approximate Cost

- Capital cost: Approximately \$4,000-\$6,500 per installation.¹³
- Cost of ongoing maintenance of the installed measure and any associated signage and striping.

A.8 Speed Table

Description

A speed table is a vertical deflection measure; it is essentially a modified speed hump with a flat top long enough (in the direction of travel) to accommodate the wheel base of most passenger vehicles, allowing for a more comfortable experience than a speed hump. These are placed midblock at least 150 feet from an unsignalized intersection or 250 feet from a signalized intersection.



Source: [VDOT - Traffic Calming Guide for Neighborhood Streets](#)

Advantages

- Self-enforcing.
- Is more comfortable than speed humps or cushions.

Disadvantages

- Impacts travel times of emergency and transit vehicles.
- Can increase noise as vehicles pass over the measure, although to a lesser extent than speed humps.
- Should avoid placing on steep grades (>8%) and can affect drainage.
- If located in locations with limited sight distance, place warning signage.
- Can damage vehicles if they pass over it too fast. Should not be installed if operating speeds are over 45 mph.

Effectiveness

- A reduction of approximately 4-11 mph in vehicle speeds.¹¹
- Can result in volume reductions of 15-20% as a result of vehicle trips rerouting to other streets.¹² It should be noted that the Town does not install traffic calming measures to lower traffic volumes, but these are a noted side effect of this form of traffic calming.

Approximate Cost

- Capital cost: approximately \$3,500 - \$13,500 per installation.¹³
- Cost of ongoing maintenance of the installed measure and any associated signage and striping.

A.9 Raised Intersection

Description

A raised intersection is a vertical deflection measure which includes a flat, raised area covering an entire intersection with ramps on all approaches. It is essentially a speed table covering an entire intersection. These are installed at intersections.



Source: [FHWA - Traffic Calming ePrimer](#)

Advantages

- Self-enforcing.
- More comfortable than speed tables and speed humps.
- Provides traffic calming on all connecting streets at the intersection.
- Can be considered visually attractive.

Disadvantages

- Impacts travel times of emergency and transit vehicles.
- Expensive and less effective than other measures.
- Can increase noise as vehicles pass over the measure.
- If located in locations with limited sight distance, place warning signage. Can affect drainage, check design.

Effectiveness

- A reduction of approximately 0-1 mph in vehicle speeds.¹¹

Approximate Cost

- Capital cost: approximately \$19,500 - \$100,000 per installation, depending on the street width at the intersection to be raised, types of pavements or pavers used, utility conflicts, manholes, or other street elements.¹³
- Cost of ongoing maintenance of the installed measure and any associated signage and striping.

A.10 Chicane

Description

A chicane is a horizontal deflection measure which causes realignment on an otherwise straight street, causing all lanes to shift in one direction. Each chicane shifts lanes from one side to the other, causing vehicles to take a S-shaped path instead of going straight and encouraging drivers to slow down. This effect can be achieved with medians or curb extensions alternating on opposite sides of the street. These are installed midblock.



Source: [FHWA - Traffic Calming ePrimer](#)

Advantages

- Self-enforcing.
- Can provide streetscape enhancements and opportunities to install landscaping elements.
- Lower impact on emergency and transit vehicle travel times compared to vertical deflection methods.

Disadvantages

- Needs a certain amount of curb-to-curb width, which is typically taken from street parking or narrowing the travel lanes.
- May obstruct cyclists depending on location and design.
- Can make it difficult for snow removal, providing a fixed object in the roadway that vehicles can strike.
- Should avoid placing on steep grades (>8%).
- If located in locations with limited sight distance, place warning signage. Can affect drainage, check design.

Effectiveness

- A reduction of approximately 3-9 mph in vehicle speeds.¹¹

Approximate Cost

- Capital cost: approximately \$10,500 - \$42,000 per installation.¹³
- Cost of ongoing maintenance of the installed measure and any associated signage and striping.

A.11 Median Island

Description

A median island is an island placed in the middle of the street in order to narrow vehicular travel lanes, causing drivers to moderate their speeds at the narrower section. These can also be used as a crosswalk refuge for pedestrians. Median islands can be installed at intersections or midblock.



Source: [VDOT - Traffic Calming Guide for Neighborhood Streets](#) (left); [FHWA - Traffic Calming ePrimer](#) (right)

Advantages

- Self-enforcing.
- Provides for adding greenery and chances to improve the attractiveness of the street.
- Applying a crosswalk at the island can improve pedestrian safety compared to a standard crosswalk.
- Low impact on emergency and transit vehicle travel times.

Disadvantages

- Depending on design, could be difficult for cyclists.
- Can make it difficult for snow removal, providing a fixed object in the roadway that vehicles can strike.
- Needs a certain amount of curb-to-curb width, which is typically taken from street parking or narrowing the travel lanes.
- Can affect drainage.
- If located in locations with limited sight distance, place warning signage.

Effectiveness

- A reduction of approximately 1-8 mph in vehicle speeds.¹¹

Approximate Cost

- Capital cost: approximately \$2,000 - \$17,000 per installation.¹³
- Cost of ongoing maintenance of the installed measure, any associated signage and striping, and upkeep of any landscaping.

A.12 Choker

Description

A choker narrows the roadway by extending the curb out from both sides of the street, reducing the width of vehicular travel lanes and causing drivers to moderate their speeds at the narrower section. These are installed midblock and can be combined with on-street parking. This improvement also creates an opportunity to provide a midblock crosswalk, if warranted.



Source: Town of Herndon

Advantages

- Self-enforcing.
- Provides for adding greenery and chances to improve the attractiveness of the street.
- Provides protection for parking.
- Low impact on emergency and transit vehicle travel times.

Disadvantages

- Can be difficult for cyclists depending on design.
- Can make it difficult for snow removal, providing a fixed object in the roadway that vehicles can strike.
- Needs a certain amount of curb-to-curb width, which is typically taken from street parking or narrowing the travel lanes.
- If located in locations with limited sight distance, place warning signage.
- Can significantly affect drainage depending on location and design.

Effectiveness

- A reduction of approximately 1-4 mph in vehicle speeds.¹¹

Approximate Cost

- Capital cost: approximately \$2,000 - \$33,500 per corner.¹³
- Cost of ongoing maintenance of the installed measure, any associated signage and striping, and upkeep of any landscaping.

A.13 Curb Extension

Description

A curb extension narrows the roadway and shortens pedestrian crossings by extending the curb from the corners of intersections. This causes drivers to moderate their speeds at the narrower section, decreases the distance pedestrians must cross through vehicular traffic, and decreases curb radii, meaning vehicles need to slow down more to turn. These are installed at intersections or midblock and often combined with on-street parking. Curb extensions can be implemented using lower-cost materials, such as striping, flexible posts, and planters.



Source: Google Street View (left); Town of Herndon (right)

Advantages

- Self-enforcing.
- Shortens crossing distance for pedestrians, improving safety and makes intersection feel “pedestrianized”.
- Provides protection for parking and reduces the likelihood of illegal parking close to the intersection.
- Low impact on emergency and transit vehicle travel times.
- Greatly reduces speeds of turning vehicles.

Disadvantages

- Bus routes and bike lanes need additional considerations.
- Needs a certain amount of curb-to-curb width, which is typically taken from street parking or narrowing the travel lanes, or simply by reducing the curb radii.
- Emergency, transit, and truck access routes should provide appropriate turning radii.
- If located in locations with limited sight distance, place warning signage.
- Installation can affect drainage depending on design.

Effectiveness

- A reduction of approximately 1-3 mph in vehicle speeds.
- A reduction of approximately 6-8 mph in vehicle turning speeds.¹¹

Approximate Cost

- Capital cost: approximately \$2,000 - \$33,500 per corner.¹³
- Cost of ongoing maintenance of the installed measure, any associated signage and striping, and upkeep of any landscaping.

A.14 Traffic Circle

Description

A traffic circle is a raised island placed in an unsignalized intersection that forces motorists to use reduced speeds. This measure may not necessitate a redesign of the intersection as the island is typically small enough to leave room for vehicles to go around it in the existing right of way. However, site-specific conditions may require a more in-depth engineering evaluation. These are installed at intersections.



Source: [FHWA - Traffic Calming ePrimer](#)

Advantages

- Self-enforcing.
- Expected reduction in angle and turning collisions.
- Provides for adding greenery and chances to improve the attractiveness of the street.

Disadvantages

- Emergency and transit vehicles may have trouble navigating the traffic circle, mountable curbs may help with this.
- Bikes merge with traffic.
- Cannot be placed when bus routes turn left at the intersection.
- Should avoid placing on steep grades (although any intersection should not be placed on steep grades).
- If located in locations with limited sight distance, place warning signage. Can affect drainage, check design.

Effectiveness

- A reduction of approximately 4 mph in 85th percentile vehicle speeds.¹¹
- A reduction of 28% to 71% in average annual collisions.¹⁴

Approximate Cost

- Capital cost: approximately \$13,000 - \$42,000 per installation.²³
- Cost of ongoing maintenance of the installed measure, and any associated signage and striping.
- Requires upkeep/maintenance of any landscaping within the traffic circle, if provided.

B APPENDIX B – CROSSWALK TREATMENTS

A description, picture examples, advantages, disadvantages, safety benefits, and relative costs of each individual treatment are shown in this Appendix. Costs are based on information from FHWA and VDOT. When cost estimates were available from these sources, they were adjusted for inflation to current-year (2024) dollars using the Bureau of Labor Statistics' Consumer Price Index (CPI). An additional 30% contingency was applied to the high end of these cost estimates to account for other potential uncertainties in the design and installation process. Costs for any individual improvement can vary depending on the size of the improvement, materials used, utility needs, and drainage, among other factors.

Crosswalk Treatments included in [Appendix B](#) are based on the list of countermeasures provided in FHWA's Guide:

- Crosswalk visibility enhancements, including the following five (5) countermeasures:
 - High-Visibility Crossing Markings
 - Improved Lighting
 - Advanced Stop Here For Pedestrian Sign and Stop line
 - In-Street Pedestrian Crossing Sign
 - Curb Extensions
- Raised Crosswalk
- Pedestrian Refuge Island (Median Island)
- Pedestrian Hybrid Beacon (PHB)
- Road Diet
- Rectangular Rapid-Flashing Beacon (RRFB)

B.1 High-Visibility Crossing Markings

Description

High-visibility crosswalks use patterns (the Town uses continental style markings or altered ladder-style markings at the Washington & Old Dominion trail crossings) that are visible to both the driver and pedestrian from farther away compared to traditional transverse line crosswalk. Use of high-visibility crosswalks should be prioritized in areas of higher pedestrian volume or in areas that have more frequent vulnerable population users such as school-aged children, seniors (65+), or physical disability (visual, auditory, or mobility). Examples may include school zones, the Downtown area, or the Transit-Oriented Core.



Source: Town of Herndon at the W&OD Trail (left), Town of Herndon (right)

Advantages

- Improved visibility enhances pedestrian safety.
- Relatively low implementation cost.

Disadvantages

- Slight increase in maintenance and installation cost compared to standard markings.
- Effectiveness depends on driver compliance.

Safety Benefits

- Up to 40% reduction in pedestrian injury crashes.⁴⁵

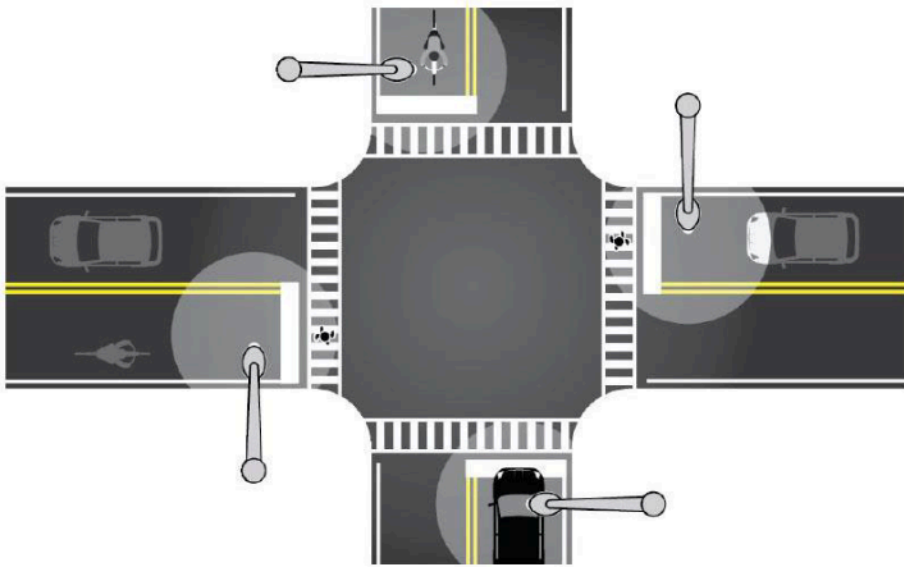
Approximate Cost

- Capital cost: approximately \$800-\$10,5000 per crosswalk.⁸
- Cost of ongoing maintenance of striping improvements.

B.2 Improved Lighting

Description

Improved crosswalk lighting is designed to help drivers see pedestrians more easily. Lighting should be placed in advance of a crosswalk to better light the front of the pedestrian and avoid silhouette lighting. The Federal Highway Administration *Lighting Handbook* suggests that an average vertical illuminance values of at least 10 lux should be maintained in the crosswalk in the direction of the approaching driver.



Source: [FHWA](#)

Advantages

- Improved visibility during low-light conditions enhances safety.
- Can deter crime and increase the sense of security.

Disadvantages

- Ongoing energy and maintenance costs.
- Requires reliable power sources and maintenance.

Safety Benefits

- Up to 42% reduction in pedestrian crashes.¹⁵

Approximate Cost

- Capital cost: approximately \$400 - \$25,000 per light fixture.⁸
- Cost of ongoing maintenance of the installed measure.

B.3 Advance Stop Here For Pedestrian Sign and Stop Line

Description

A “STOP Here for Pedestrians” sign is placed in advance of a marked crosswalk along with the stop line to indicate where a driver should stop for pedestrians.



Source: Google Street View

Advantages

- Clearly defines safe stopping points for drivers and improves visibility of crossing pedestrians.
- Enhances predictability in traffic flow.

Disadvantages

- Effectiveness relies on driver compliance.
- May not be as effective in complex intersections.
- Stop lines may be confusing to drivers if placed at uncontrolled crosswalk locations.

Safety Benefits

- Up to 25% reduction in pedestrian crashes.¹⁵

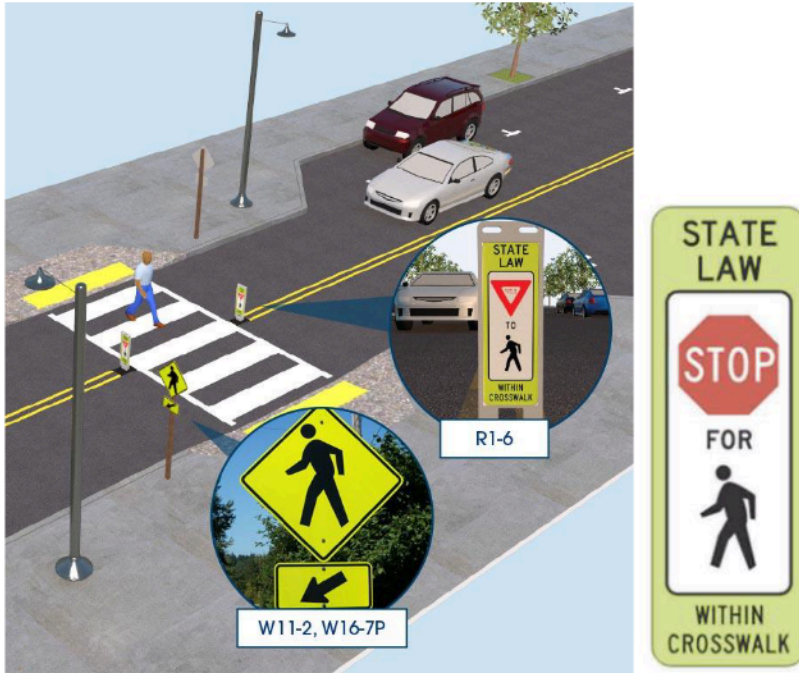
Approximate Cost

- Capital cost: approximately \$300 - \$1,000 per sign and \$100 - \$1,000 per advance stop bar.⁸
- Cost of ongoing maintenance of the installed measure.

B.4 In-Street Pedestrian Crossing Sign

Description

An in-street “STOP Here for Pedestrians” sign is placed in the middle of the road at a crossing and is often used in conjunction with refuge islands.



Source: [FHWA](#)

Advantages

- Provides visual cues for drivers and is easily noticeable.
- Relatively low-cost solution.

Disadvantages

- Effectiveness depends on driver compliance.
- May not stand out in busy or visually cluttered areas.
- Signs are frequently damaged when installed on a centerline without median.

Safety Benefits

- Up to 25% reduction in pedestrian crashes.¹⁵

Approximate Cost

- Capital cost: approximately \$300-\$450 per sign.⁸
- Cost of ongoing maintenance of the installed measure.

B.5 Curb Extension

Description

A curb extension narrows the roadway and crossings by extending the curbs from the corners of intersections. This causes drivers to moderate their speeds at the narrower section, decreases the distance pedestrians must cross through vehicular traffic, and decreases curb radii, meaning vehicles need to slow down more to turn. These are installed at intersections or midblock and often combined with on-street parking. These can be implemented using lower-cost materials, such as striping, flexible posts, and planters.



Source: [VDOT - Traffic Calming Guide for Neighborhood Streets](#) (left); Google Street View (right)

Advantages

- Self-enforcing.
- Shortens crossing distance for pedestrians, improving safety and makes intersection feel “pedestrianized”.
- Provides protection for parking and reduces the likelihood of illegal parking close to the intersection.
- Low impact on emergency and transit vehicle travel times.
- Greatly reduces speeds of turning vehicles.

Disadvantages

- Bus routes and bike lanes need additional considerations.
- Needs a certain amount of curb-to-curb width, which is typically taken from street parking or narrowing the travel lanes, or simply by reducing the curb radii.
- Emergency, transit, and truck access routes should provide appropriate turning radii.
- If located in locations with limited sight distance, place warning signage.
- Installation can affect drainage depending on design.

Effectiveness

- A reduction of approximately 1-3 mph in vehicle speeds.
- A reduction of approximately 6-8 mph in vehicle turning speeds.¹¹

Approximate Cost

- Capital cost: approximately \$2,000 - \$33,500 per corner.¹³
- Cost of ongoing maintenance of the installed measure, any associated signage and striping, and upkeep of any landscaping.

B.6 Raised Crosswalk

Description

A raised crosswalk is a variation of a speed table. The raised crosswalk is marked and signed as a pedestrian crossing. Raised crossings are often level with the street curb. This height makes pedestrians more visible to motorists and improves pedestrian's line of sight. Raised crosswalks can be installed midblock or at an intersection.



Source: [FHWA - Traffic Calming ePrimer](#) (left); [VDOT - Traffic Calming Guide for Neighborhood Streets](#) (right)

Advantages

- Self-enforcing.
- Provides improved visibility and safety for pedestrians.
- Enhances pedestrian environment at the crossing.
- Can increase the rate of motorists yielding to pedestrians crossing at the raised crosswalk.

Disadvantages

- Impacts travel times of emergency and transit vehicles.
- Can increase noise as vehicles pass over the measure, although to a lesser extent than speed humps.
- Should avoid placing on steep grades (>8%).
- If located in locations with limited sight distance, place warning signage. Can affect drainage, check design.
- Can damage vehicles if they pass over it too fast. Should not be installed if operating speeds are over 45 mph.

Effectiveness

- No studies available for raised crosswalks alone. Effectiveness is anticipated to be similar to speed tables.

Approximate Cost

- Capital cost: approximately \$3,500 - \$13,500 per installation, depending on the length, materials used, and drainage.¹³
- Cost of ongoing maintenance of the installed measure and any associated signage and striping.

B.7 Pedestrian Refuge Island (Median Island)

Description

A median island is an island placed in the middle of the street in order to narrow vehicular travel lanes, causing drivers to moderate their speeds at the narrower section. These can also be used as a crosswalk refuge for pedestrians. Median islands can be installed at intersections or midblock.



Source: [VDOT - Traffic Calming Guide for Neighborhood Streets](#) (left); Town of Herndon (right)

Advantages

- Self-enforcing.
- Provides for adding greenery and chances to improve the attractiveness of the street.
- Applying a crosswalk at the island can improve pedestrian safety compared to a standard crosswalk.
- Low impact on emergency and transit vehicle travel times.

Disadvantages

- Depending on design, could be difficult for cyclists.
- Can make it difficult for snow removal, providing a fixed object in the roadway that vehicles can strike.
- Needs a certain amount of curb-to-curb width, which is typically taken from street parking or narrowing the travel lanes.
- Can affect drainage.
- If located in locations with limited sight distance, place warning signage.

Effectiveness

- A reduction of approximately 1-8 mph in vehicle speeds.¹¹

Approximate Cost

- Capital cost: approximately \$2,000 - \$17,000 per installation.¹³
- Cost of ongoing maintenance of the installed measure, any associated signage and striping, and upkeep of any landscaping.

B.8 Pedestrian Hybrid Beacon (PHB)

Description

A PHB is a user-actuated traffic signal that illuminates when a pedestrian manually pushes a button. Upon activation, the signal illuminates a flashing yellow beacon, then changes to solid yellow to communicate to drivers to prepare to stop. The beacon changes to a steady red once it is safe for a pedestrian to cross, followed by a flashing red during the pedestrian clearance interval.



Source: [FHWA](#)

Advantages

- Offers controlled pedestrian crossings for increased safety.
- High visibility ensures clear signaling.

Disadvantages

- Higher installation and maintenance costs.
- May require education for drivers on proper usage.

Safety Benefits

- A reduction of approximately 55% in pedestrian crashes, 29% reduction in total crashes, and 15% reduction in serious injury and fatal crashes.¹⁶

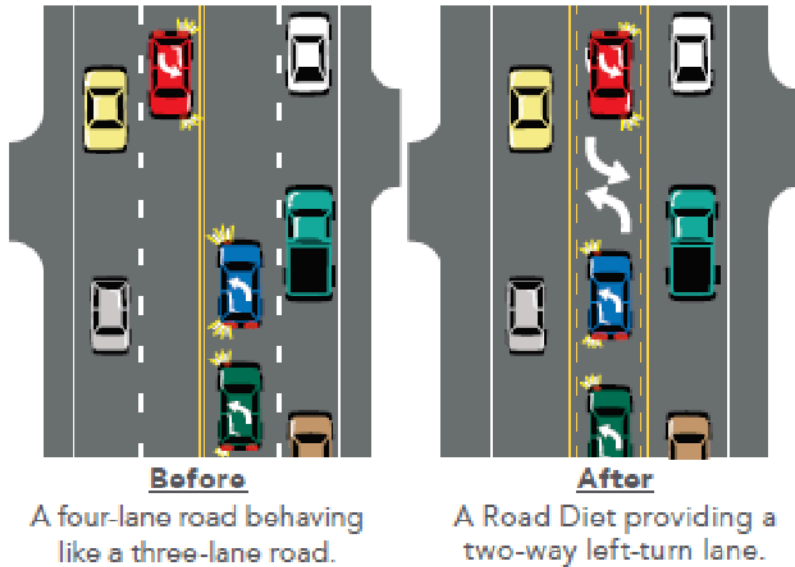
Approximate Cost

- Capital cost: approximately \$30,000 - \$230,500 per installation.⁸
- Cost of ongoing maintenance of signal equipment and any associated signage and striping.

B.9 Road Diet

Description

A road diet reconfigures the roadway by narrowing or repurpose wide or multiple travel lanes to improve pedestrian crossing safety. Typically, a road diet is implemented on a roadway with a current and future daily traffic of 25,000 or less.



Source: [FHWA](#)

Advantages

- Reduction of rear-end and left-turn crashes due to the dedicated left-turn lane.
- Reduced right-angle crashes as side street motorists cross three versus four travel lanes.
- Fewer lanes for pedestrians to cross.
- Opportunity to install pedestrian refuge islands, bicycle lanes, on-street parking, or transit stops.
- Traffic calming and more consistent speeds.
- A more community-focused, Complete Streets environment that better accommodates the needs of all road users.

Disadvantages

- Potential community concerns due vehicular capacity reduction.
- Impact on traffic flow may vary based on specific conditions.

Safety Benefits

- A reduction of approximately 19-47% in total crashes with 4-lane to 3-lane road diet conversions.¹⁷

Approximate Cost

- Capital cost varies depending on the extent of the roadway reconfiguration.
- Cost of ongoing maintenance of the installed measure, and any associated signage and striping.

B.10 Rectangular Rapid-Flashing Beacon (RRFB)

Description

A RRFB is a pedestrian-actuated conspicuity enhancement that consists of two rectangular-shaped LED lights flashing rapidly in a strobe-like pattern when activated by a pedestrian push a button.



Source: [FHWA](#)

Advantages

- Grabs driver attention effectively.
- Provides clear signaling for pedestrian crossings.
- Actuation occurs much faster than a PHB.

Disadvantages

- Higher installation and maintenance costs.
- May require a power source if solar power is insufficient.
- Requires proper education and understanding by drivers.

Safety Benefits

- Up to 47% reduction in pedestrian crashes.¹⁸
- Up to 98% increase in motorist yielding rates, depending on speed limit, number of lanes, crossing distance, and time of day.¹⁸

Approximate Cost

- Capital cost: approximately \$6,500 - \$94,000 per installation.⁸
- Cost of ongoing maintenance of signal equipment and any associated signage and striping.

REFERENCES

- ¹ https://herndon_redesign.prod.govaccess.org/home/showpublisheddocument/607/635838909802630000
- ² *Manual on Uniform Traffic Control Devices (MUTCD)*, published by the United States Department of Transportation Federal Highway Administration
- ³ *A Policy on the Geometric Design of Highways and Streets (the "Green Book")*, published by the American Association of State Highway and Transportation Officials
- ⁴ <https://highways.dot.gov/safety/speed-management/traffic-calming-eprimer>
- ⁵ <https://highways.dot.gov/media/15206>
- ⁶ https://www.researchgate.net/publication/245559162_Study_of_the_Impact_of_Police_Enforcement_on_Motorists'_Speeds
- ⁷ <https://www.fhwa.dot.gov/publications/research/safety/08067/>
- ⁸ <http://www.pedbikesafe.org/pedsafe/countermeasures.cfm>
- ⁹ https://rosap.ntl.bts.gov/view/dot/57513/dot_57513_DS1.pdf
- ¹⁰ <https://www.vdot.virginia.gov/media/vdotvirginiagov/about/programs/neighborhood-traffic/Traffic-Calming-Guide-For-Neighborhood-Streets.pdf>
- ¹¹ https://highways.dot.gov/sites/fhwa.dot.gov/files/2022-06/eng_ctm_spd_14.pdf
- ¹² https://highways.dot.gov/sites/fhwa.dot.gov/files/2022-06/eng_ctm_crsh_14.pdf
- ¹³ <https://www.ite.org/technical-resources/traffic-calming/traffic-calming-measures/>
- ¹⁴ <https://safety.fhwa.dot.gov/saferjourney1/library/pdf/toolsintro.pdf>
- ¹⁵ <https://highways.dot.gov/safety/proven-safety-countermeasures/crosswalk-visibility-enhancements>
- ¹⁶ <https://highways.dot.gov/safety/proven-safety-countermeasures/pedestrian-hybrid-beacons>
- ¹⁷ <https://highways.dot.gov/safety/proven-safety-countermeasures/road-diets-roadway-reconfiguration>
- ¹⁸ <https://highways.dot.gov/safety/proven-safety-countermeasures/rectangular-rapid-flashing-beacons-rrfb>