# Chapter 18 – Traffic Calming

In this chapter there are references to future chapters that are currently not included in this Publication 13.

Until they are included in this Publication, please refer to relevant topics in Publication 13M.

# Chapter 18 – Traffic Calming

## 18.0 – Introduction

The Institute of Transportation Engineers (ITE) defines traffic calming as the combination of measures that reduce the negative effects of motor vehicle use, alters driver behavior, and improves conditions for non-motorized street users. This chapter contains updated material based on current research and supersedes Publication 383, *Pennsylvania's Traffic Calming Handbook*. Note that Pennsylvania Code, Title 67, Chapter 212, § 212.9, *Traffic Calming*, refers to "*Pennsylvania's Traffic Calming Handbook"* (Department Publication 383)." Therefore, the Department must maintain Publication 383 as a "redirect publication". Publication 383 will be voided of contents and consist only of a title page redirecting the reader to this chapter. Until Chapter 212 is revised, or an administrative action is taken, both this chapter and Publication 383 will remain in effect.

The primary focus of traffic calming is to manage and reduce the speed of vehicular movements through self-enforcing designs to enhance the safety of all users. It is intended to reduce the severity and likelihood of crashes, increase safety and comfort for pedestrians and bicyclists, enhance aesthetics and landscaping, provide a more equitable balance among transportation modes, and reduce noise pollution. Traffic-calming measures are not applicable to Interstates and Freeways.

Traffic calming also:

- Reduces the number of crashes with fatalities or serious injuries.
- Supports Vision Zero goals and Safe System Approach.
- Increases livability, and quality of life.
- Encourages use of the street by all modes of transportation.

However, in some cases traffic calming will negatively impact traffic operations to some degree. This effect should be analyzed and considered. This chapter covers considerations in determining appropriate treatments and provides guidance on the evaluation of traffic-calming measures. It also defines a process to assist in the justification of traffic calming, including traffic-calming applicability in Pennsylvania, multimodal considerations, and study and approval processes (see Appendix 18.A).

Additionally, this chapter includes a Toolbox of Traffic-Calming Measures and Design Guidelines that provides designers with detailed guidance on traffic-calming measures.

## 18.0.1 – References and Resources

- AASHTO, *A Guide for Achieving Flexibility in Highway Design*, 2004.
- AASHTO, *Highway Safety Manual* (HSM) (edition defined in Publication 638A).
- FHWA, *Engineering Speed Management Countermeasures: A Desktop Reference of Potential Effectiveness in Reducing Speed*, 2014.
- FHWA, *Interactive Highway Safety and Design Model (IHSDM)*.
- FHWA, *Flexibility in Highway Design* (FHWA-PD-97-062).
- FHWA, *Speed Concepts: Informational Guide*, 2009.
- FHWA, *Traffic Calming ePrimer*, 2017.
- Institute of Transportation Engineers (ITE), *Traffic Calming Measures*, 2018.
- ITE, *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*.
- National Association of City Transportation Officials (NACTO), *Urban Street Design Guide*, 2013.
- PennDOT, Publication 46, *Traffic Engineering Manual*, 2014.
- PennDOT, Publication 111, *Traffic Control-Pavement Markings and Signing Standards*.
- PennDOT, Publication 212, *Official Traffic Control Devices*, 2006.
- PennDOT Publication 236, *Handbook of Approved Signs*, 2013.
- PennDOT, Publication 295, *Transportation Project Development Process – Public Involvement Handbook*, 2021.
- PennDOT, Publication 383, *Pennsylvania's Traffic Calming Handbook*, 2012.
- PennDOT, Publication 638, *Highway Safety Program Guide,* 2021.
- PennDOT, Publication 787, *Pennsylvania Active Transportation Plan,* 2020.

## 18.0.2 – PennDOT Policies and Regulations

Publication 212, *Official Traffic Control Devices*, Section 212.9, *Traffic Calming*, includes the following:

a) ***General policy.*** *The Department (on State-designated highways) and local authorities (on any highway within their boundaries) may implement traffic-calming measures in conformance with Pennsylvania's Traffic Calming Handbook (Department Publication 383).*

b) ***Department approval.*** *Local authorities shall obtain approval of the Department prior to implementing a traffic-calming measure on a State-designated highway, except when the Department's handbook provides otherwise or when the Department has entered into an agreement with local authorities that provides otherwise.*

Section 212.4, Application, includes the following:

a) ***General.*** *This chapter (Pub 212) applies to the approval, location, installation, revision, operation, maintenance and removal of all traffic signs, signals, markings and other traffic-control devices on all streets and highways in this Commonwealth. All signs, signals, markings, and other traffic-control devices erected shall conform to this chapter. Traffic restrictions, which were posted or erected prior to February 4, 2006, in accordance with any regulations in effect at that time, are not subject to this chapter (Pub 212).*

b) ***New restrictions.*** *Except as noted in § 212.109 and 212.117 (relating to bridge speed limits; and weight, size, and load restrictions), engineering and traffic studies can be performed by police officers, roadmasters, maintenance supervisors or traffic technicians. The establishment or revision of a traffic restriction may be warranted if one of the following applies:*

   (1) *One or more of the engineering and traffic study warrants covered in this chapter (Pub 212) justifies the traffic restriction.*

   (2) *Sound engineering judgment based upon a combination of all data sources substantiates the need for the restriction.*

PennDOT supports the implementation of traffic-calming measures. In line with national best practices, such as Complete Streets initiatives, Context-Sensitive Solutions (CSS), and Context-Sensitive Design (CSD), PennDOT encourages designing for all modes of transportation by addressing issues on existing streets and designing new or reconstructed streets.

## 18.1 – Objectives of Traffic Calming

### 18.1.1 – Speed Reduction

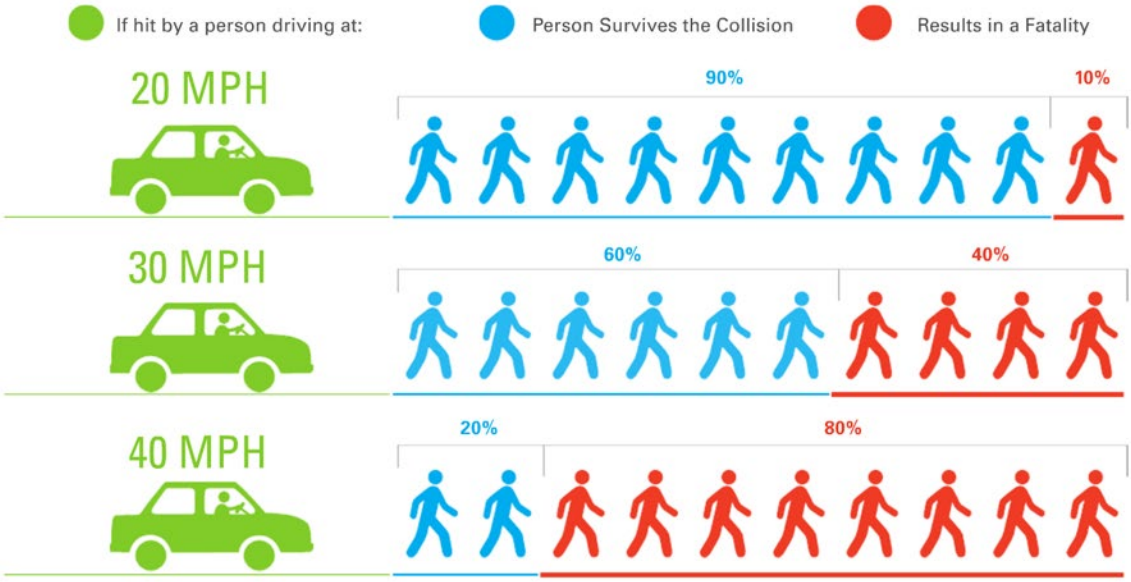
Traffic calming aims to reduce operating speeds along a roadway. For more information refer to Chapter 2, *Design Control*. Changing a roadway's geometric design (along with the posted speed) to support a desired operating speed is more effective than solely changing the posted speed. Horizontal and vertical traffic-calming measures modify the roadway geometry in order to reduce and self-enforce vehicle operating speeds.

## 18.1.2 – Crash Reduction

According to FHWA's, *Speed Concepts: Informational Guide*, reducing vehicular speed simultaneously reduces the number and severity of motor vehicle crashes. Implementing traffic-calming measures often results in fewer crashes, fewer fatalities, and less severe injuries, thus supporting Vision Zero goals and Safe System Approach.

**Exhibit 18.1.1** depicts the relationship between vehicular speed and the likelihood of a pedestrian fatality upon collision. As illustrated, a pedestrian has a 20% chance of surviving a collision with a vehicle traveling 40 mph, as compared to a 90% chance of surviving a collision with a vehicle traveling 20 mph.

**Exhibit 18.1.1 Vehicle Speeds and Pedestrian Fatality Rates**




## 18.1.3 – Quality of Life

Traffic calming can improve the quality of life by increasing the comfort level of pedestrians and bicyclists. Some of the ways it does this is by incorporating landscape design elements, creating pedestrian and bicycle amenities, enhancing aesthetics and reducing noise. Traffic calming also reduces vehicle speeds which allows for more reaction time among motorists, bicyclists, and pedestrians. Traffic calming is consistent with the increasing interest in Active Transportation Plans. Studies have demonstrated that traffic calming has led to an increase in the number of pedestrians, bicyclists, and transit riders.

## 18.2 – Traffic Calming Applicability

PennDOT's *Speed Management Action Plan*, identifies traffic-calming measures as one of the tools for speed management along with public education, enforcement, and other engineering measures.

Traffic calming is used by many municipalities to manage vehicle speeds. However, for State Routes traffic-calming measures should typically only be considered after education, enforcement, and other low-cost efforts fail to produce desired results. Traffic-calming measures must be evaluated against potential negative impacts to regional operational demand. For measures being implemented, an acceptable balance of effectiveness for all modes of transportation should be attained.

Most projects, whether they are minor or major, on new, modified, or existing roads, are potential candidates for traffic calming or speed management. Other project candidates include Complete Streets projects and projects that meet the goals of the Active Transportation Plan. Community input should be obtained from roadway users, local residents, adjacent property owners, and others.

Roadway and project characteristics to evaluate include:

- Crash history.
- Roadway functional classification, typology, and context.
- Existing and proposed land use.
- Roadway users (including pedestrians and bicyclists).
- School zones and parks.
- Alignment of posted speed and operating speed.
- Roadway geometry.
- Transit routes.
- Drainage and utilities.
- Maintenance.
- Traffic volume.
- Emergency response vehicles.
- Noise.

### 18.2.1 – Context

Context classifications assess the context of the roadway by indicating who the roadway users are, how the roadway is used, and how the roadway fits into the larger transportation area.

Context considerations include access, mobility, livability, land use, economic development, density, and building setbacks. Consideration should also be given to the larger transportation network, the planning vision, and any issues specific to the location. Consideration should also be given to corridor access management (see FHWA's, *Access Management Manual*, Second Edition and PennDOT's, *Access Management Manual Application Guidelines.*)

For more information on context, refer to Chapter 1, *Context Based Design and Flexibility*.

Local governments or regional agencies may benefit from refining the statewide context classifications to better define context-sensitive solutions within their jurisdictions.

| ----- LOCAL AUTHORITY SPECIFIC CONTEXT CLASSIFICATION ----- |
| --- |
| Local authorities may create a traffic-calming program and guidance catered to their unique or specific needs. While the guidance may not replicate the exact details of this chapter, the tenets of the program should be similar. When creating a local traffic-calming program, deviations from the guidance in this chapter, such as roadway classification or context, should be based on a thorough engineering evaluation of data and the most current information, studies, and research available. Local authorities creating their own program shall obtain PennDOT District approval if the program involves state-owned roadways. |

## 18.2.2 – Volumes

Roadway volumes may be used to determine the applicability of traffic-calming measures. Traffic calming may be justifiable on a high-volume roadway if there is existing or projected high pedestrian activity. (Noted throughout the chapter as “high pedestrian activity.”) However, traffic-calming measures should be avoided on high-volume roadways that serve as major throughways or emergency detours for major highways.

## 18.2.3 – Speed

Traffic-calming measures encourage appropriate operating speeds consistent with the level of multimodal activity and context to create a comfortable environment for all modes of transportation.

Refer to Publication 46*, Traffic Engineering Manual,* and to Chapter 2 for more information on determining appropriate design speeds based on functional classifications, context, and typologies.

### 18.2.4 – Roadway Users

Roadways serve a mix of users, including those who drive, walk, bike, or use public transportation. These users deserve safe and comfortable connected transportation networks. When considering roadway changes, all modes should be considered in early planning and design phases. Consideration should be given to the possibility of increased pedestrian and bicycle usage if facilities were implemented. While traffic-calming measures are intended to improve conditions for some transportation modes, they should not cause undue burden to other modes or users. Ensure that operational aspects of other users are adequately considered.

For more information on pedestrians, refer to Chapter 13, *Pedestrian Facilities*. For more information on bicyclists, refer to Chapter 14, *Bicycle Facilities*.

### 18.2.5 – Regional Roadway Network Impacts

The designer must consider the overall context and roadway network when implementing traffic-calming measures instead of focusing solely on spot treatments which could lead to traffic diversion. Traffic diversion can negatively impact regional levels of service and operations for motor vehicles. Implementing additional treatments along parallel routes or at a network level can reduce traffic diversion. Regional roadway network considerations include:

- Context of vehicle network and viable alternate routes.
- Adjacent roadways.
- Intersection spacing and type of traffic control.

Where spot treatments are being considered, temporary treatments may be installed to monitor the traffic diversion impacts. Then, before-and-after studies can be used to assess the impact of rerouted vehicular trips on parallel roadways to determine if permanent traffic-calming measures are appropriate.

### 18.2.6 – Emergency Response Vehicles

Police departments and emergency service providers are generally supportive of the traffic-calming goals of speed and crash reduction. However, these emergency responders must slow their vehicles to a greater extent than passenger cars in order to navigate some traffic-control measures and traffic-calming measures. These entities should be involved in the planning, design, and implementation to ensure that the traffic-calming measures will not overly impede their operations.

Traffic-calming measures must be designed to accommodate fire trucks, ambulances, and other large vehicles that require specific turning radii and clearances. For example, vertical deflection treatments such as raised crosswalks and speed humps, may impair emergency-vehicle access

to hospitals or on-call sites and may be jarring for passengers on board. Additionally, horizontal treatments, such as roundabouts or curb extensions, must accommodate the wide turning radii of emergency response vehicles. Modifications to traffic-calming measures, such as traversable curb extensions, flex posts, and truck aprons may accommodate fire trucks and ambulances. Street closures and diverters can be designed with operable, transponder-responsive removable bollards that allow emergency access only.

FHWA's *Traffic Calming ePrimer* documents a range of studies which found speed tables and speed humps caused between 0 to 9 seconds of delay on emergency response times. The general magnitude of delay may vary by jurisdiction and other factors such as: vehicle type, type of traffic-calming measure, and testing procedure.

### 18.2.7 – Noise

By reducing vehicular speeds, traffic calming can reduce the volume of vehicular noise. Alternatively, vehicles traversing speed humps or other vertical treatments may generate noise upon impact (due to vehicle deceleration and acceleration). Potential consequences of traffic-calming measures on the adjacent community beyond the travel mode improvements desired, should be considered.

## 18.3 – Traffic Calming Design Considerations

Traffic-calming measures are intended to improve conditions for all transportation modes. Treatments should not cause undue burden on any single mode of transportation or categories of user. Traffic-calming planning requires interagency coordination and collaboration. The following sections provide an overview of traffic-calming considerations for pedestrians and bicyclists, emergency and transit vehicles, streetscape elements, snow removal, drainage, network impacts, and noise considerations. These considerations are expanded upon for each traffic-calming measure in Section 18.5.

### 18.3.1 – Pedestrian and Bicycle Passage

Pedestrian and bicycle passage should not be impeded or fully blocked by traffic-calming measures (curb extensions, etc.). Refer to Chapter 13, *Pedestrian Facilities,* and Chapter 14, *Bicycle Facilities*, for specific information regarding the design of pedestrian and bicycle infrastructure.

Per recent research, bicycle Infrastructure can serve as a traffic-calming measure. See FHWA's, *Separated Bike Lane Planning and Design Guide*, for additional information.

### 18.3.2 – Vehicle Accommodation

Public transit vehicles require accommodations in traffic-calming design. The local authority should coordinate with transit agencies to identify transit routes and stops when considering changes in geometric roadway design, especially vertical or horizontal treatments that may impede bus maneuvering or impact travel times. Transit vehicles typically drive along the curbside lane and require minimum clearances for lane width, curb height, vertical height, and lateral clearance.

More information on public transit accommodations may be found in Chapter 15, *Transit Facilities.* For more information on design controls, design vehicles, and control vehicles, refer to Chapter 2.

### 18.3.3 – Drainage

To avoid water accumulation (ponding) and ice formation, drainage shall be considered when determining appropriate traffic-calming measures and locations. Treatments may be designed to accommodate or improve existing drainage systems. Appropriate accommodation includes curb extensions with cutouts for curbs and gutters or landscaping to improve drainage and runoff.

### 18.3.4 – Snow Removal

Traffic-calming measures may impede the removal of snow and ice and should therefore be discussed in advance with PennDOT's County Maintenance Office or the local municipality's public works department. Refer to Appendix 18.B, Maintenance and Ownership.

Appropriate signage helps to alert snowplow operators where traffic-calming measures are present. Vertical traffic-calming measures constructed with more gradual slopes will allow for easier snow removal.

### 18.3.5 – Streetscape Elements

Traffic-calming projects are often coupled with streetscape and landscape improvements, such as tree-lined streets, landscaped curb extensions, permeable pavers, bioswales, and rain gardens. These can improve the aesthetics, stormwater management, and the overall effectiveness of the traffic-calming measures.

Streetscape and landscape designs at intersection should not include large trees or rocks, but should consist of smaller shrubs, plants, and features that will not obstruct sight distance. Sight-distance problems may also result from poor plant selection, lack of maintenance, or improper placement. Designers should consider plant type, growth, and location.

Typically, the local authority is responsible for maintenance of landscape and streetscape features. Responsibility can be legally assigned through a maintenance agreement or as part of a highway occupancy permit.

## 18.4 – Selection of Traffic-Calming Measures

### 18.4.1 – Traffic-Calming Study and Approval Process

Implementing a traffic-calming measure should be based on an established process. Refer to Appendix 18.A for information about the Traffic-Calming Study and Approval Process.

### 18.4.2 – Screening Tools and Process

The following two decision matrices can aid designers in the preliminary screening of traffic-calming measures for a site or project.

**Exhibit 18.4.1** shows the typical applicability of various traffic-calming measures with respect to intended outcomes.

**Exhibit 18.4.2** shows the applicability of each traffic-calming measure with respect to the five context classifications and posted speed ranges.

After a preliminary screening of potential traffic-calming measures, the toolbox criteria in Section 18.5, *Toolbox of Traffic-Calming Measures and Design Guidelines*, should be reviewed and consulted for further details. The toolbox outlines each of the potential traffic-calming measures with respect to advantages, disadvantages, impacts, opportunities, and effectiveness.

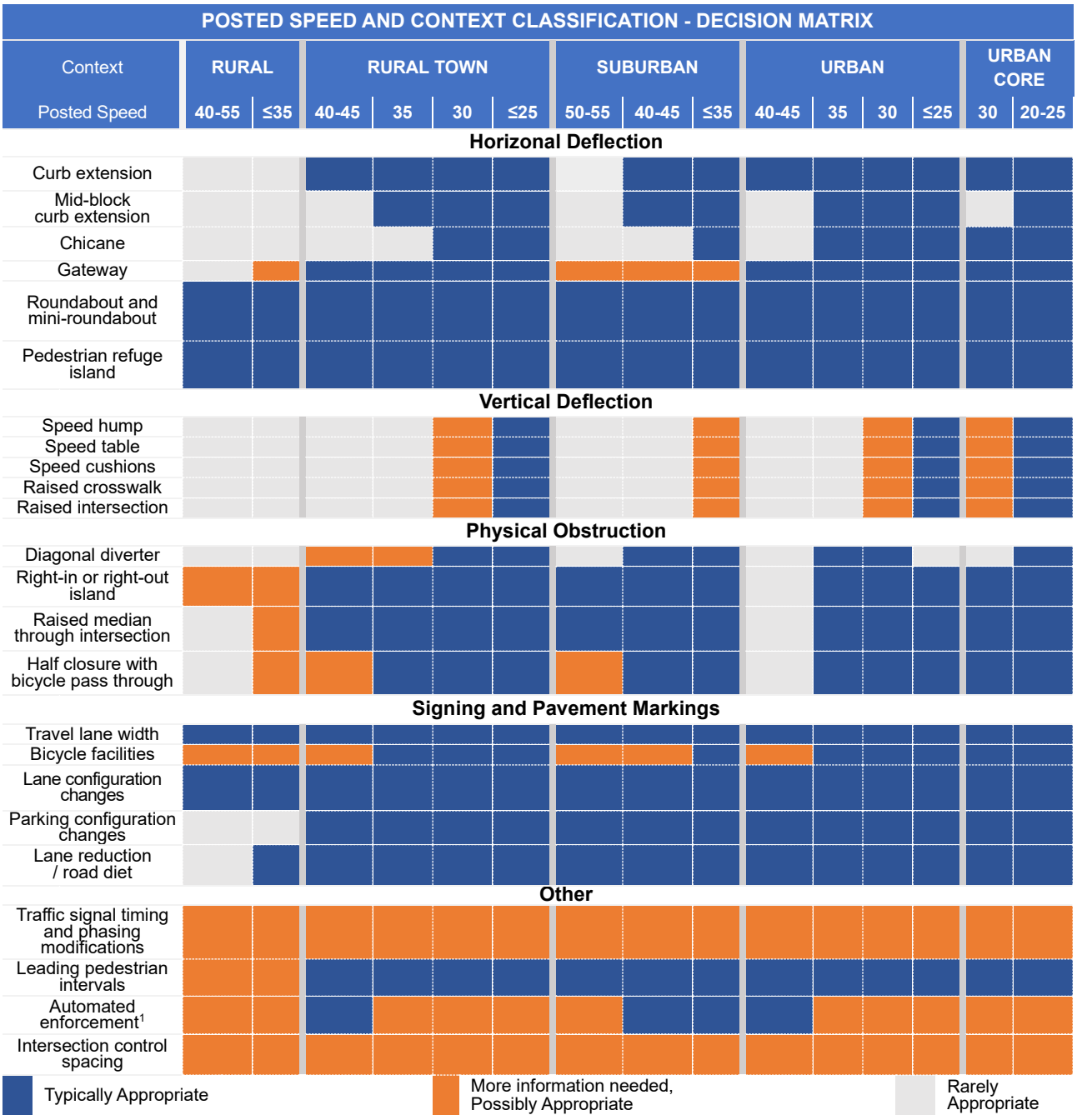
## Exhibit 18.4.1 Intended Outcome

| INTENDED OUTCOME OF TRAFFIC-CALMING IMPLEMENTATION – DECISION MATRIX | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Traffic-Calming Measure | Reduce Vehicular Operating Speeds | Reduce Vehicular Crash Severity and Frequency | Reduce Crossing Distance | Decrease Pedestrian Exposure | Increase Pedestrian Safety and Comfort | Reduce Conflict Points | Improved Visibility of Pedestrians | Improve Line of Sight for Pedestrians | Enhance Multimodal Connectivity and Access |
| **Horizonal Deflection** | | | | | | | | | |
| Curb extension and Mid-block curb extension | ■ | | ■ | ■ | ■ | | ■ | ■ | ■ |
| Chicane | ■ | | | | | | | | |
| Gateway | ■ | | | | ■ | | | | |
| Roundabout and mini-roundabout | ■ | ■ | ■ | ■ | | ■ | | | |
| Pedestrian refuge island | ■ | | ■ | ■ | ■ | | ■ | ■ | |
| **Vertical Deflection** | | | | | | | | | |
| Speed hump | ■ | ■ | | | ■ | | | | |
| Speed table | ■ | ■ | | | ■ | | | | |
| Speed cushions | ■ | | | | ■ | | | | |
| Raised crosswalk | ■ | ■ | | | ■ | | ■ | ■ | ■ |
| Raised intersection | ■ | | | | ■ | | ■ | ■ | ■ |
| **Physical Obstruction** | | | | | | | | | |
| Diagonal diverter | | | | | | ■ | | | |
| Right-in or right-out island | | | ■ | ■ | | ■ | | | |
| Raised median through intersection | | | ■ | | | ■ | | | |
| Half closure with bicycle pass through | | | | | | ■ | | | ■ |
| **Signing and Pavement Markings** | | | | | | | | | |
| Travel lane width | ■ | | ■ | ■ | ■ | | | | |
| Bicycle facilities | | | | | | ■ | | | ■ |
| Lane configuration changes | ■ | | ■ | | ■ | | | | ■ |
| Parking configuration changes | ■ | | | | ■ | | | | ■ |
| Lane reduction and road diet | ■ | | ■ | ■ | ■ | | | | ■ |
| **Other** | | | | | | | | | |
| Traffic signal timing and phasing modifications | ■ | | | | | | | | |
| Leading pedestrian intervals | | | | ■ | | | ■ | | |
| Automated enforcement | ■ | | | | | | | | |
| Intersection control spacing | ■ | | | | | | | | ■ |

■ **Applicable outcome**

NOTE: Refer to the traffic-calming toolbox for a complete description of the appropriate application of each measure.

## Exhibit 18.4.2 Posted Speed and Context Classification




NOTE: Refer to the traffic-calming toolbox for a complete description of the appropriate application of each measure.[1] As applicable per regulations.

## 18.5 – Toolbox of Traffic-Calming Measures and Design Guidelines

Traffic-calming measures are chosen based upon criteria such as the site-specific context and conditions, the potential of measures to address volume or speed reduction on affected roadways, and the type of roadway. The intended goal of implementing traffic-calming measures is to enhance the safety of all users by reducing driver speeds, reducing conflicts between vehicles, pedestrians, and bicyclists, and reducing the frequency and severity of crashes.

Key points for traffic-calming measure selection include:

- Weighing the advantages and disadvantages associated with potential traffic-calming measures by comparing the measures' effectiveness in achieving intended outcomes.
- Considering tradeoffs, such as safety, accessibility, cost, maintenance, multiple roadway users, vehicles, and other modes of transportation.

Detailed information is provided for each traffic-calming measure within the toolbox, such as:

- Description and Purpose.
- Typical Application (e.g., traffic volumes, speed, functional classification, number of travel lanes, grade, curves, context: land use and area) with example images.
- Advantages and Disadvantages.
- Effectiveness (e.g., speed and crash reduction).
- Design, including criteria (e.g., dimensions, spacing, pavement marking, location, signage, lighting) and details.
- Design Considerations and Context.

Traffic-calming measures are organized into five categories in the toolbox: horizontal deflection, vertical deflection, physical obstruction, signing and pavement markings, and other.

### 18.5.1 – Horizontal Deflection

Horizontal deflection refers to two types of traffic-calming measures for managing speeds. The first type hinders the driver's ability to drive in a straight line by creating a horizontal shift in the roadway. This shift forces drivers to slow their vehicles to safely navigate the measure.

The second type of horizontal deflection measure is designed to narrow the width of the travel lane. Reducing the width of the travel lane causes drivers to slow their vehicles to maintain an acceptable level of comfort. In addition, horizontal deflection measures that narrow the travel lane can improve pedestrian safety by reducing the length of the crossing.

Horizontal deflection measures may also have the secondary effect of reducing volumes; however, the effects will typically be minor.

The toolbox includes the following horizontal deflection traffic-calming measures:

18.5.2 – Curb extension and Mid-Block Curb Extension

18.5.3 – Chicane

18.5.4 – Gateway

18.5.5 – Single-lane Roundabouts and Mini-Roundabouts

18.5.6 – Pedestrian Refuge Island

## 18.5.2 – Curb Extension and Mid-Block Curb Extension

### Description and Purpose

Curb extensions narrow the width of a roadway through the expansion of the sidewalk and curb, usually to the edge of an on-street parking lane. Curb extensions, also referred to as bulb-outs or bump-outs, can be implemented at an intersection or at mid-block.

The purpose of a curb extension is to reduce pedestrian crossing distance and exposure to traffic, improve the line of sight for pedestrians, make pedestrians more visible to oncoming traffic, encourage slower vehicular speeds by narrowing the street width, and reduce right-turn vehicle speeds by reducing the curb radius.

Mid-block curb extensions (often referred to as chokers, pin points, or neckdowns) can be created by a pair of curb extensions located mid-block or by using other roadway-narrowing physical devices, such as planters or roadside islands. Mid-block curb extensions provide opportunities to increase public space, including additional sidewalk and greenspace.

Daylighting is when parking restrictions are created at intersection corners using signage, pavement markings, or flexible post delineators. This short-term or temporary traffic-calming measure provides many of the same benefits as curb extensions (e.g., improve pedestrian visibility, shorten unprotected crossing distance, narrow street widths). See Publication 111, TC-8604, for pavement delineation details type SM-1 and Chapter 13. See **Exhibit 18.5.5** for an example of daylighting.

**Exhibit 18.5.1 Intersection Curb Extension**


**Exhibit 18.5.2 Mid-Block Curb Extension**

## Exhibit 18.5.3 Curb Extension Typical Application

| CURB EXTENSION TYPICAL APPLICATION | | |
|---|---|---|
| | **INTERSECTION** | **MID-BLOCK** |
| **SPEED** | Appropriate for a maximum speed limit of 40 mph. Additional consideration should be given to mid-block curb extensions if the travel lanes are narrowed, such as adequate shy distance between the travel lane and the mid-block curb extension. Refer to Chapter 13 for additional design considerations for mid-block crosswalks, or crosswalks at unsignalized intersections. | |
| **STREET FUNCTIONAL CLASSIFICATION** | Appropriate for all street types with on-street parking. | Appropriate on all roadway types, but contexts such as land use, speeds, and geometry should be considered. |
| **NUMBER OF TRAVEL LANES** | Appropriate for streets with any number of travel lanes. | May be used on one-lane, one-way, two-lane, one-way, and two-lane, two-way streets. |
| **CURVES** | May be installed on a vertical curve, when adequate stopping sight distance and/or warning signs are provided. | |
| **CONTEXT: LAND USE AND AREA** | Appropriate in urban, suburban, and rural town settings. Works well in downtown areas and near pedestrian generators or high levels of pedestrian activity. Also applicable in residential areas, commercial corridors, community places (e.g., transit stop, school, library, park), or an emergency route. | Generally, not acceptable in rural areas where vehicle speeds are typically higher and pedestrian volumes are low or non-existent. Work well in rural towns and on non-arterial suburban, urban, and urban core roadways. |

**Exhibit 18.5.4 Advantages and Disadvantages of Curb Extensions**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Reduces right-turn vehicle speeds at intersections with tighter curb radii and slows traffic by narrowing vehicle travel lanes.<br>• Manages traffic volumes by reducing cut through traffic.<br>• Improves pedestrian safety: reduces crossing distance and therefore decreases pedestrian exposure, improves pedestrians' line of sight, and improves visibility of pedestrians for oncoming traffic.<br>• Facilitates pedestrian access to transit.<br>• Enhances neighborhood appearance through the inclusion of landscaping, green stormwater infrastructure, or textured treatments.<br>• Can prevent motorists from parking too close to an intersection or crosswalk.<br>• Can have lower cost options through use of pavement marking and flexible post delineators as a short-term improvement.<br>• Improves traffic signal operations. | • May result in the loss of one on-street parking space on each side of the roadway.<br>• May cost more than other traffic-calming measures.<br>• Makes turning movements more difficult for large vehicles and trucks.<br>• Presence of existing drainage features may increase the cost of implementation, because of drainage impacts.<br>• Potential for utility impacts in urban areas. (Some jurisdictions use pavement markings to designate curb extension areas and use raised pedestrian median refuge islands to reduce drainage and utility impacts.)<br>• Impacts snow removal. |

### Effectiveness

Research has shown a reduction in speeds at mid-block locations where curb extensions are installed. Studies conducted in urban locations measured a reduction in the 85$^{th}$ percentile speeds by 1 to 4 mph.

**Exhibit 18.5.5 Curb Extension Design Features and Typical Design Criteria**

| TRAFFIC-CALMING MEASURE DESIGN FEATURES | TYPICAL DESIGN CRITERIA |
|---|---|
| **DIMENSIONS** | • Typical width is 6 to 8 ft from the existing curb (typically 1 to 2 ft narrower than the parking lane).<br>• 10-ft corner curb radii are typical, but it is determined by design and/or control vehicle (e.g., trucks, emergency vehicles, school buses).<br>• 10-ft transition curb radii are typical as depicted in **Exhibit 18.5.6**.<br>• Length of choker or mid-block curb extension should include the full width of the crosswalk, and it is best practice to design the curb extension to extend 20 ft from the edge of the crosswalk to the point of reverse curvature to provide a clear sight line from where vehicles are able to park. |
| **PAVEMENT MARKING** | • Daylighting with pavement markings and flexible post delineators can provide similar benefits to curb extensions in a short-term or temporary application. |
| **LOCATION** | • Primarily located at intersections.<br>• Can be installed at mid-block locations. Mid-block curb extensions may be combined with a crosswalk. (The designer can refer to Form TE-113 for mid-block crosswalk criteria and Publication 46, *Traffic Engineering Manual,* for unsignalized midblock crosswalk information.) When mid-block curb extensions are not combined with a crosswalk, they are typically referred to as a choker. |
| **LIGHTING** | • Placement near street lighting is preferred for mid-block curb extensions. |
| **LANDSCAPING** | • May be incorporated into the design of curb extensions but adequate sight lines must be provided. Likewise, consideration should be given to the safety requirements and depth needed to support plants and the depth required for utility lines, as well as provide a safe space for pedestrians. |

**Exhibit 18.5.6 Typical Curb Extensions or Bulb Outs**

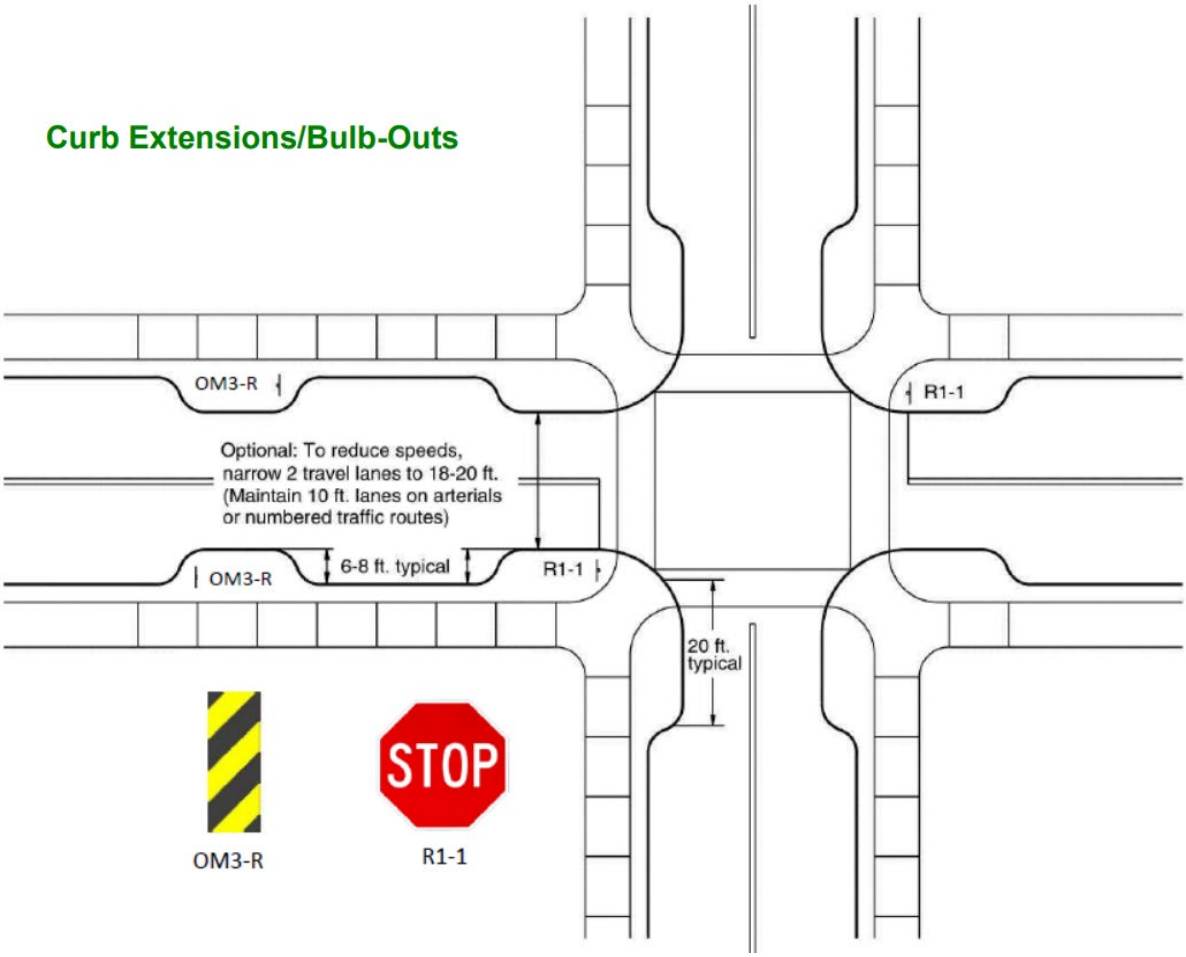


**Exhibit 18.5.7 Curb Transition Radii with 10 ft Radii**

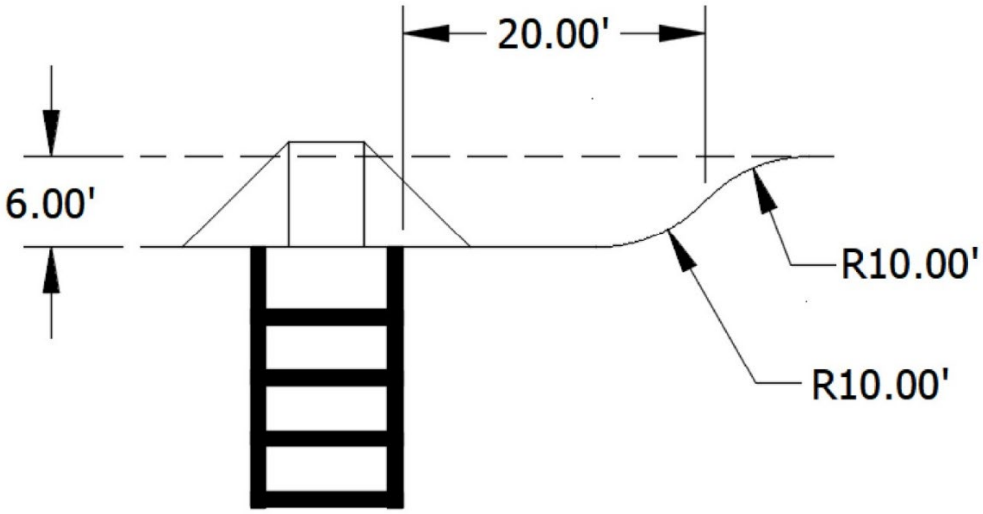
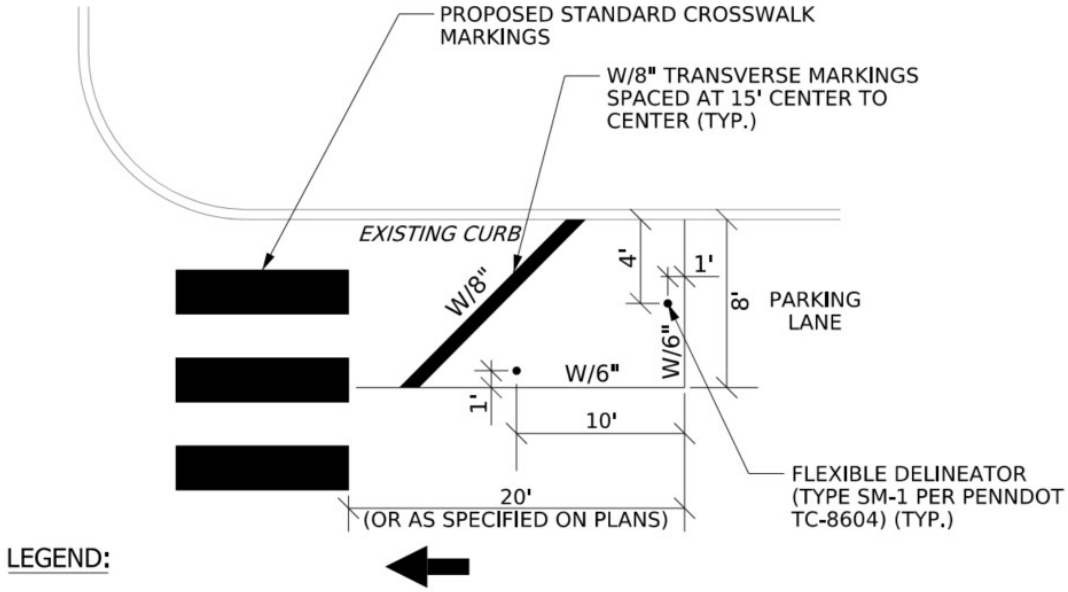



**Exhibit 18.5.8 Intersection Daylighting**




INTERSECTION DAYLIGHTING

NOT TO SCALE

### Design Considerations and Context

- **Located at transit stops (bus bulbs).** Curb extensions located at transit stops can provide advantages to riders boarding and alighting. In this context, the location of the bus doors could impact the length of the curb extension, which should be long enough to accommodate simultaneous loading and unloading from front and rear doors.
- **Located at mid-block locations.** Mid-block curb extensions that include vertical features should not obstruct the driver's view of pedestrians. It is preferable that mid-block curb extensions be located at crosswalk locations. Raised crosswalks may be combined with mid-block curb extensions to accommodate pedestrian activity and further slow traffic.
- **Multifunctional use.** Intersection and mid-block curb extensions can incorporate landscaping features and be used to collect stormwater.
- **Bicycle and pedestrian facilities.** Curb extensions should be designed to accommodate bicycle movements that avoid vehicular conflicts and incorporate accessible curb ramps and detectible warnings for pedestrians. Travel lane width may be reduced for bicyclists. Curb extensions can be used in conjunction with separated bicycle facilities, where the curb extension includes an opening for the bike facility along the curb or a bypass lane for bicyclists.

  Mid-block curb extensions provided on both sides of a street (i.e., pin points) can narrow the roadway and serve as a form of speed control on neighborhood bikeways or bicycle boulevards. Bicycle facilities can be designed to cut through curb extensions.
- **Maintenance.** With the implementation of curb extensions, typical maintenance considerations include street sweeping impacts, snowplowing impacts, and landscaping maintenance.
- **Temporary materials.** The application of pavement markings, flex curb, and flexible post delineators can be used for daylighting at intersection approaches as a short-term or temporary application.

## 18.5.3 – Chicanes

### Description and Purpose

Chicanes (also referred to as lane offsets, serpentines, or reversing curves) lower speeds by requiring motorists to shift laterally through a series of alternating curves, staggered parking, or alternating curb extensions. Chicanes may narrow the width of the roadway or width of travel lanes. They provide opportunities to increase public space, including additional sidewalks and greenspace. Medians may be used at deflection points to prevent speeding motorists from disregarding roadway markings.

### Exhibit 18.5.9 Examples of Chicanes

(Source: United States Department of Transportation, *PedSafe*)

### Exhibit 18.5.10 Chicane Typical Application

| CHICANE TYPICAL APPLICATION | |
|---|---|
| **TRAFFIC VOLUMES** | Appropriate on low to moderate volume roadways. Most effective when traffic volumes are balanced in each direction. For higher volume roadways, additional considerations should be documented. |
| **SPEED** | Maximum posted speed limit of 35 mph. |
| **STREET FUNCTIONAL CLASSIFICATION** | Typically, only implemented on local roadways in non-rural locations. |
| **NUMBER OF TRAVEL LANES** | Appropriate on single-lane, one-way streets and two-lane, two-way streets. |
| **GRADE** | Avoid locations where grades exceed 8%. |
| **CURVES** | Applicable on vertical curves, given adequate stopping sight distance, appropriate lighting, and warning signs. |
| **CONTEXT: LAND USE AND AREA** | Works well in downtown areas and near pedestrian generators or high levels of pedestrian activity. Also applicable in mixed land uses, including residential areas and community places (e.g., transit stop, school, library, park). Not recommended in rural contexts. |

**Exhibit 18.5.11 Advantages and Disadvantages of Chicanes**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Reduces travel speeds by introducing horizontal deflection, narrowing vehicle travel lanes, and narrowing the roadway.<br>• Manages traffic volumes by reducing cut through traffic.<br>• Improves pedestrian safety; reduces crossing distance and therefore decreases pedestrian exposure; improves the visibility of pedestrians for oncoming traffic.<br>• Enhances neighborhood appearance through the inclusion of landscaping, green stormwater infrastructure, or textured treatments.<br>• Can be created by alternating on-street parking but must be occupied with parked vehicles to effectively promote traffic calming.<br>• Minimally impacts drainage.<br>• Reduces traffic noise. | • May result in the loss of some on-street parking.<br>• Impacts emergency response time and heavy vehicle movements.<br>• The presence of existing drainage features may increase the cost of implementation, due to drainage impacts.<br>• Impacts snow removal. |

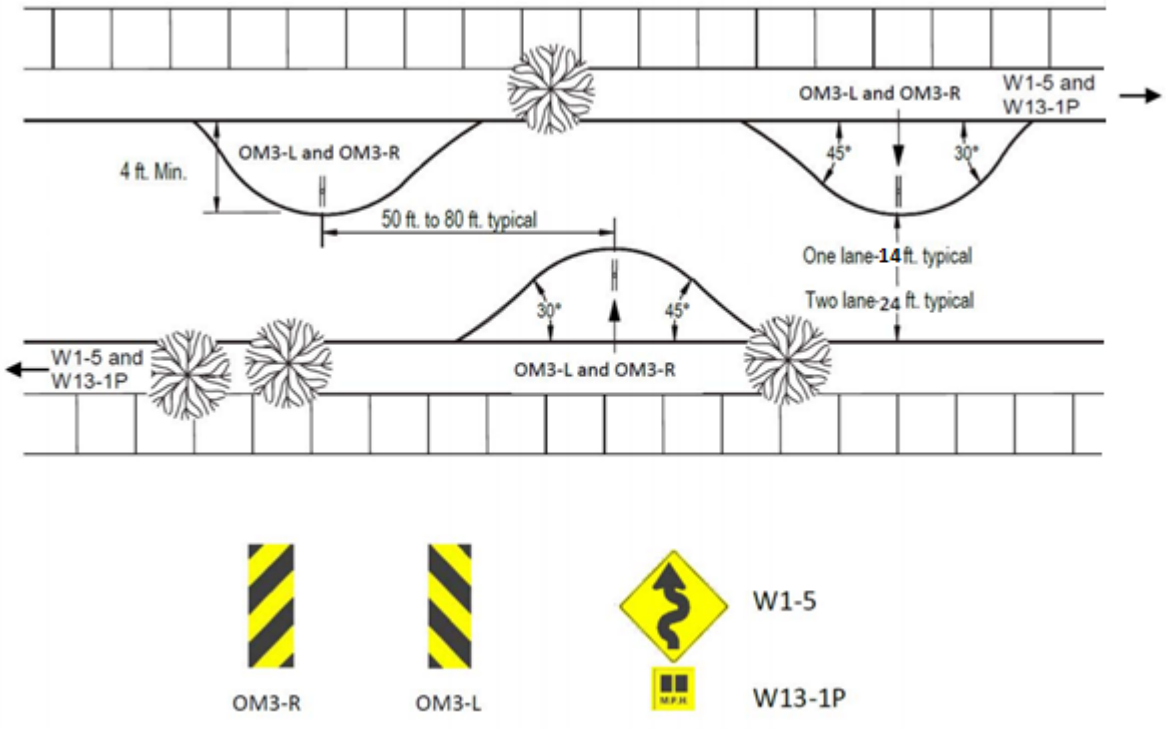
### Effectiveness

Chicanes can reduce vehicle speeds within the chicane by 5 to 13 mph and vehicle speeds approaching and exiting the chicane by 1 to 6 mph. Studies have demonstrated that chicanes can reduce 85$^{th}$ percentile speeds by 3 to 9 mph.

## Exhibit 18.5.12 Chicane Design Features and Typical Design Criteria

| TRAFFIC-CALMING MEASURE DESIGN FEATURES | TYPICAL DESIGN CRITERIA |
|---|---|
| **DIMENSIONS** | • The recommended average lane width between chicane build-out and the opposite curb is a 14-ft clearance on one-way streets and a 24-ft clearance on two-way streets and determined by the design and/or control vehicle (e.g., emergency, transit vehicles). In addition, minimum required lane widths in Chapters 3, 4 and 5 must be met.<br>• Flexibility can be considered if narrower spaces are desired, but decisions should be supported by design vehicle turning templates to ensure no overlapping vehicle paths.<br>• The path angle of chicane treatments impacts speed reduction. A deflection angle of 30 to 45 degrees is recommended.<br>• The number and length of chicane treatments depend on the length of roadway between intersections. A chicane should include a minimum of three shifts in the travel lanes using alternating treatments such as curb extensions, islands, or parking.<br>• For design speeds of 15 to 20 mph, create a chicane with at least one reverse curve, minimum radius of 50 ft (15 mph) to 100 ft (20 mph) and offset curb extensions into travel lane (minimum of 4 ft to a full travel lane.) |
| **SPACING** | • The stagger length between chicane treatments is dependent on the location of driveways and drainage systems.<br>• Stagger length has a direct impact on vehicle speeds. Reducing the stagger length has been shown to reduce speeds more effectively. The typical spacing ranges from 50 ft to 80 ft. |
| **PAVEMENT MARKING** | • Pavement markings can be used to increase safety and alert motorists to a curvature in the street. Street centerlines keep vehicles from traveling straight through chicanes. |
| **LOCATION** | • Must be installed at mid-block locations. |
| **SIGNAGE** | • The Winding Road (Left) sign, W1-5L, with an appropriate Advisory Speed plaque, W13-1P, should be used at least 150 ft in advance of a chicane. Reflectors, street lighting, and elevated landscaping can be used to improve visibility. |

**Exhibit 18.5.13 Chicane Dimension Details**




**Design Considerations and Context**

- **Located at mid-block.** Chicanes may utilize curb extensions paired with mid-block pedestrian crosswalks, where appropriate.
- **Multifunctional use.** Chicanes can incorporate landscaping features, on-street parking, or additional sidewalk pavement, and can be used to collect and filter stormwater.
- **Bicycle facilities.** Chicane treatments should accommodate bicycles on major bicycle thoroughfares, as the effective roadway width is reduced. Where bicycle routes and chicane treatments are paired, effective striping of shared-lane markings and shared-roadway signage should be used to alert motorists and bicyclists. Chicane designs can feature bike lane cutouts to create additional space and allow bicyclists to bypass the traffic-calming measure.
- **Warning measures.** Chicanes may require additional lighting, signing, and striping to ensure that motorists are aware of a winding roadway.
- **Drainage.** Where a chicane design might adversely impact drainage, curb extensions can be designed as islands located 1 to 2 ft from the curb.

- **Maintenance.** Landscaping should only be incorporated into traffic-calming devices where clear maintenance responsibilities have been established. PennDOT typically requires an agreement with municipalities for maintenance responsibilities.
- **Materials.** Short-term materials, such as flex-posts, planters, and other street furniture, may be used as interim treatment options.

## 18.5.4 – Gateway

### Description and Purpose

Gateways use physical and textural changes to indicate the entrance to areas with higher pedestrian activity and slower-speed environments, such as urban cores, residential neighborhoods, school zones, or shared streets. Gateways provide identity to an area and include features such as curb extensions, raised crosswalks, signs, textured pavement, street furniture, and landscaping to narrow the apparent width of the roadway and potentially reduce the operating speed of motorists.

**Exhibit 18.5.14 Example Neighborhood Slow Zone Gateway**


(Source: Kittelson & Associates, Inc.)

**Exhibit 18.5.15 Gateway Typical Application**

| GATEWAY TYPICAL APPLICATION | |
|---|---|
| **SPEED** | Applicable for transition areas between roadways with higher speeds and roadways with lower speeds. |
| **STREET FUNCTIONAL CLASSIFICATION** | Appropriate on arterials, collectors, and local roads. |
| **NUMBER OF TRAVEL LANES** | Appropriate on single-lane, one-way streets and two-lane, two-way streets. |
| **CURVES** | Applicable on vertical curves given adequate stopping sight distance. |
| **CONTEXT: LAND USE AND AREA** | Works well in rural towns, urban areas, and urban cores. Also applicable in residential areas, commercial corridors, and community places (e.g., transit stop, school, library, park). Not typically applicable in rural contexts (without high pedestrian activity, or in higher speed areas) but could be considered as part of other potential traffic-calming measures to increase effectiveness (for example, curb extensions or textured pavement). May be used to maintain neighborhood character and create a sense of place. |

**Exhibit 18.5.16 Advantages and Disadvantages of Gateways**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Reduces travel speeds.<br>• Manages traffic volumes by reducing cut through traffic.<br>• Improves pedestrian safety: reduces speeds in pedestrian activity areas and increases motorist awareness.<br>• Enhances neighborhood appearance through the inclusion of landscaping, green stormwater infrastructure, or textured treatments.<br>• May be combined with other traffic-calming measures (e.g., raised crosswalks, curb extensions) to increase effectiveness.<br>• Improves parking compliance. | • Impacts emergency response time and heavy vehicle turning movements.<br>• The presence of existing drainage features may increase the cost of implementation, due to drainage impacts.<br>• Impacts snow removal.<br>• Increases traffic noise if textured pavements are used. |

### Effectiveness

Research has shown a reduction in speeds at mid-block locations where gateway curb extensions are installed. European studies report that gateway traffic-calming measures achieve speed reductions of 3 to 13 mph.

**Exhibit 18.5.17 Gateway Design Features and Typical Design Criteria**

| TRAFFIC-CALMING MEASURE DESIGN FEATURES | TYPICAL DESIGN CRITERIA |
|---|---|
| **DIMENSIONS** | • Dependent on the type of gateway treatment. To be designed for an appropriate design and/or control vehicle (e.g., trucks, emergency vehicles, school buses).<br>• Curb Extensions may be implemented as part of gateway design details.<br>• Raised Median Through Intersection may be implemented as part of gateway design details. |
| **LOCATION** | • Located at entrances to Slow Zone areas, such as a school zone, neighborhood, or high-pedestrian traffic area.<br>• May be installed at intersection or mid-block locations. Mid-block curb extensions may be combined with a crosswalk. |
| **SIGNAGE** | • Gateways may include signage to indicate entrance into a Slow Zone area. |

### Design Considerations and Context

- **Land use or speed limit changes.** Gateways can be used to mark a change in land use or speed limit.
- **Combination of traffic-calming measures.** Gateways are most effective when used in combination with other traffic-calming measures. Textured pavements, curb extensions, and medians may be combined to create effective gateway treatments.
- **Multifunctional use.** Gateways can incorporate landscaping features and be used to collect stormwater. Serves to slow vehicles and increase awareness for drivers entering slower zones.
- **Bicycle and pedestrian facilities.** Treatments should not impede bicyclists or pedestrians and should further accommodate comfortable movement. Curb extensions can be used in conjunction with a separated bicycle facility, where the curb extension includes an opening for the bicycle facility along the curb.
- **Maintenance.** Landscaping should only be incorporated into traffic-calming devices where clear maintenance responsibilities have been established. Additionally, snowplow operators should be informed where gateway treatments are present.

## 18.5.5 – Single-lane Roundabouts and Mini-Roundabouts

### Description and Purpose

A roundabout is an intersection control treatment where traffic entering the circulatory roadway yields to circulating vehicles. They are not to be confused with traffic circles which are designed and operate differently.

There are safety and operational benefits to installing a roundabout. Safety benefits include a reduction in crash frequency, a reduction in crash severity, and slower vehicle speeds. Operational benefits include the potential for lower delays and queues compared to other intersection forms, in addition to the opportunity to reduce turn-lane requirements due to geometric characteristics.

Single-lane roundabouts and mini-roundabouts are included as traffic-calming measures because the geometric design of these intersection treatments can change the operating character of a roadway and slow speeds. Roundabouts can be effective in conjunction with other traffic-calming measures to reinforce a change in environment (for example, as a gateway treatment where higher-speed facilities transition to lower-speed facilities with pedestrian presence). A single-lane roundabout typically has a non-traversable central island. A mini-roundabout is a small roundabout with a fully traversable central island. They are typically used in an urban environment with operating speeds of 30 mph or less.

National Cooperative Highway Research Program's (NCHRP) Research Report 1043: *Guide for Roundabouts,* describes planning, operations, safety, geometric design, illumination, landscaping, and the construction and maintenance of roundabouts.

Refer to Chapter 6, *Intersections and Driveways,* Section 6.12, for more information about roundabout design.

**Exhibit 18.5.18 Example Roundabout Constructed for Traffic Calming**

**Exhibit 18.5.19 Example Mini-Roundabout**

(Source: Jimmie Brown, PennLive)

**Exhibit 18.5.20 Single-lane Roundabout and Mini-Roundabout Typical Application**

| ROUNDABOUT TYPICAL APPLICATION | |
|---|---|
| **TRAFFIC VOLUMES** | • Typical daily traffic volume for a single-lane roundabout is up to approximately 25,000 vehicles per day.<br>• Typical daily traffic volume for a mini-roundabout is up to approximately 15,000 vehicles but could potentially be higher. |
| **SPEED** | • Typical operating speeds for a single-lane roundabout or a mini-roundabout range from 20 to 25 mph or 15 to 20 mph, respectively. |
| **STREET FUNCTIONAL CLASSIFICATION** | • Appropriate for the intersections of arterial, collector, and local roadways. |
| **GRADE** | • Roundabouts are typically not recommended in locations where the grades through the intersection exceed 4%. |
| **CURVES** | • Provide adequate sight distance and visibility of the intersection. |
| **CONTEXT: LAND USE AND AREA** | • Can be appropriate in both urban and suburban settings. |

**Exhibit 18.5.21 Advantages and Disadvantages of Single-lane Roundabouts and Mini-Roundabouts**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Improves safety by:<br>  ○ reduces crash frequency and severity<br>  ○ eliminates left-turn crashes<br>  ○ slows vehicle speeds<br>  ○ reduces conflict points compared to a traditional four-approach intersection<br>  ○ allows pedestrians to cross one direction of traffic at a time when splitter islands are provided<br>• Improves operational benefits with fewer delays and queues compared to other intersection forms and provides an opportunity to reduce turn-lane requirements.<br>• Enhances neighborhood appearance with landscaping.<br>• Accommodates trucks and large vehicles. | • A larger right-of-way is required at the intersection but raises the potential for decreased right-of-way along the roadway approaches. (Turn lanes may not be required for achieving desired operations.)<br>• The yield control entry to a roundabout presents challenges for pedestrians with visual disabilities. Consult Chapter 6 and NCHRP's *Report 834* for guidance on addressing these challenges at roundabouts. |

### Effectiveness

A roundabout is an FHWA Proven Safety Countermeasure and provides safety and operational benefits. Speed reduction is a factor of the design of the approach lanes of the roundabout. Research demonstrates a reduction in speeds at roundabouts. A study conducted in an urban area measured a 14-mph reduction in 85$^{th}$ percentile speeds; a study conducted in a suburban area measured an 8-mph reduction in 85$^{th}$ percentile speeds.

Research shows converting a two-way stop-controlled intersection to a roundabout yields an 82% reduction in severe crashes. Similarly, converting a signalized intersection to a roundabout yields a 78% reduction in severe crashes.

## Exhibit 18.5.22 Single-lane Roundabout and Mini-Roundabout Design Features and Typical Design Criteria

Refer to Chapter 6 for single-lane roundabout geometric design features.

| TRAFFIC-CALMING MEASURE DESIGN FEATURES | TYPICAL DESIGN CRITERIA |
|---|---|
| **DIMENSIONS** | • Inscribed circle diameter (ICD) varies for each type of roundabout. The ICD of a modern single-lane roundabout typically ranges from 90 to 160 ft and 45 to 90 ft for a mini-roundabout. The ICD can vary, depending on the site context. |
| **SPACING** | • Closely spaced roundabouts may create a traffic-calming effect. However, design considerations include providing adequate spacing of 95$^{th}$ percentile queues. |
| **LIGHTING** | • May require additional street lighting on a roadway. |
| **LANDSCAPING** | • Landscaping must not interfere with minimum sight distance requirements. |

### Design Considerations and Context

- **Mini-roundabout.** Key additional design considerations for mini-roundabouts include vehicle channelization, design vehicle paths, and intersection visibility.
- **Context Considerations.** For additional context considerations, the designer can refer to Chapter 1 and NCHRP Research Report 1043, Guide for Roundabouts, Chapter 3: *A Performance-Based Planning and Design Approach*.
- **Accessible Design.** The designer can refer to NCHRP's *Report 834: Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities: A Guidebook* for accessible design considerations.
- **Bicycle and Pedestrian Facilities.** The designer can refer to NCHRP Research Report 1043, Guide for Roundabouts, Chapter 4: *User Considerations*; and to Chapter 13, *Pedestrian Facilities*, and Chapter 14, *Bicycle Facilities*, for additional considerations.
- **Maintenance.** The designer can refer to NCHRP Research Report 1043, Guide for Roundabouts, Chapter 15: *Construction and Maintenance,* which discusses landscaping maintenance, snow plowing and storage, and pavement maintenance and rehabilitation. The operating and maintenance costs of a roundabout tend to be higher than other unsignalized intersections but less than a signalized intersection.
- **Temporary materials.** Pavement markings and flex-posts can be used to convert an existing traffic circle, or intersection of two-lane roads to a roundabout.

## 18.5.6 – Pedestrian Refuge Island

### Description and Purpose

Pedestrian median refuge islands provide added protection for pedestrians and bicyclists crossing at an intersection or mid-block and simplify each crossing into stages dealing with traffic from one direction at a time. Refuge islands may be incorporated into medians that are depressed, raised, or flush with the road surface. Pedestrian refuge islands are particularly helpful for assisting people with disabilities, older adults, children, and others less able to cross the street in a single stage.

Information regarding the design of pedestrian refuge islands is provided in Chapter 13.

**Exhibit 18.5.23 Examples of Pedestrian Refuge Islands**

(Source: NACTO)

(Source: NACTO)

**Exhibit 18.5.24 Pedestrian Refuge Island Typical Application**

| PEDESTRIAN REFUGE ISLAND TYPICAL APPLICATION | |
|---|---|
| **TRAFFIC VOLUMES** | Applicable for all volumes. Recommended on urban and suburban roadways with a mix of bicycle and pedestrian activity and an ADT volume greater than 9,000. |
| **SPEED** | Applicable for all urban speed limits. Recommended for roadways with travel speeds of 35 mph or greater. |
| **STREET FUNCTIONAL CLASSIFICATION** | Appropriate on local, collector, and arterial roadways in both urban and suburban settings. |
| **STREET WIDTH** | Recommended if the crossing distance is greater than 60 ft. Depending on context, pedestrian refuge islands may be installed on narrower streets (30 ft wide minimum) or narrower if using the through crosswalk example. |
| **NUMBER OF TRAVEL LANES** | Appropriate on any size street. On larger streets pedestrian refuge island would need to be accompanied with other measures (such as signalized crossings). |
| **CURVES** | Can be applied on crest curves given adequate stopping sight distance, appropriate lighting, and warning signs. |
| **CONTEXT: LAND USE AND AREA** | Acceptable in all land use contexts. |

**Exhibit 18.5.25 Advantages and Disadvantages of Pedestrian Refuge Islands**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Separates conflict points by allowing pedestrians to focus on one direction of traffic at a time and reduces crossing distance.<br>• Improves pedestrian and bike safety: narrows lane width which results in slower vehicle speeds.<br>• Can enhance neighborhood appearance with landscaping, green stormwater infrastructure, or added pedestrian infrastructure.<br>• Minimizes impacts on drainage.<br>• Improves pedestrian visibility of vehicles, vehicles have better visibility of pedestrians and can reduce right turning vehicle conflicts.<br>• Limited impacts on emergency response and large vehicles access and operations. | • May impact snow removal efforts. Median delineators can be used to alert snow removal teams.<br>• May require the removal of on-street parking to maintain appropriate travel lane width and turning radii. |

### Effectiveness

Pedestrian refuge islands reduce pedestrian exposure and increase the visibility of people who walk and bike. Pedestrian refuge islands and raised medians are FHWA Proven Safety Countermeasures and provide safety benefits, although the expected speed reduction is relatively low. Speed reductions range from 2 to 3 mph on average.

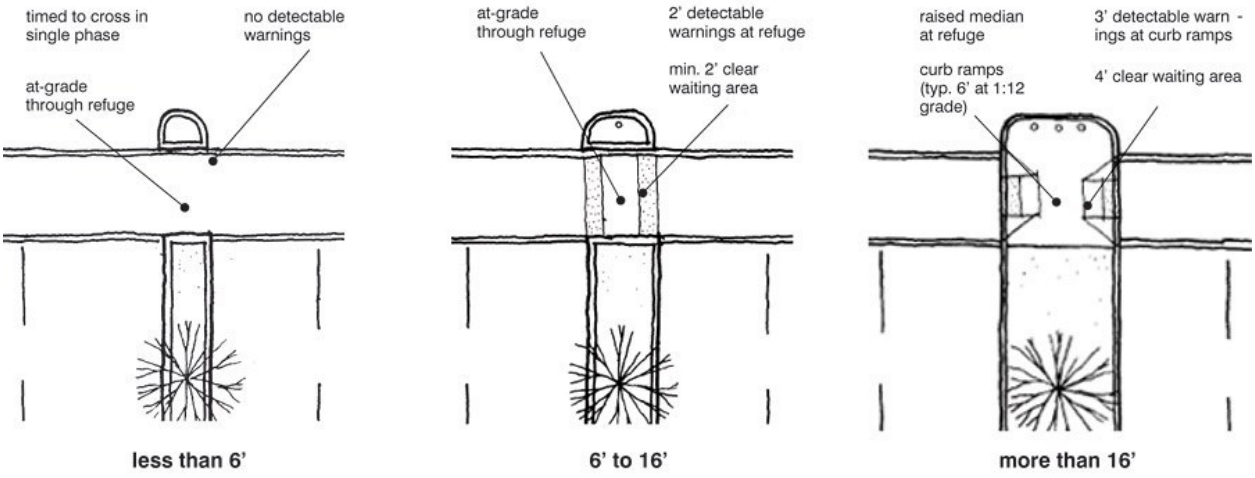
Research demonstrates that the installation of raised medians with marked crosswalks in urban or suburban areas results in a 46% reduction in pedestrian crashes; the installation of pedestrian refuge islands results in a 56% reduction in pedestrian crashes. Research also shows that raised medians and pedestrian refuge islands reduce the likelihood of crashes occurring as pedestrians cross the road in evening conditions by 78%.

Adding lighting, signage, and pedestrian crossing devices to the installation of raised medians and pedestrian refuge islands will ensure they are visible to motor vehicles.

**Exhibit 18.5.26 Pedestrian Refuge Island Design Features and Typical Design Criteria**

| TRAFFIC-CALMING MEASURE DESIGN FEATURES | TYPICAL DESIGN CRITERIA |
|---|---|
| **DIMENSIONS** | • Refer to Chapter 13.<br>• Medians should be approximately 20 ft in length to discourage vehicle violations (e.g., illegal U-turns, parking).<br>• The width of a pedestrian refuge island should be a minimum of 6 ft wide in the direction of travel to allow for 24-in detectable warning surface at each edge, and at least 24 in between the surfaces. When the 6-ft width cannot be achieved, detectable warning surfaces are not required.<br>• The length of the pedestrian opening in refuge islands could be 5 ft minimum but should be 8 to 10 ft if accommodating bi-directional pedestrian and bicycle travel. |
| **SPACING** | • Spacing and length of medians to prevent violations can be found in Chapter 3 and Chapter 6. |
| **PAVEMENT MARKING** | • Reflective markers and/or markings should be used on the approaching sides of the curve.<br>• Pavement markings should follow the *Approach Markings for Obstructions* section in the MUTCD.<br>• The refuge pavement should be different than the roadway pavement, especially if the refuge is at grade. |
| **LOCATION** | • Refuge islands can be added at an existing crosswalk or with the addition of a crossing at an intersection or mid-block. |
| **SIGNAGE** | • Recommended signage includes R6-1, R4-7, R7-4 (Advanced Stop).<br>• Bicycle signals or Rectangular Rapid Flashing Beacons (RRFB) can be used to inform drivers when a bicyclist or pedestrian is present at mid-block locations. |
| **LIGHTING** | • Median islands can be used for additional lighting infrastructure and signage. Signs over 2 ft tall should be checked to assure clear line of sight. |

**Exhibit 18.5.27 Pedestrian Refuge Island Dimension Details**




(Source: SF Better Streets)

**Design Considerations and Context**

- **Raised median requirements.** The designer should consider raised median design requirements and suggestions outlined in NCHRP Report 500, Volume 10: *A Guide for Reducing Collisions Involving Pedestrians, Strategy 9.1 A3*.
- **Multifunctional use.** Raised medians can incorporate landscaping features, on-street parking, additional sidewalk pavement, transit facilities, and water treatment facilities.
- **Maintenance.** Landscaping should only be incorporated in traffic-calming devices where clear maintenance responsibilities have been established. PennDOT requires a maintenance agreement with local municipalities.
- **Local driveways.** Placing medians at or near home or business driveways should be avoided.
- **Landscaped medians.** Medians should have a 2-ft walkable edge to safely accommodate maintenance workers.
- **Raised versus at-grade refuge.** If the median width is greater than 16 ft, the refuge should be raised with ADA-compliant ramps and a 4-ft clear waiting area. If the median width is between 6 and 16 ft, the refuge should be at grade with 2-ft detectable warning strips on each side and a minimum 2-ft clear zone. If the pedestrian refuge area is primarily for bicycle use, at-grade refuges are recommended.
- **Angled refuge and Z-shaped refuge islands.** Angled 45-degree or Z-shaped refuge islands can be placed to turn users toward the oncoming traffic lane. Angled 45-degree refuges are recommended for exclusive bicyclist paths. Z-shaped refuges are

recommended for pedestrians, as the adjacent crosswalk should be perpendicular to the direction of vehicular travel; however, pedestrians may find them unattractive.

## 18.5.7 – Vertical Deflection

Vertical deflection refers to traffic-calming measures that create a change in the height of the roadway. When designed properly, drivers must slow down when traveling over these measures to maintain driver comfort. As with horizontal deflection measures, vertical deflection measures can be used to manage vehicle speeds, with only minor effects on traffic volumes. Vertical deflection measures can also be used to improve the safety of pedestrian crossings.

The toolbox includes the following vertical deflection traffic-calming measures:

- 18.5.8 – Speed Hump, Speed Cushion, and Speed Table
- 18.5.9 – Raised Crosswalk
- 18.5.10 – Raised Intersection

## 18.5.8 – Speed Hump, Speed Cushion, and Speed Table

### Description and Purpose

A speed hump is a raised traffic-calming device located mid-block in the roadway to slow vehicular traffic and reduce speeds through vertical deflection. Typically, speed humps are 12 to 14 ft long in the direction of vehicle travel and 3 to 4 in high.

The spacing of speed humps typically determines the speed at which motorists can drive. For example, spacing of approximately 250 to 400 ft tends to achieve an 85$^{th}$ percentile operating speed of between 25 and 35 mph.

Speed cushions have similar dimensions and applications as speed humps, and are typically 3 in high, 6 ft wide, and 7 to 14 ft long. Speed cushions comprise two or more raised areas placed laterally across a roadway, with space between the raised areas that allow wider-axle emergency vehicles to cross with minimal disruption. Speed slots (a modified speed cushion) are typically 3 in high, 6 to 7 ft wide, and 22 ft long. On arterials, PennDOT recommends installing speed slots.

Speed tables also have similar dimensions and applications as a speed hump, except that they have a flat top designed to accommodate the wheelbase of a passenger car (generally 10 ft long). Speed tables are typically 22 ft long, with a 10-ft plateau and 6-ft approaches on either side.

If a speed table is designated as a crosswalk, it is known as a raised crosswalk.

**Exhibit 18.5.28 Example Speed Hump, Speed Cushion, and Speed Table**


Speed Hump (Source: Lucy Gibson)

Speed Cushion (Source: Jeff Gulden)

Speed Table (Source: NACTO)

## Exhibit 18.5.29 Speed Hump, Speed Cushion, and Speed Table Typical Applications

| SPEED HUMP, SPEED CUSHION, AND SPEED TABLE – TYPICAL APPLICATION | |
|---|---|
| **TRAFFIC VOLUMES** | • Appropriate where total traffic flow volume comprises no more than 5% long-wheelbase vehicles.<br>• Appropriate on low to moderate volume roadways. |
| **SPEED** | • Research recommends a spacing of 200 to 400 ft to maintain an 85th percentile operating speed between 25 and 30 mph. On short blocks of 350 to 500 ft in length, install only one traffic-calming measure mid-block.<br>• The design speed is determined by the dimensions and spacing of the speed hump. Posted speed limit typically 30 mph or less.<br>• Not appropriate for roadways with 85th percentile speeds of 45 mph or more. |
| **STREET FUNCTIONAL CLASSIFICATION** | • The function and context of the street should be considered, particularly if the street serves as a community main street, includes large numbers of pedestrians, or has low traffic volumes.<br>  ○ Speed humps: Local, collector, residential, or any street where the primary function is to provide access to residential properties.<br>  ○ Speed cushions: Local, collector, and lower volume arterial roadways that also serve as primary residential access. Speed slots are recommended for use on arterials.<br>  ○ Speed tables: Local, collector, and lower volume arterial roadways that also serve as primary residential access. |
| **NUMBER OF TRAVEL LANES** | • Appropriate for one-lane or two-lane, one-way streets or two-lane, two-way streets. |
| **GRADE** | • Speed humps are typically limited to installation on roadways with longitudinal grades of 8% or less. On a project-by-project basis following engineering evaluation, speed humps and other vertical traffic-calming measures may be installed on street sections with steeper grades up to 10%. |
| **CURVES** | • Should not be placed on sharp curves; the minimum recommended street curve is defined as a roadway with a centerline radius of 200 ft or less, or a roadway which has a curve with less than minimum safe stopping sight distance. |
| **CONTEXT: LAND USE AND AREA** | • Works well in residential areas and on local or collector roadways.<br>• Should not be placed at curb cuts or obstruct driveways. |

| | |
|---|---|
| **EMERGENCY OR TRANSIT ROUTE** | • Speed humps:<br>  ○ Additional considerations needed if locating on a primary emergency vehicle route, due to 3- to 7-second delays for fire trucks or ambulances. For example, limiting the number of speed humps on an emergency vehicle route.<br>  ○ Not typically used on major roadways, bus routes, or primary emergency access routes.<br>• Speed cushions:<br>  ○ May be a viable alternative, providing similar speed reduction while allowing wide-axle emergency vehicles the ability to navigate unimpeded through the gaps in cushions.<br>  ○ Appropriate for a bus transit route or a primary emergency vehicle route.<br>• Speed tables:<br>  ○ Not generally appropriate for primary emergency vehicle route or bus transit route unless the posted speed limit is 30 mph or less. |

**Exhibit 18.5.30 Advantages and Disadvantages of Speed Humps, Speed Cushions, and Speed Tables**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Low cost to install and maintain compared to other traffic-calming measures.<br>• Self-enforcing traffic-calming measure that effectively reduces vehicle speeds.<br>• Increases pedestrian and bicyclist safety and comfort due to reduced travel speeds.<br>• Minimally impacts on-street parking (speed humps or cushions.)<br>• Drainage impacts along curb line are negligible: speed humps and speed cushions are typically installed on a roadway with a curb. Speed humps are typically spaced 1 ft from a curb.<br>• Can be implemented in a system-wide approach. | • Impacts to drainage: For speed tables, the presence of existing drainage features could increase the cost of implementation.<br>• Impact to emergency response time: Speed humps could cause delay for emergency vehicles. Speed cushions provide gaps for emergency response vehicles. Speed tables cause less delay than speed humps and a less jarring effect on passengers.<br>• Impact to bus travel: Speed humps could be inappropriate on streets with bus traffic, due to rider comfort and reduced travel speeds. Speed cushions are more appropriate for a bus route while speed tables have less impact than speed humps.<br>• Impacts on network if not used in a system-wide approach.<br>• Impacts snow removal. However, speed humps have been successfully implemented in many jurisdictions with heavy snowfall.<br>• Impacts on-street parking (speed table). |

### Effectiveness

Research shows a reduction in speeds at locations where speed humps, speed cushions, and speed tables are installed.

- Studies conducted on local roadways within urban areas to determine the effect of speed humps on vehicle speed show a reduction in 85$^{th}$ percentile speeds of 5 to 13 mph.
- Studies conducted to determine the effect of speed cushions on vehicle speed show a reduction in 85$^{th}$ percentile speeds of 5 to 7 mph.
- Studies conducted to determine the effect of speed tables on vehicle speed show a reduction in 85$^{th}$ percentile speeds of 6 to 11 mph in urban areas.

Research shows a reduction in crashes at locations where speed humps, speed cushions, and speed tables are installed.

- Studies conducted in urban areas regarding the effect of speed humps on crashes demonstrate a reduction of between 33% to 48% for all crash types. Studies documenting a change in volume due to speed humps also show a reduction in crashes.
- Studies conducted in urban areas to determine the effect of speed tables on crashes show a 38% reduction in total crashes, 93% reduction in injury crashes, and a 36% to 64% reduction in all crash types.
- There were no crash studies found for speed cushions.

## Exhibit 18.5.31 Design Features and Typical Design Criteria of Speed Humps, Speed Cushions, and Speed Tables

| TRAFFIC-CALMING MESURE DESIGN FEATURES | TYPICAL DESIGN CRITERIA |
|---|---|
| **DIMENSIONS** | • 3 to 4 inches in height, with a trend toward 3 to 3.5 in maximum.<br>• Speed humps and speed cushions are typically 12 to 14 ft in length in the direction of travel.<br>• Speed tables are typically 22 ft in length in the direction of travel.<br>• Speed cushions are typically 6 ft wide, and 10 to 11 ft long in the direction of travel, with a 2-ft gap.<br>• Speed slots are typically 6 to 7 ft wide, and 22 ft in length in the direction of travel, with a 2 to 3-ft gap.<br>• Slopes should not exceed 1:10 or be less steep than 1:25.<br>• Side slopes on tapers should be no greater than 1:6.<br>• The vertical lip should be no more than 0.25 in. |
| **SPACING** | • Typically spaced between 200 and 400 ft apart in the direction of travel to achieve an 85th percentile speed between 25 and 35 mph.<br>• Studies showed that speed humps placed at intervals of 275 ft resulted in 85th percentile speeds of 25 mph, while intervals of 550 ft resulted in 85$^{th}$ percentile speeds of 30 mph.<br>• The configuration and layout of speed cushions (and speed slots) depends on the number of lanes, lane widths, and width of roadway to avoid instances of vehicles traveling across lanes to avoid vertical deflection. |
| **PAVEMENT MARKING** | • Typically, pavement markings are included on speed humps. Advanced Warning Markings can also be applied where added visibility is desired.<br>• All pavement markings should comply with MUTCD. Details regarding speed hump pavement markings are provided in PennDOT's *TC-8600.* |
| **LOCATION** | • Treatments should be used mid-block. Installation within 250 ft of the approach to a signal, within 100 ft approaching a collector, or 20 ft to a local uncontrolled intersection should be avoided.<br>• Locating speed humps directly in front of driveways should be avoided. |
| **SIGNAGE** | • Often have associated signing, such as an advance warning sign before first hump in series.<br>• It is recommended that Speed Hump Warning signs (e.g., W8-1, W17-1) and optional Advisory Speed plaque (W13-1) be installed either 100 ft in advance of speed humps, at the speed humps, or in both locations.<br>• All signage should comply with MUTCD and Publication 236, *Handbook of Approved Signs*. |
| **CONSTRUCTION MATERIALS** | • May be constructed from asphalt, textured or colored asphalt, or poured and stamped concrete. |

## Exhibit 18.5.32 Speed Hump Design Profiles

**Profiles for Vertical Devices (Speed Humps)**

**Sinusoidal Profile**

- reduces speed slightly less (compared to circular or parabolic profiles.)
- more difficult and expensive to construct
- provides greater comfort level for drivers and bicyclists.

| 3.00 | 2.55 | 2.07 | 1.50 | 0.69 | 0.27 | 0.00 | Height (Inches) |
|---|---|---|---|---|---|---|---|
| 100% | 85% | 69% | 50% | 23% | 9% | 0% | |
| 1 | 1 | 1 | 1 | 1 | 1 | Length of approach (feet) | |

**Circular Profile**

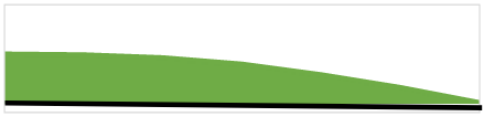
- reduces speed moderately (compared to sinusoidal or parabolic profiles.)
- provides moderate comfort levels for drivers and bicylists.

| 3.00 | 2.91 | 2.67 | 2.25 | 1.65 | 0.90 | 0.00 | Height (Inches) |
|---|---|---|---|---|---|---|---|
| 100% | 97% | 89% | 75% | 55% | 30% | 0% | |
| 1 | 1 | 1 | 1 | 1 | 1 | Length of approach (feet) | |

**Parabolic Profile**

- reduces speed the most (compared to sinusoidal or circular profiles.)
- least comfortable for drivers and bicyclists.
- avoid on streets with bicycle traffic.

| 3.00 | 2.94 | 2.76 | 2.37 | 1.71 | 0.93 | 0.00 | Height (Inches) |
|---|---|---|---|---|---|---|---|
| 100% | 98% | 92% | 79% | 57% | 31% | 0% | |
| 1 | 1 | 1 | 1 | 1 | 1 | Length of approach (feet) | |



Note: When balancing tradeoffs and considerations for comfort (bicyclists and drivers), sinusoidal profiles are preferred. Due to sinusoidal profiles being more difficult and expensive to construct, circular profiles are acceptable.

### Design Considerations and Context

- **Land use.** Speed humps are typically used in residential areas on local and collector streets. However, they may be appropriate in areas with high pedestrian volumes, mixed-land uses, and denser land uses.
- **Pedestrian and bicycle safety and mobility.** The *Traffic Calming ePrimer* provides several considerations related to pedestrians and bicyclists. For example, some jurisdictions use a maximum grade of 5% for streets designated as a bicycle route.
- **Placement of speed hump in a series.** Speed humps should typically be located where they cannot be approached at a high speed.

- **Temporary materials.** The use of temporary speed cushions and speed humps is an alternative to permanent installations. For example, some municipalities install hard rubber speed cushions for use in pilot programs.
- **Maintenance.** Considerations related to the maintenance of speed humps, speed cushions, and speed tables include both snowplowing and street sweeping. Some jurisdictions alert snowplow operators to treatment locations; some work collaboratively with operators and use signage to alert drivers and operators. For example, a flexible delineator may be used to alert operators to lift their blades.

  The designer should recognize that temporary devices tend to come loose over time and require repair. Constructed devices may be designed with reinforcements for heavy vehicles and snowplows, as well as unique geometry to prevent edges from crumbling.

## 18.5.9 – Raised Crosswalk

### Description and Purpose

A raised crosswalk is a vertical traffic-calming measure applied at pedestrian crossing locations to elevate a crosswalk from street level to sidewalk level. Raised crosswalks combine the benefits of a speed hump with enhanced visibility, improved awareness of pedestrians, reduced vehicle speeds, and enhanced pedestrian comfort and safety.

Typical approach ramps are 5 to 7 ft, with a top flattened width of 10 ft and a total length of 20 to 24 ft.

### Exhibit 18.5.33 Raised Crosswalk Typical Application

| RAISED CROSSWALK TYPICAL APPLICATION | |
|---|---|
| **TRAFFIC VOLUMES** | • Typically installed at locations with high pedestrian activity or near pedestrian generators, high vehicle volume, and low design speed. |
| **SPEED** | • Acceptable on roadways with posted speed limits of 30 mph or less.<br>• Not appropriate where 85$^{th}$ percentile speeds are 45 mph or more.<br>• Should be located where the desired speed is 20 to 25 mph. |
| **STREET FUNCTIONAL CLASSIFICATION** | • Appropriate on local roadways except in rural contexts. May be appropriate in rural towns.<br>• May be appropriate on collector and arterial streets depending on context, including pedestrian activity, mixed-land uses, building proximity to streets, and vehicle speeds and volumes.<br>• Additional analysis and context evaluation may be required under these context-sensitive scenarios. |
| **NUMBER OF TRAVEL LANES** | • Appropriate on single-lane, one-way or two-lane, two-way streets. |
| **GRADE** | • Raised crosswalks are typically limited to installation on roadways with longitudinal grades of 8% or less. On a project-by-project basis following engineering evaluation, vertical traffic-calming measures may be installed on street sections with steeper grades up to 10%. |
| **CURVES** | • Street should not have a curve with a radius of less than 300 ft for mid-block locations. |
| **CONTEXT: LAND USE AND AREA** | • Acceptable in all land use and area contexts except rural. May be appropriate in rural towns.<br>• Commonly found in areas with high pedestrian activity. |

### Exhibit 18.5.34 Example Raised Crosswalks

**Exhibit 18.5.35 Advantages and Disadvantages of Raised Crosswalks**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Reduces travel speeds.<br>• Manages traffic volumes by reducing cut through traffic.<br>• Improves pedestrian safety by creating better visibility, clearly demarcating crossing areas, and proven to increase vehicles yielding to pedestrians.<br>• Improves ADA accessibility by providing a level crosswalk.<br>• Reduces illegal parking by preventing motorists from parking too close to an intersection or crosswalk. | • May result in the loss of one on-street parking space at mid-block locations. Unlikely to impact parking at intersections, due to roadway design standards.<br>• May cause delay for emergency response vehicles but demonstrates less speed delay than traditional speed humps.<br>• Requires more maintenance than traditional crosswalks.<br>• The presence of existing drainage features could increase the cost of implementation, due to drainage impacts.<br>• Impacts snow removal.<br>• Creates traffic noise from vehicles braking and accelerating. |

### Effectiveness

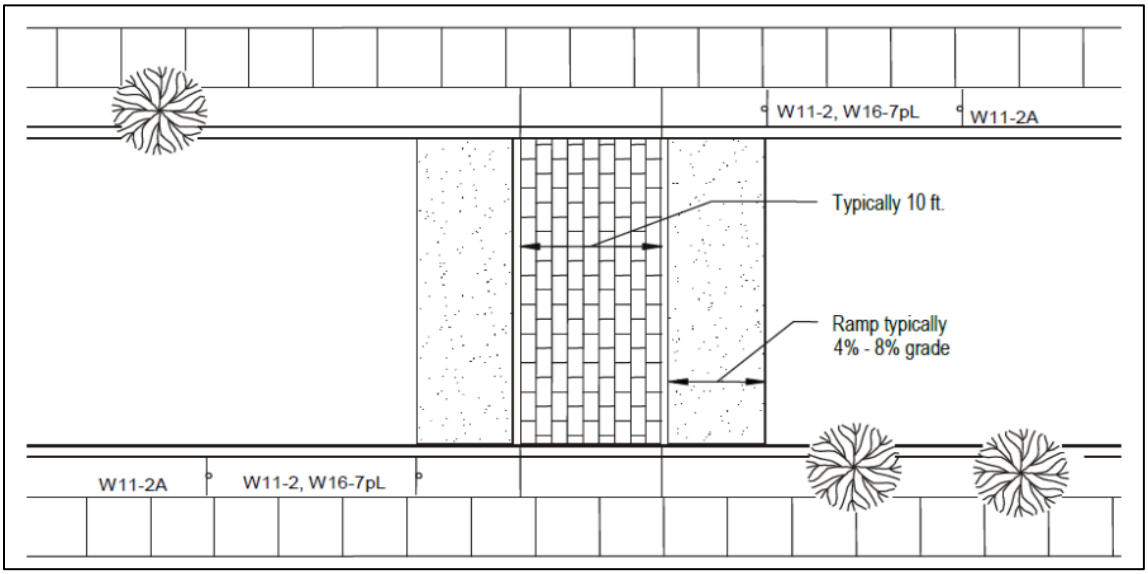
Raised crosswalks are one of the FHWA's Proven Safety Countermeasures for effectively reducing pedestrian crash rates at unsignalized intersections. Raised crosswalks have proven effective in improving motorists' yielding to pedestrians, with research demonstrating a 45% reduction in pedestrian crashes with raised crosswalk implementation.

Raised crosswalks have been shown to reduce speeds by 6 mph on average and to reduce 85$^{th}$ percentile speeds within the range of 20 to 30 mph for vehicles traversing the crosswalk. A series of raised devices is needed to maintain lower speeds throughout a roadway corridor and raised crosswalks have not been shown to decrease speeds as effectively as traditional speed humps.

## Exhibit 18.5.36 Design Features and Typical Design Criteria of Raised Crosswalks

| TRAFFIC-CALMING MEASURE DESIGN FEATURES | TYPICAL DESIGN CRITERIA |
|---|---|
| **DIMENSIONS** | • Should be 3 to 6 in above street level.<br>• Approach ramps should be 5 to 7 ft (4% to 8% slope.)<br>• Top of crosswalk should have a minimum width of 10 ft.<br>• Total length of 20 to 24 ft. |
| **SPACING** | • Spacing of 250 to 600 ft is recommended.<br>• Should be located so that vehicles cannot approach at high speeds. May be located near other raised traffic-calming devices, near stop-controlled intersections, or near small-radius curves.<br>• Typically spaced 5 ft from driveways. |
| **PAVEMENT MARKING** | • Should be marked with paint and/or pavement markings that denote an elevated surface.<br>• Change in material or texture can be used to alert drivers and pedestrians of a crossing.<br>• Pavement markings should conform to typical pavement markings for speed tables or speed humps with crosswalks as defined in the *Pavement Marking Standard (TC-8600)*.<br>• Detectable warnings and/or color contrasting materials should be used to differentiate the roadway, raised crosswalk, sidewalk, and crosswalks. |
| **LOCATION** | • Located at intersections or mid-block.<br>• Must be located at an existing crosswalk or a location where a crosswalk is warranted.<br>• Can be used in isolation at channelized turn lanes. |
| **SIGNAGE** | • W11-2 (Pedestrian Crossing sign) and W16-7pL (Arrow Indication plaque) should be in proximity to raised crosswalk.<br>• Refer to PennDOT Publication 236 for details regarding W11-2A (Raised Pedestrian Crossing) sign. |
| **LIGHTING** | • Location near existing lighting should be prioritized to improve visibility. |

**Exhibit 18.5.37 Raised Crosswalks Dimension Details**




### Design Considerations and Context

- **Tactile warning surfaces.** Where raised crosswalks are the same height as the curb, detectable warning surfaces should be used to alert visually impaired people. The designer should also provide enhanced crossings and access to push buttons. The same principles apply for a typical crosswalk location.
- **Mid-block locations.** If curb extensions include vertical features, they should not obstruct a driver's view of the pedestrian. The designer can refer to PennDOT's Publication 46*, Traffic Engineering Manual,* Section 11.9, *Unsignalized Midblock Crosswalks,* for more information regarding improving the visibility of pedestrians.
- **Maintenance.** Rebar or granite may be incorporated into the design to reinforce raised devices for heavy vehicles and snowplows.

## 18.5.10 – Raised Intersection

### Description and Purpose

A raised intersection is a vertical treatment that raises the entire intersection above the surrounding roadway level. The intersection is typically raised to sidewalk height (3 to 6 in above street grade) and uses brick or other textured materials.

Also referred to as raised junctions, intersection humps, or plateaus, raised intersections combine the benefits of speed humps and raised crosswalks, resulting in improved pedestrian visibility and safety, reduced vehicle speeds, and increased driver awareness.

**Exhibit 18.5.38 Example Raised Intersection**

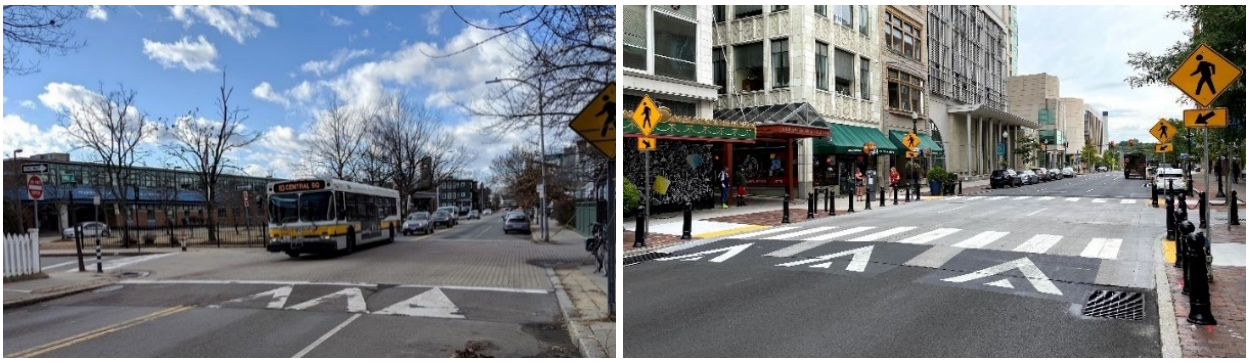


**Exhibit 18.5.39 Raised Intersection Typical Application**

| RAISED INTERSECTION TYPICAL APPLICATION | |
|---|---|
| **TRAFFIC VOLUMES** | • Appropriate if the ADT on each intersection approach is low volume. |
| **SPEED** | • Should be located where the desired vehicle operating speed is 20 to 25 mph.<br>• Speeds are of less concern, as raised intersections are constructed at intersections which may be signalized or have all-way or two-way stop-controlled approaches. Intersection operations and safety are the primary priorities.<br>• Maximum speed limit should be 30 to 35 mph. |
| **STREET FUNCTIONAL CLASSIFICATION** | • Appropriate on local roadways, except in rural contexts. May be appropriate in rural towns.<br>• May be appropriate on collector and arterial streets depending on context, including pedestrian activity, mixed-land uses, building proximity to streets, and vehicle speeds and volumes.<br>• Additional analysis and context evaluation may be required under these context-sensitive scenarios. |
| **NUMBER OF TRAVEL LANES** | • Appropriate on intersections with one-way or two-way roadway approaches.<br>• No limit on number of travel lanes. |
| **GRADE** | • Raised intersections are typically limited to installation on roadways with longitudinal grades of 8% or less. On a project-by-project basis following engineering evaluation, vertical traffic-calming measures may be installed on street sections with steeper grades up to 10%. |
| **CURVES** | • Adequate stopping sight distance and/or warning signs should be used if constructed on a vertical curve. |
| **CONTEXT: LAND USE AND AREA** | • Acceptable in all land use and area contexts except rural. May be appropriate in rural towns.<br>• Raised intersections are commonly found in areas with high pedestrian activity. |

**Exhibit 18.5.40 Advantages and Disadvantages of Raised Intersections**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Reduces vehicle travel speeds. More effective when implemented along with other traffic-calming measures.<br>• Improves pedestrian safety by creating better visibility and clearly demarcating crossing areas.<br>• Enhances neighborhood appearance.<br>• Reduces illegal parking by preventing motorists from parking too close to an intersection or crosswalk.<br>• Incorporates other traffic-calming measures such as textured pavement and curb extensions.<br>• Includes bicycle facilities.<br>• Reduces diversions.<br>• Maintains access to surrounding businesses and driveways | • May cost more to construct and maintain compared to other traffic-calming measures.<br>• Results in an average delay of 4 to 6 seconds for emergency vehicles.<br>• Presence of existing drainage features could increase the cost of implementation, due to drainage impacts.<br>• Impacts snow removal.<br>• Creates traffic noise from vehicle braking and accelerating. |

### Effectiveness

Raised intersections target speeds at intersections. The reduction in mid-block speeds is typically less than 10%. Research at five raised intersections showed a reduction of 1 to 5 mph in 85$^{th}$ percentile speeds. An improvement in safety, rather than speed reduction, should be the primary focus when implementing raised intersections.

**Exhibit 18.5.41 Design Features and Typical Design Criteria of Raised Intersections**

| TRAFFIC-CALMING MEASURE DESIGN FEATURES | TYPICAL DESIGN CRITERIA |
|---|---|
| **DIMENSIONS** | • 3 to 6 in above street level.<br>• Approach ramps should be designed at a 4 to 8% grade. |
| **SPACING** | • A series of raised intersections can establish a Slow Zone and may be more effective in reducing area-wide speeds. |
| **PAVEMENT MARKING** | • Tactile pavement should be used where the raised intersection is the same height as the surrounding curb.<br>• Detectable warnings and/or color contrasting materials should be used to differentiate the roadway, raised intersection, sidewalk, bicycle facilities, and crosswalks.<br>• Bollards may be used to define the edge of the road.<br>• Pavement markings should conform to typical pavement markings for speed tables or speed humps with crosswalks as defined in the *Pavement Marking Standard (TC-8600)*. |
| **LOCATION** | • Located frequently at signalized or all-way stop-controlled intersections but may be appropriate at two-way stop-controlled intersections.<br>• Appropriate at intersections with crosswalks on all legs.<br>• Appropriate only on roadways with curbs and sidewalks. |
| **SIGNAGE** | • Advance warning signs should be installed to alert drivers approaching a raised intersection.<br>• Refer to PennDOT Publication 236 for details regarding W11-2A (Raised Pedestrian Crossing) sign. |

### Design Considerations and Context

- **High pedestrian activity.** Raised intersections should be considered in commercial districts, business cores, and other areas with high pedestrian activity.
- **Traffic-calming zones.** Raised intersections may be used as area-wide traffic calming. When implemented in conjunction with other nearby raised crosswalks or other traffic-calming measures, speed reduction may be more effective.
- **Safety.** The primary purpose of raised intersections is to improve intersection safety for all users. Raised crosswalks provide a safe crossing for vehicles, pedestrians, and bicyclists.
- **Maintenance.** Rebar or granite may be incorporated into the raised crosswalks surrounding the raised intersection to reinforce devices for heavy vehicles and snowplows.

## 18.5.11 – Physical Obstruction

Physical obstruction refers to measures that prevent vehicle movements, thereby discouraging or eliminating cut-through traffic. The overall traffic volume reduction depends upon the nature of the traffic-calming measure and the number of movements obstructed. Physical obstruction may be appropriate on local, neighborhood roadways and may be used to prioritize pedestrians or bicyclists. These measures can have undesired network effects, so care should be taken to address diversion concerns (see Section 18.2.5, *Regional Roadway Network Impacts*.)

The toolbox includes the following physical obstruction traffic-calming measures:

- 18.5.12 – Diagonal diverter
- 18.5.13 – Right-in or right-out island
- 18.5.14 – Raised median through intersection
- 18.5.15 – Half closure with bicycle pass through

## 18.5.12 – Diagonal Diverter

### Description and Purpose

Diagonal diverters are physical barriers that are placed diagonally across a four-way intersection to create two unconnected intersections. Diagonal diverters, also referred to as diagonal road closures and full diverters, are typically used to prevent unwanted through-traffic.

Cutouts or gaps in the diagonal diverters can be used to accommodate bicycle through-movements or permit emergency vehicle movements.

**Exhibit 18.5.42 Example Diagonal Diverter**


(Source: Pedbikesafe.org)

**Exhibit 18.5.43 Example Diagonal Diverter**

(Source: NACTO)

**Exhibit 18.5.44 Diagonal Diverter Typical Application**

| DIAGONAL DIVERTER TYPICAL APPLICATION | |
|---|---|
| **TRAFFIC VOLUMES** | Appropriate where volumes are typically low. Cut-through traffic should be a significant percentage (i.e., greater than 25%) of the total daily volume. Additional context considerations should be documented. |
| **SPEED** | Maximum posted speed limit of 25 mph. Requires vehicles to navigate the sharp intersection curve without stop control on some approaches. |
| **STREET FUNCTIONAL CLASSIFICATION** | Appropriate on local and collector streets in non-rural locations. Diagonal diverters should not be used on arterial streets. Can be implemented on streets with or without bicycle infrastructure. A grid of parallel streets is typically beneficial to provide several alternative routes with minimal out-of-direction travel. |
| **STREET WIDTH** | Not dependent on the width of the street. Typically used on roads with curbs. |
| **NUMBER OF TRAVEL LANES** | Appropriate on one-way and two-way streets. |
| **GRADE** | Locations where grades exceed 8% are typically not recommended. |
| **CURVES** | Applicable on vertical curves, given adequate stopping sight distance, appropriate lighting, and warning signs. |
| **CONTEXT: LAND USE AND AREA** | Diagonal diverters are acceptable on urban core, urban, and suburban roadways. They are not relevant on rural roadways and additional context may be required for implementation in rural towns. Diagonal diverters are typically used in residential settings where undesired through traffic is present. |

**Exhibit 18.5.45 Advantages and Disadvantages of Diagonal Diverters**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Manages traffic volumes by reducing cut through traffic.<br>• May reduce conflict points for vehicles.<br>• Improves bicycle and pedestrian safety and should be constructed to allow bicycle and pedestrian through movements.<br>• Enhances neighborhood appearance through the inclusion of landscaping, green stormwater infrastructure, or added pedestrian infrastructure.<br>• Minimizes drainage impacts.<br>• Reduces traffic noise due to lower speeds and volumes. | • Provides limited speed reduction.<br>• May create diversion to adjacent streets.<br>• May delay emergency response times.<br>• Impacts local access, typically requires local support.<br>• Drainage may need to be modified if the diagonal diverter is integrated with existing sidewalks and curbs.<br>• May impact snow removal efforts.<br>• May restrict large vehicle mobility. |

### Effectiveness

The effectiveness of a diagonal diverter depends on the availability and relative appeal of alternate routes. The installation of diagonal diverters increases travel time for motor vehicles and reduces traffic volumes by 20 to 70% (with an average reduction of 35%). Diagonal diverters reduce 85$^{th}$ percentile speeds by an average of 1 mph.

**Exhibit 18.5.46 Design Features and Typical Design Criteria of Diagonal Diverters**

| DESIGN FEATURES | TYPICAL DESIGN CRITERIA |
|---|---|
| **DIMENSIONS** | • The design should maintain full-lane widths on local roadways, with a minimum turning radius of 7.5 ft.<br>• The recommended width of the narrowest point of the diverter is 4 ft.<br>• The recommended radius of the corner of a curb cutout for pedestrians and/or bicyclists is 3 ft. |
| **SPACING** | • Spacing of landscaping, patterning, or flexible post delineators on diverters may vary. Recommended spacing is 5 ft to 6.5 ft wide to prevent vehicles from traversing the diverter (5-ft minimum width). Review Bulletin 15 (Publication 35) – *Qualified Products List for Construction* for prequalified materials.<br>• A width of 14 ft may be allocated to allow emergency vehicles to pass through the diverter, although an evaluation should determine whether the route should prioritize emergency vehicles or whether alternative routes would suffice. |
| **PAVEMENT MARKING** | • Pavement markings can be used to improve safety and alert motorists of a curvature in the street. |
| **LOCATION** | • Must be installed at intersections.<br>• Applicable with both one-way and two-way roads. |
| **SIGNAGE** | • W1-2R (Right Curve) and W1-2L (Left Curve) signs should be used in advance of the diverter.<br>• No parking signs should be used in advance of diverter, through the curve, and at the diverter.<br>• Any clear width for emergency vehicles should be marked as emergency use only. |

### Design Considerations and Context

- **Located at four-way intersections.** Diagonal diverters must be installed at four-way intersections, typically where curbs are present.
- **Multifunctional use.** Diagonal diverters can incorporate landscaping features and additional sidewalk pavement and be used to collect and filter stormwater.
- **Bicycle and pedestrian facilities.** Diverter design should provide a safe bypass for bicycles, pedestrians, and wheelchairs. Pedestrian crossings can be maintained with sidewalk extensions across the diverter. If a sidewalk is included in the diverter, the design must ensure that the width of the travel lanes is maintained.
- **Warning measures.** Single Curve and No Parking signs should be incorporated to alert users.

- **Emergency routes.** Diagonal diverters may be modified with gates, operable transponder-responsive removable bollards, flexible post delineators, or mountable curbs to allow emergency vehicle access.
- **Drainage.** Modifications should be considered if space is left between the curb, gutter, and diverter. Modifications may be necessary if the diagonal diverter connects to existing sidewalks.
- **Maintenance.** Landscaping should only be incorporated into traffic-calming devices where clear maintenance responsibilities have been established. PennDOT requires a maintenance agreement with local jurisdictions.
- **Materials.** Materials may consist of a landscaped island, walls, gates, side-by-side flexible post delineators, or any obstructions that disallow vehicle through-movements. Temporary materials may be installed as an interim treatment option.
- **Temporary measures.** Temporary materials may be used to introduce diverters. A 6-to-12-month trial period is recommended before a measure is made permanent.
- **Traffic diversion.** A series of diagonal diverters may be used to mitigate unwanted traffic diversion to other streets.
- **Legal implications.** Restriction of vehicles on public streets may lead to legal issues, including access to businesses or emergency routes.
- **Transit routes.** Diagonal diverters are not appropriate along transit routes.

## 18.5.13 – Right-In or Right-Out Island

### Description and Purpose

Right-in or right-out islands are used to prevent left turns and through-movements to and from side streets at intersections with major streets. Right-in/right-out islands, also referred to as raised islands, channelization islands, pork chops, and forced turn islands, may be used as a less intrusive and less expensive version of a median through an intersection.

Right-in or right-out islands can reduce cut-through traffic on local streets. A right-in or right-out island is typically triangular and placed at the mouth of an intersection.

**Exhibit 18.5.47 Example Right-In or Right-Out Island**


### Exhibit 18.5.48 Right-In or Right-Out Island Typical Application

| RIGHT-IN OR RIGHT-OUT ISLAND TYPICAL APPLICATION | |
|---|---|
| **TRAFFIC VOLUMES** | There is no maximum volume requirement for side streets configured with right-in or right-out islands. Some jurisdictions require a percentage of cut-through traffic (such as 25% or more of total daily street volume) to warrant treatment. |
| **SPEED** | Maximum posted speed limit of 25 mph on side street. |
| **STREET FUNCTIONAL CLASSIFICATION** | Appropriate on local, collector, and arterial roads. Appropriate on local streets at intersections with arterials and major collectors. |
| **STREET WIDTH** | Not dependent on street width. Typically found on roadways with urban cross sections. |
| **NUMBER OF TRAVEL LANES** | Appropriate on single-lane, one-way streets, and two-lane, two-way streets. |
| **GRADE** | Maximum grade should comply with local standards and criteria. |
| **CURVES** | Applicable on vertical curves, given adequate stopping sight distance, appropriate lighting, and warning signs. |
| **CONTEXT: LAND USE AND AREA** | Acceptable in all land use contexts. |

### Exhibit 18.5.49 Advantages and Disadvantages of Right-In or Right-Out Islands

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Manages traffic volumes by reducing cut through traffic and reducing unwanted turning movements.<br>• Reduces conflict points and crash severity by eliminating left turns or through movements.<br>• Improves pedestrian safety by reducing crossing distances and providing refuge areas.<br>• Improves bicyclist safety by reducing vehicle volume.<br>• Enhances neighborhood appearance.<br>• Drainage impacts along curb lines are negligible. | • Provides limited impact on speeds.<br>• May restrict residential access.<br>• Restricts emergency vehicles from passing straight through the intersection or turning left from and into a minor street.<br>• May divert traffic to other parallel roads.<br>• Impacts snow removal.<br>• Limits turning movements and reduces overall street connectivity. |

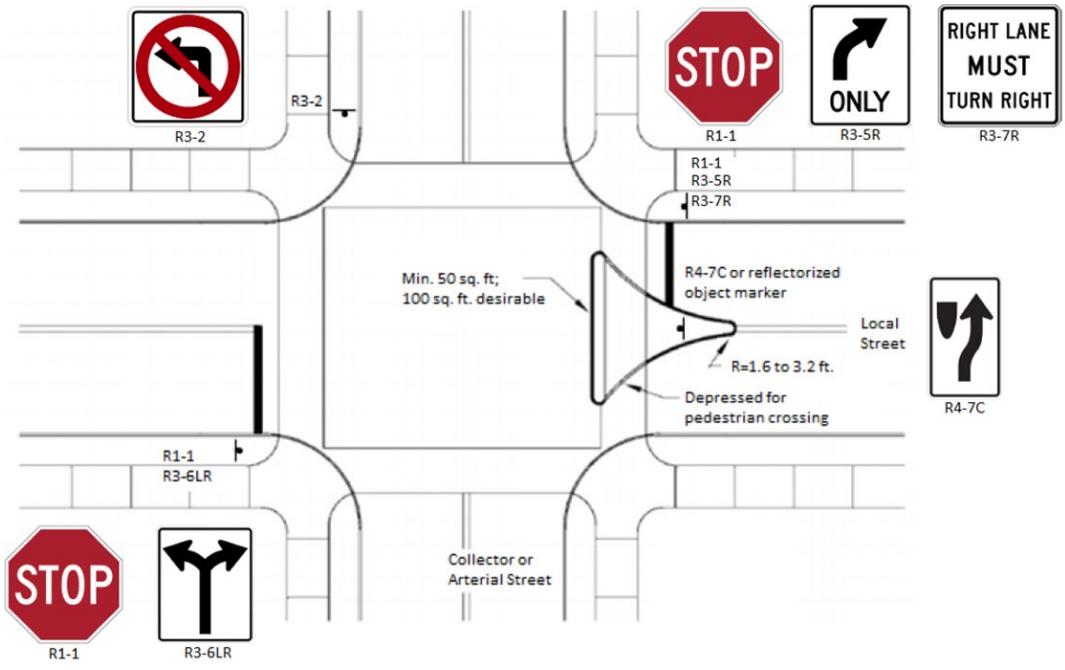
### Effectiveness

Studies have shown treatments may reduce volumes by 20 to 60%. Volume reduction improves when used in combination with other area-wide measures.

**Exhibit 18.5.50 Design Features and Typical Design Criteria of Right-In or Right-Out Islands**

| TRAFFIC-CALMING MEASURE DESIGN FEATURES | TYPICAL DESIGN CRITERIA |
|---|---|
| **DIMENSIONS** | • The recommended island dimension is 50 to 100 square ft.<br>• The radius of the tip of the island should be 1.6 to 3.2 ft.<br>• Minimum width of the island should be 6 ft to accommodate pedestrians. |
| **PAVEMENT MARKINGS** | • No additional pavement markings are required unless crosswalks are routed through the island. |
| **SIGNAGE** | • Stop signs or Yield signs should be used when appropriate. Other signs include Right-Turn Only (R3-5R), Keep Right (R4-7c), and Optional Movement Left or Right (R3-6LR). |
| **EMERGENCY ACCOMMODATIONS** | • Designs can include mountable curbs to accommodate large vehicles. |

**Exhibit 18.5.51 Right-In or Right-Out Island Dimension Details**



### Design Considerations and Context

- **Located at intersections.** Right-in or right-out islands are typically used at intersections with a minor and major approach. Traffic turning restrictions are like those of a median.
- **Located at access points.** Right-in or right-out islands may be appropriate for access points to and from businesses.
- **Multifunctional use.** A right-in or right-out island of sufficient width (6-ft minimum) can be designed to provide a pedestrian refuge for crossing the appropriate leg of the affected intersection.
- **Area-wide traffic calming.** Right-in or right-out islands are most effective when used in conjunction with nearby traffic calming and volume reduction treatments. This treatment is often used in sets to reduce cut through traffic in neighborhoods.
- **Bicycle facilities.** Right-in or right-out islands should be constructed to maintain or improve bicycle safety and mobility. Facilities, such as bicycle lanes, should be provided to separate bicyclists from vehicles.
- **Safety.** Right-in or right-out islands may be warranted by crash history. Right-in or right-out islands prevent left turning and through-movements, reducing conflict points.
- **Maintenance.** Landscaping should only be incorporated into traffic-calming devices where clear maintenance responsibilities have been established. PennDOT requires a maintenance agreement with local jurisdictions.

## 18.5.14 – Raised Median Through Intersection

### Description and Purpose

Raised medians though intersections, also referred to as intersection barriers, intersection diverters, island diverters, and median diverters, incorporate raised islands along the centerline of a street that prohibit left turns.

The width of raised medians varies widely, depending on the total road width. Raised medians discourage through-traffic in residential areas by restricting turning movements. They may also be used for speed and volume reduction purposes.

**Exhibit 18.5.52 Example Raised Median Through Intersection without and with Pedestrian Refuge Island**

(Source: James R. Barrera, FHWA)

(Source: Steven Vance, FHWA)

**Exhibit 18.5.53 Raised Median Through Intersection Typical Application**

| RAISED MEDIAN THROUGH INTERSECTION TYPICAL APPLICATION | |
|---|---|
| **SPEED** | Posted speed limit up to 45 mph, assuring adequate shy distance between the median and lane. |
| **STREET FUNCTIONAL CLASSIFICATION** | Appropriate on local, collector, and arterial roads in urban and suburban settings. |
| **STREET WIDTH** | Must maintain adequate lane width for design vehicle. |
| **NUMBER OF TRAVEL LANES** | Appropriate on two-lane, two-way streets. |
| **GRADE** | Locations where grades exceed 6% are typically not recommended. |
| **CURVES** | Applicable on vertical and horizontal curves, given adequate stopping sight distance, appropriate lighting, and warning signs. |
| **CONTEXT: LAND USE AND AREA** | Acceptable in all land use contexts. |

**Exhibit 18.5.54 Advantages and Disadvantages of Raised Medians Through Intersections**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Reduces conflicts and head on collisions.<br>• Manages traffic volumes by reducing through traffic and preventing unwanted turning movements.<br>• Improves pedestrian and bike safety: narrows lane width which results in slower vehicle speeds.<br>• Enhances neighborhood appearance.<br>• Drainage impacts along curb lines are negligible.<br>• Reduces traffic noise because of lower speeds and volumes. | • Provides limited impact on speeds.<br>• Restricts access for emergency response and heavy vehicles.<br>• May divert traffic volumes to parallel routes.<br>• Impacts snow removal.<br>• The addition of the median may require the removal of on-street parking to maintain appropriate lane width and turning radii.<br>• Due to the potential to limit access, local community support is necessary. |

### Effectiveness

Raised medians through intersections are designed to reduce cut-through motor vehicle volumes by restricting specific movements. The design of median barriers should accommodate bicycle and pedestrian crossings.

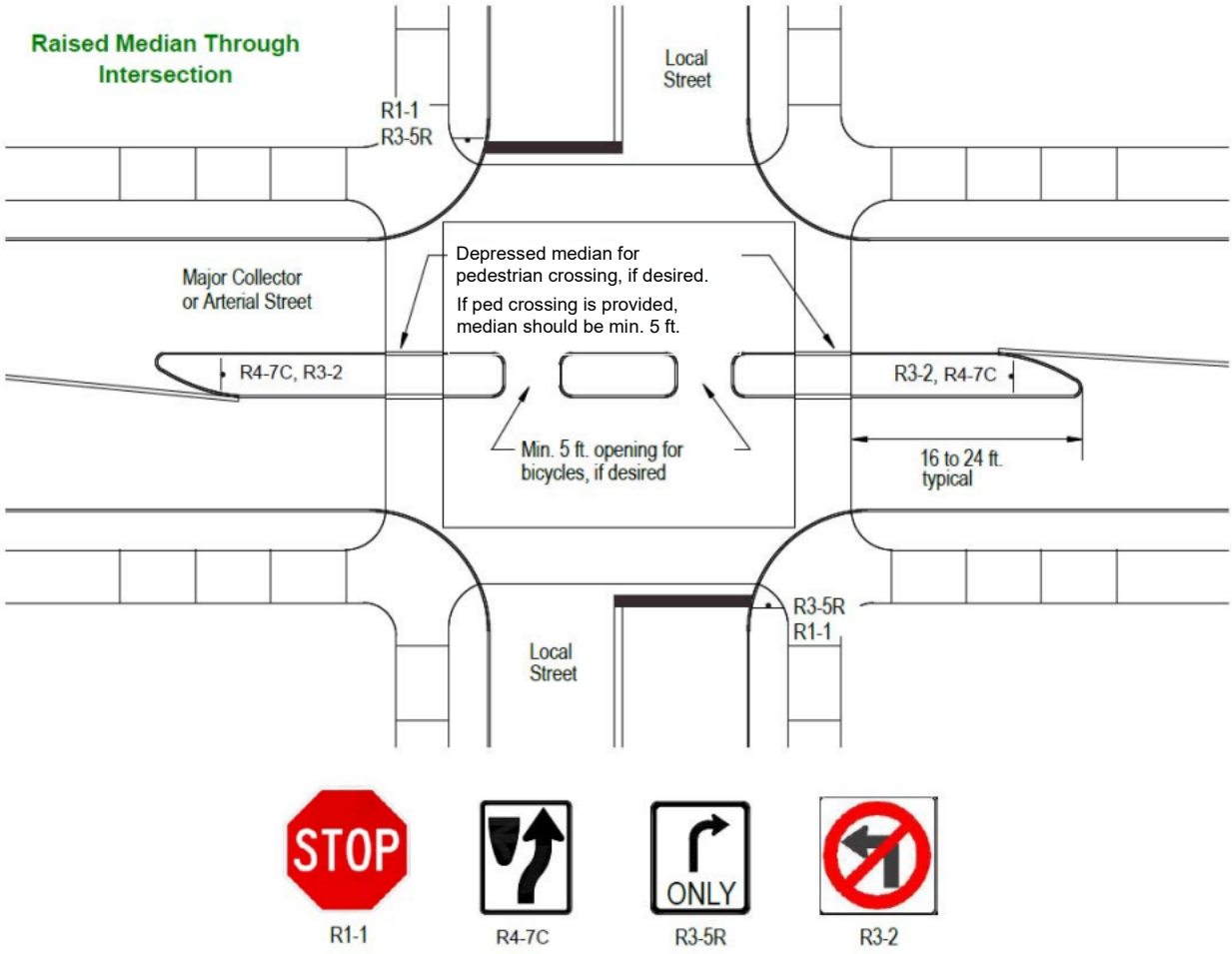
There are generally not significant impacts on speeds around or near the median application. However, speed reductions range from 2 to 3 mph on average depending on lane widths, and some research demonstrates reductions as great as 8 mph.

Median barriers can reduce volumes on local streets up to 70%.

**Exhibit 18.5.55 Design Features and Typical Design Criteria of Raised Medians Through Intersections**

| TRAFFIC-CALMING MEASURE DESIGN FEATURES | TYPICAL DESIGN CRITERIA |
|---|---|
| **DIMENSIONS** | • No requirement for median width.<br>• May be designed to include pedestrian refuge islands (Refer to Chapter 13) which would require 6-ft minimum width in the direction of pedestrian travel with an opening of 5-ft wide minimum (or as wide as the crosswalk.) |
| **SPACING** | • The median should divide the entirety of the intersection, with potential cutouts for pedestrians and bicyclists, and extend 15 to 25 ft beyond the intersection to prevent violations. |
| **PAVEMENT MARKING** | • Shared lane pavement markings may be necessary if bicyclists and vehicles are forced to share the lane. |
| **LOCATION** | • Raised medians must be installed through intersections. Raised medians may extend beyond the intersection extents. |
| **SIGNAGE** | • Recommended signage includes R6-1, R4-7, and R7-4. |

**Exhibit 18.5.56 Raised Medians Through Intersections Dimension Details**




## Design Considerations and Context

- **Multifunctional use.** Raised medians through intersections can incorporate landscaping features, on-street parking, additional sidewalk pavement, and can be used to collect and filter stormwater.
- **Design considerations for safer pedestrian and bicycle facilities.** The design of raised medians through intersections with pedestrian refuges can increase safety for pedestrians and bicyclists.
- **Maintenance.** Landscaping should only be incorporated where clear maintenance responsibilities have been established. PennDOT requires a maintenance agreement with local jurisdictions.
- **Materials.** Short-term materials, such as flexi-posts, planters, and other street furniture, may be used as interim treatment options.

- **Emergency routes.** Raised medians through intersections are not recommended on primary emergency response routes. Mountable barriers can be used to allow emergency vehicles and discourage non-emergency vehicles.
- **Local driveways.** The designer should avoid placing median barriers at or near local home or business driveways.

## 18.5.15 – Half Closure with Bicycle Pass Through

### Description and Purpose

Half closures are intended to reduce traffic volumes by limiting vehicular traffic movements and creating a one-way roadway with a contraflow bike lane at the point of construction.

Half closures (also referred to as semi-diverters or partial diverters) use a physical barrier to block vehicle travel in one direction on an otherwise two-way street. Barriers are typically located near intersections to obstruct selected traffic movements to or from the intersection.

A bicycle pass-through provides a separate right-of-way that maintains bicycle accessibility and improves bicycle safety.

**Exhibit 18.5.57 Example of Half Closure with Bicycle Pass Through**


Note: The orange one-way sign is not standard.
(Source: Adam Fukushima)


(Source: NACTO)

**Exhibit 18.5.58 Half Closure Typical Application**

| HALF CLOSURE TYPICAL APPLICATION | |
|---|---|
| **TRAFFIC VOLUMES** | Appropriate on low to moderate volume roadways. Additional context considerations should be documented. |
| **SPEED** | With appropriate advanced warning, speed limit is not constrained. |
| **STREET FUNCTIONAL CLASSIFICATION** | Appropriate at intersections with local roads and minor collectors intersecting with a collector or arterial to accommodate diverted traffic. |
| **NUMBER OF TRAVEL LANES** | Appropriate on two-way streets with an urban cross section (curb). |
| **GRADE** | Locations where grades exceed 6% should be avoided. |
| **CURVES** | Applicable on vertical curves, given adequate stopping sight distance, appropriate lighting, and warning signs. |
| **CONTEXT: LAND USE AND AREA** | Acceptable on urban core, urban, and suburban roads. Not acceptable on rural roadways; additional context may be required for implementation in rural towns. Typically used in residential settings where undesired through-traffic is present. |

**Exhibit 18.5.59 Advantages and Disadvantages of Half Closures**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Manages traffic volumes by reducing cut through traffic.<br>• Improves pedestrian and bicyclist safety through a reduction in conflict points and should be constructed to allow pedestrian and bicycle through movements.<br>• Enhances neighborhood appearance.<br>• Negligible drainage impacts along curb lines.<br>• Reduces traffic noise due to lower speeds and volumes. | • May result in the loss of some on-street parking but unlikely to impact parking at intersections due to street design standards.<br>• Challenges heavy vehicles; however, may provide greater access than full closures for emergency vehicles, if designed appropriately.<br>• Impacts snow removal.<br>• Impacts to local access, requires strong community support.<br>• Half closures preventing motor vehicle exits are more likely to be violated. Drivers are also more likely to violate the closures at night and on low-volume roadways. Increasing the length of the closure can reduce violations. |

### Effectiveness

Half closures have a small impact on speed reduction, but a significant impact on volume reduction. Half closures with bicycle pass-throughs have varying levels of effectiveness for speed and volume reduction.

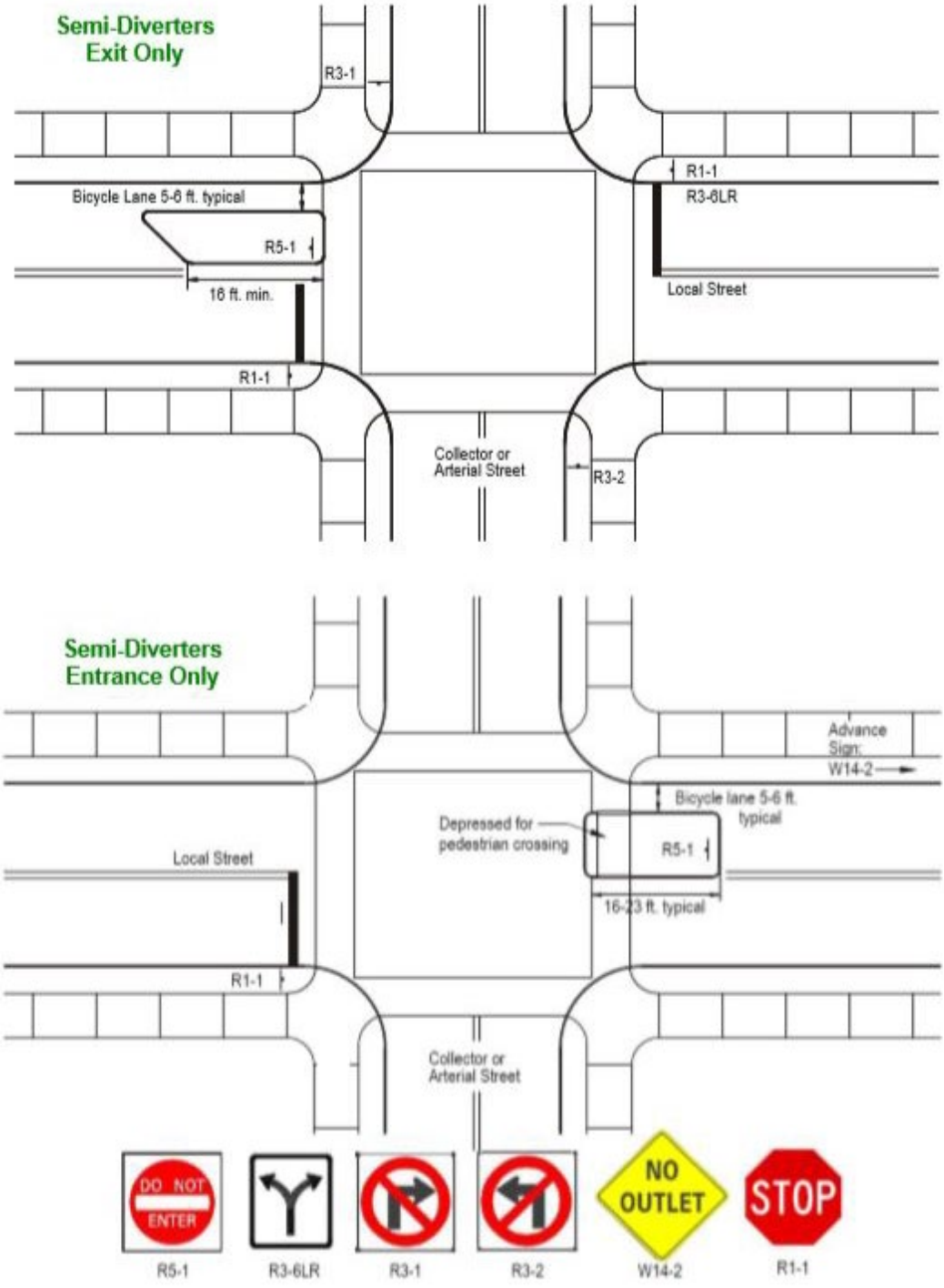
Effective half closures deter speeding cut-through vehicles from passing through a neighborhood or Slow Zone. Speeds may be reduced by 2 to 5 mph. Research shows that the 85$^{th}$ percentile speed reduction is 6 mph.

Half closures reduce volumes by at least 40%, with some reductions of 60%. They add protection for bicyclists and have limited impact on the mobility of emergency vehicles.

**Exhibit 18.5.60 Design Features and Typical Design Criteria of Half Closures**

| TRAFFIC-CALMING MEASURE DESIGN FEATURES | TYPICAL DESIGN CRITERIA |
|---|---|
| **DIMENSIONS** | • Recommended length is 16 to 30 ft. May be longer to prevent violations.<br>• Should maintain the full width of the opposing travel lane and provide a sufficient curb radius for turning vehicles.<br>• Bicycle pass-throughs should maintain the width of a bicycle lane and gutter (typically 5 to 6 ft). If rolled curbs are used, then the width may be reduced to 4 ft.<br>• Should have vertical curbs, especially on the outer edges of the closure, to discourage vehicles from mounting the half closure. However, closures can be mountable to allow emergency vehicles to use the route. |
| **SPACING** | • Spacing of landscaping, patterning, or flexible post delineators may vary to prevent drivers from traversing the closure. |
| **PAVEMENT MARKING** | • There are no specific pavement markings for this treatment. |
| **LOCATION** | • Installed at intersections and mid-block locations. They are typically located at intersections to reduce cut-through traffic. These closures are less restrictive than diagonal diverters or full closures. |
| **SIGNAGE** | • Adequate signing should be used before the half closure on main and minor roadways. Signage can also be used on the half closure.<br>• Suggested signs include R5-1, R3-6LR, R3-1, R3-2, W14-2, R3-7bP, and R1-1.<br>• Do Not Enter signs should be used for exit-only closures. |

## Exhibit 18.5.61 Half Closure with Bicycle Pass Through Dimension Details



**Design Considerations and Context**

- **Multiple closures.** To prevent the generation of unwanted traffic on other local roads, multiple closures should be used to eliminate cut-through traffic throughout the entire area.
- **Multifunctional use.** Treatments may incorporate landscaping features and additional sidewalk pavement and can be used to collect and filter stormwater.
- **Bicycle facilities.** Half closures provide a safe bypass and physical barrier to protect bicyclists at the intersection. Pedestrian crossing distance is reduced with the addition of a half closure.
- **Warning measures.** Signs should be used to inform drivers of the one-way roadway.
- **Drainage.** Modifications should be considered, depending on the location of the bicycle pass-through and any changes to the curb geometry.
- **Maintenance.** Landscaping should only be incorporated into traffic-calming devices where clear maintenance responsibilities have been established. PennDOT requires a maintenance agreement with local jurisdictions.
- **Materials.** Short-term materials, such as flexible post delineators, planters, and other street furniture, may be used as interim treatment options.
- **Trial period.** A 6-to-12-month temporary trial period is recommended before permanent installation.
- **Transit routes.** Half closures are not recommended along transit routes where transit operations are impacted but they may be suitable on side streets which intersect a transit route.

## 18.5.16 – Signing and Pavement Markings

Signs and pavement markings can be used as traffic-calming measures that regulate traffic movements in lieu of physical changes to the roadway. In certain applications, these measures may produce the same effect as the physical traffic-calming measures. However, police enforcement is often required to ensure motorist compliance. These measures may be made permanent with physical changes in future road reconstruction projects.

The MUTCD and Publication 236 should be used for all standard signing and all standard pavement markings.

The toolbox includes the following signing and pavement marking traffic-calming measures:

- 18.5.17 – Travel Lane Width
- Bicycle Facilities – Reference Chapter 14, *Bicycle Facilities*.

- 18.5.18 – Lane and Parking Configuration Changes
- 18.5.19 – Lane Reduction and Road Diet
- 18.5.20 – Yield to Pedestrian Channelizing Devices

## 18.5.17 – Travel Lane Width

### Description and Purpose

Travel lane width influences driver comfort, operations of the roadway, and the likelihood of crashes. Narrower travel lanes promote slower vehicular speeds, which can also reduce crash severity. Lane-width design decisions should consider traffic-calming goals while also providing adequate space for trucks and buses.

Refer to Chapters 3, 4 and 5 for required minimum lane widths. Information on the effect of lane width on capacity and level of service is provided in the *Highway Capacity Manual* (*HCM*). Travel lane width considerations are appropriate within other categories of traffic-calming measures, not just pavement markings.

**Exhibit 18.5.62 Advantages and Disadvantages of Narrowing Travel Lane Widths**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Narrows travel lanes.<br>• Improves pedestrian safety by reducing pedestrian crossing distance and exposure to motor vehicle traffic.<br>• Ability to provide more lanes in constrained right-of-way.<br>• Lower construction cost.<br>• Research has shown narrowing travel lane widths may reduce vehicle speeds on roadways.<br>• Redistributes roadway space for other modes of transportation (e.g., bicycle facilities), network users, or other features (e.g., medians, sidewalks.). | • Challenges for larger vehicles if adequate space is not provided.<br>• May slightly increase travel time. |

### Effectiveness

Physically narrowing the roadway tends to have a greater impact than using pavement markings to narrow lane widths. Wider longitudinal pavement markings may not directly affect speeds, but

they may increase driver awareness, although for this application there is no conclusive data showing a reduction in crashes associated with these treatments.

The designer can refer to NCHRP's *Report 613, Guidelines for Selection of Speed Reduction Treatments at High-Speed Intersections, Section 4.11.4: Speed Effects,* and *Section 4.11.5: Safety Effects,* for more information regarding reduced lane widths.

**Design**

Applicable design tools include:

- **Roadway narrowing with edge lines.** Applying pavement marking edge lines and centerlines to create 9-to-10-ft lanes (check that this meets minimum lane width requirements in Chapters 3, 4 and 5). This reduces speeds by approximately 1 to 2 mph and up to 5 mph in some locations.

  Roadway narrowing with edge lines is generally applicable on local roadways and low-volume minor collectors. Documented uses of reduced lane widths include work zones, low-speed urban and residential locations, and rural two-lane highways.

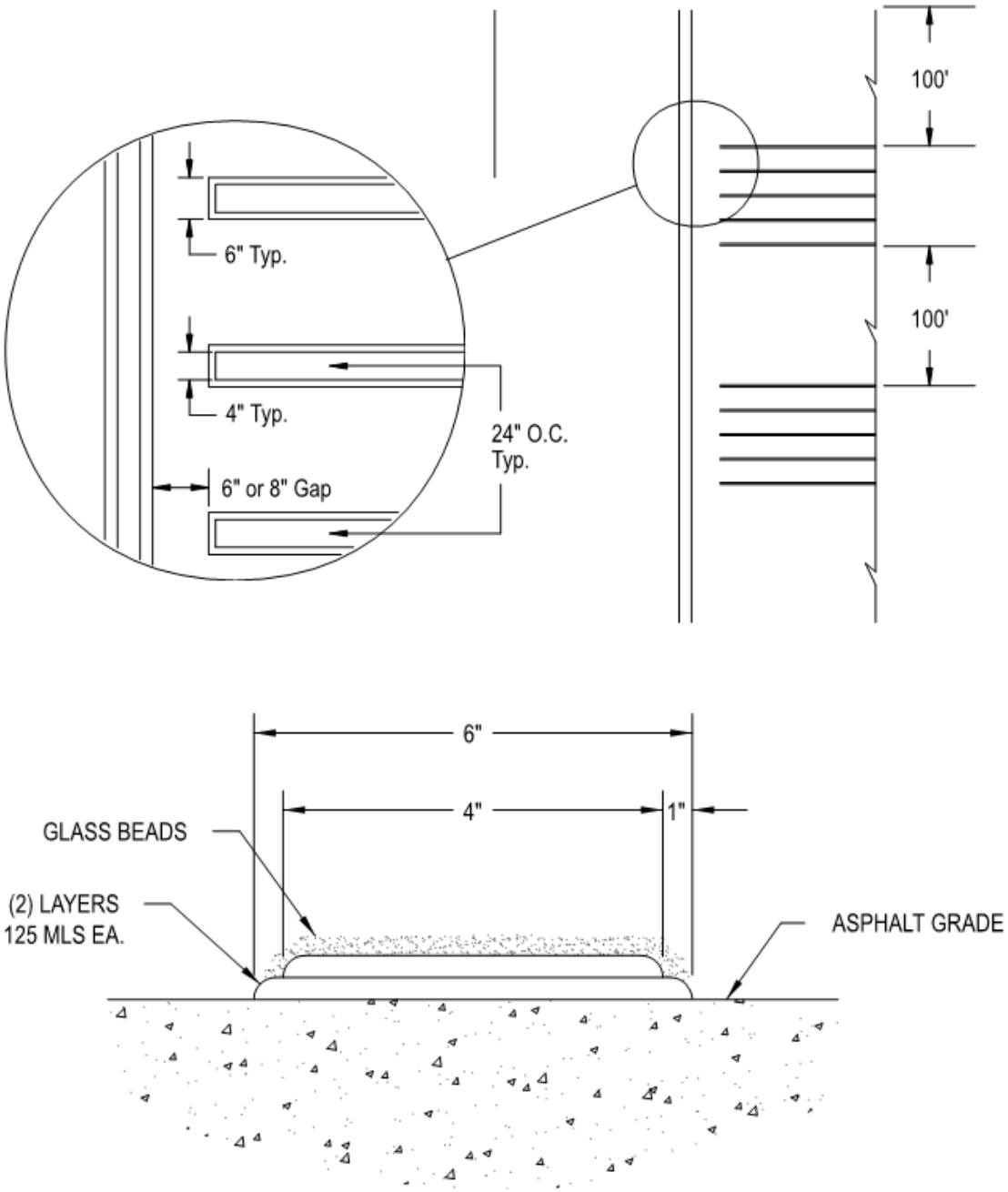
  The designer can refer to NCHRP *Report 613, Guidelines for Selection of Speed Reduction Treatments at High-Speed Intersections*, Section 4.11: Reduced Lane Width, for more information.

- **Wider longitudinal pavement markings.** The application of wider-than-normal line striping (i.e., 6 inches instead of 4 in) on roadways improves the visibility of travel lanes, demarks the intersection influence area, and calms traffic. Documented uses of wider longitudinal pavement markings include locations with a crash history involving curves, hills, roadway cross sections, and work zones.

  The designer can refer to NCHRP Report 613, *Guidelines for Selection of Speed Reduction Treatments at High-Speed Intersections*, Section 4.6: Wider Longitudinal Pavement Markings, for more information.

- **Transverse markings.** Double-thick thermoplastic transverse pavement markings can slow traffic in areas such as school zones, hospitals, approaches to severe curves, and stop signs. As illustrated in **Exhibit 18.5.63**, these markings typically consist of five transverse, 6-in-wide stripes, installed 2 ft on center, repeated every 100 ft. Depending on conditions, three to five sets of clusters are installed per approach. It is estimated that each cluster reduces approach speeds by 1 to 3 mph. As vehicles travel over these markings, the noise and vibration alert the driver. However, it may be inappropriate to use this application in locations with nearby residents, because of the noise generated. Avoid installing in shoulders.

**Exhibit 18.5.63 Transverse Pavement Markings**




## Design Considerations and Context

- **Target operating speed.** Target operating speeds in urban districts are generally 35 miles per hour or 25 miles per hour in a residential district if the roadway is not a numbered traffic route and is classified as a local highway. Therefore, lane widths generally range from 10 to 12 ft on arterials and 10 to 11 ft on collectors. When target

operating speeds are below 30 mph, lane widths are typically 10 to 11 ft on arterials and 10 ft on collectors unless other design elements warrant a wider travel lane. Refer to Chapters 3, 4 and 5 for minimum required lane widths.

- **Multi-lane roadways with transit and freight.** On multi-lane roadways, a wider travel lane width may be provided as an outside lane (adjacent to the curb) for transit and freight, with inside lanes designed to a narrower width. A 20-ft clear distance is typically provided for fire truck access.
- **Urban areas.** In urban areas, travel lane widths of 10 ft typically provide adequate safety, slowing traffic without otherwise impacting traffic operations. For truck or transit routes, 11-ft designated lanes are typically provided.
- **Right-of-way.** The design should incorporate narrow lane widths for motor vehicles, reallocate roadway width, and prioritize space for bicyclists and pedestrians to maximize the use of right-of-way. Where capacity constraints exist, alternatives to widening street width or lanes, such as two-way to one-way conversions, should be considered.
- **Safety.** The designer should consider the safety of all users when designing with minimum-width travel lanes. Using minimum widths for adjacent street elements, such as travel, parking, and bicycle lanes, should be avoided, as minimum widths may reduce vehicle-bicycle or vehicle-pedestrian separation. The designer should consider widening the bicycle lane first to provide adequate separation. The designer can refer to Chapter 14, *Bicycle Facilities*, for information about bicycle facility selection and considerations for physically separated bike lanes.

## 18.5.18 – Lane and Parking Configuration Changes

### Description and Purpose

On-street parking causes the visual perception of narrowing the roadway travel lanes. Parking may be allocated on alternate sides of a roadway to create a chicane effect but must be occupied with parked vehicles to effectively promote traffic calming.

On-street parking may be parallel, front-in, or front-out angled. Additionally, on-street parking may be combined with other physical treatments, such as curb extensions, mid-block chokers, chicanes, or road diets to have a greater traffic-calming impact.

The designer can refer to Section 19.2, *On-Street Parking Guidelines*, for more information about on-street parking design.

## Exhibit 18.5.64 Examples of Lane and Parking Configuration

(Source: Google Maps)


(Source: Google Earth)

## Exhibit 18.5.65 Lane and Parking Configuration Changes Typical Application

| LANE AND PARKING CONFIGURATION CHANGES TYPICAL APPLICATION | |
|---|---|
| **TRAFFIC VOLUMES** | Appropriate to consider at all levels of traffic volume. |
| **SPEED** | Applicable on any common urban speed limit, provided an adequate shy distance is provided between the travel lane and parking lane. |
| **STREET FUNCTIONAL CLASSIFICATION** | Appropriate on all roads in rural towns, suburban, urban, and urban core contexts. Not applicable on rural roadways. |
| **STREET WIDTH** | On-street parking is preferable on streets with an urban cross section (curb). Can be applied both with and without a bicycle facility. The incorporation of bicycle facilities may require additional roadway width to protect bicyclists from dooring. (Refer to Section 14.3.4a for recommended bike lane buffer widths.) |
| **NUMBER OF TRAVEL LANES** | Appropriate on single-lane, one-way streets, and two-lane, two-way streets. |
| **GRADE** | Maximum grade should comply with local standards and criteria. |
| **CURVES** | Applicable on vertical curves, given adequate stopping sight distance, appropriate lighting, and warning signs. |
| **CONTEXT: LAND USE AND AREA** | Works well in downtown areas and near pedestrian generators or high levels of pedestrian activity. Also applicable in mixed-land uses, including residential areas and community places (e.g., transit stop, school, library, park). Not applicable in rural contexts. May be applicable in rural towns. |

**Exhibit 18.5.66 Advantages and Disadvantages of Lane and Parking Configuration Changes**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • May reduce vehicle travel speeds.<br>• Improves pedestrian safety as parked vehicles provide a buffer between traffic and pedestrians on sidewalks.<br>• Enhances neighborhood appearance.<br>• Negligible drainage impacts.<br>• Reduces traffic noise due to lower speeds and volumes.<br>• Design can retain sufficient width to allow for transit and emergency vehicles.<br>• Can be combined with other traffic-calming measures such as road diets, chicanes, curb extensions, and chokers, to further reduce speed.<br>• Minimal impacts on motorist comfort. | • May create visibility issues by reducing driver visibility of pedestrians, or limiting sight distance at driveways, alleys, or intersections. (Unless combined with other measures such as curb extensions or daylighting.)<br>• In high demand areas, may result in additional circulating trips as vehicles locate parking spots. |

### Effectiveness

The effectiveness of on-street parking on speed reduction depends on its demand. If half or more of the block face is not occupied by parked vehicles, the effect on vehicle speeds lessens and may be negligible.

Research has shown that on-street parking can slow speeds by 1 to 5 mph, with a 2 to 3 mph reduction most common. The most pronounced effect on speed occurs on a narrow two-way street with parking on both sides. Studies have shown that reducing the lane width with markings reduced 85$^{th}$ percentile speeds by about 1 mph.

On-street parking has little effect on traffic volumes. It also has limited effect on the number and severity of pedestrian-vehicle conflicts, except for the movement of persons to and from a parked vehicle.

**Exhibit 18.5.67 Design Features and Typical Design Criteria of Lane and Parking Configuration Changes**

| TRAFFIC-CALMING MEASURE DESIGN FEATURES | TYPICAL DESIGN CRITERIA |
|---|---|
| **DIMENSIONS** | • Typically, the recommended minimum width for a parking lane is 7 ft. See Exhibit 19.2.1 for more information about the recommended minimum parking lane width.<br>• Refer to Section 14.3.3 for bike lane widths due to parking configuration. |
| **PAVEMENT MARKING** | • Exhibit 19.2.2 provides recommendations for parallel parking lane markings.<br>• Refer to section 19.2.3, *Angled Parking*. Section 19.2.3.a describes the recommended design parameters for head-in angled parking and Section 19.2.3.b describes back-in angled parking.<br>• May be designated using pavement markings, which may also be used to designate space where parking is not permitted.<br>• When using pavement markings, parking facilities must be designated with a 4-in solid white-line edge. Parking lane surfaces will generally match adjacent streets. |
| **LOCATION** | • May be permitted between intersections.<br>• Vehicle Code Title 75 §3353 - This section identifies parking restrictions, such as within 20 ft of a crosswalk per 3353(2)(iii), or within 30 ft of the approach to a stop sign or traffic signal per 3353(2)(iv).<br>• Parking should not be permitted within 5 ft of driveways. |
| **SIGNAGE** | • Signs should indicate where parking is and is not permitted.<br>• Signs should inform drivers of permitted and prohibited parking times. |

### Design Considerations and Context

- **Parallel and Angle Parking.** Angle parking has the potential to cause more crashes than parallel parking and is generally not recommended to achieve speed reduction. See Publication 46*, Traffic Engineering Manual,* Section 11.6, *Angle Parking*, or Chapter 19, for more information.

- **Demand.** Impact is directly affected by demand; there must be parked vehicles present to encourage traffic calming. For lower-demand locations, curb extensions may be used to further provide road narrowing features.

- **Pedestrian Accommodations.** On-street parking design should include curb extensions at intersections where pedestrians are expected to cross or where visibility is poor. The designer can refer to PennDOT's Publication 46*, Traffic Engineering Manual,* Section

11.6, *Angle Parking*, and Section 11.9, *Unsignalized Midblock Crosswalks,* for more information.

- **Restrictions.** On-street parking should be restricted at least 20 ft on both approaches to marked and unmarked crosswalks.
- **Multifunctional use.** The space resulting from lane and parking configuration changes can serve multiple uses. For example, the space can incorporate landscaping features, on-street parking, additional sidewalk pavement, transit stops and can be used to collect and filter stormwater.
- **Bicycle facilities.** Refer to Section 14.3.3 and 14.3.4 for information regarding bike lane widths with parking configurations.
- **Maintenance.** Landscaping should only be incorporated into traffic-calming devices where clear maintenance responsibilities have been established. PennDOT typically requires a maintenance agreement with municipalities for maintenance responsibilities.
- **ADA accessibility.** Accessible parking should be provided and located as close as possible to an available curb ramp. See Section 19.2.4, *Accessibility (ADA) for Parallel and Angled Parking – On Street*.
- **One-way to two-way conversion.** Depending on context, converting a multi-way one-way street to a two-way street can reduce vehicle speeds, and may provide improved pedestrian and bicycle access.

## 18.5.19 – Lane Reduction and Road Diet

### Description and Purpose

A road diet involves removing vehicle lanes from a roadway and reallocating the space for other uses or modes, including bicycle infrastructure, wider sidewalks, landscaping, on-street parking, and transit facilities. The removal of through lanes may be reallocated to turn lanes. Road diets are also known as lane reductions and roadway reconfigurations. Relevant criteria for a road diet may include high crash rates for pedestrians and bicyclists, areas where speeding and frequent lane changes occur, desired changes to traffic flow, or to address intersection congestion.

The most common road diet configuration is the conversion of an undivided four-lane roadway into a three-lane undivided roadway, made up of two through-lanes and a center two-way, left-turn lane. (See Exhibits 8.1 and 8.2 for examples of Road Diet configurations.)

Refer to Chapter 8, *Road Diets,* for more information about the design of road diets. This chapter focuses primarily on the traffic-calming applications.

### Exhibit 18.5.68 Example of Before and After Road Diet Configurations


Before

After

### Exhibit 18.5.69 Lane Reduction and Road Diet Typical Application

| LANE REDUCTION AND ROAD DIET TYPICAL APPLICATION | |
|---|---|
| **TRAFFIC VOLUMES** | • Varies depending on context.<br>• The FHWA advises that roadways with ADT of 15,000 vehicles per day (vpd) or less may be good candidates for a four-lane to three-lane road diet. However, if the ADT is near 20,000 vpd, designers should conduct further analysis to determine its operational feasibility.<br>• See Section 8.2.5, *Average Daily Traffic (ADT)*, for more information. |
| **SPEED** | • Applicable for any common urban speed limits. |
| **STREET FUNCTIONAL CLASSIFICATION** | • Appropriate on arterial and collector roadways in rural areas and roads in rural town, suburban, urban, and urban core contexts. |
| **STREET WIDTH AND NUMBER OF TRAVEL LANES** | • Most common on a four-lane section, but also applicable on wide two-lane sections. Typical lane widths are 10 to 12 ft.<br>• See Exhibit 8.0.2 for potential road diet configurations. |
| **GRADE** | • Must comply with local standards and criteria.<br>• Maximum grades typically range from 5 to 12%.<br>• See Section 8.6.2 for more information. |
| **CURVES** | • Applicable on vertical curves, given adequate stopping sight distance, appropriate lighting, and warning signs. |
| **CONTEXT: LAND USE AND AREA** | • Works well in downtown areas and near pedestrian generators or high levels of pedestrian activity. Also applicable in mixed-land uses, including residential areas and community places (e.g., transit stop, school, library, park). Not applicable in rural contexts except in rural towns. |

**Exhibit 18.5.70 Advantages and Disadvantages of Lane Reductions and Road Diets**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Reduces speeds while maintaining throughput.<br>• Improves pedestrian safety and comfort by reducing the number of conflict points and shortening crossing distances.<br>• Improves bicyclist safety by reallocating roadway space for bicycle infrastructure.<br>• Enhances neighborhood appearance.<br>• Road diets that include center left-turn lanes may mitigate queues associated with left-turns.<br>• If designed correctly, drainage impacts along curb lines are negligible.<br>• Reduces traffic noise due to lower speeds.<br>• May result in gain of on-street parking.<br>• A low-cost solution. | • May result in the loss of on-street parking.<br>• Challenges emergency response and heavy vehicles if not designed correctly. |

### Effectiveness

A road diet is an FHWA Proven Safety Countermeasure and provides safety and operational benefits. Road diets have operational benefits, including separating left turns, improving the safety for side-street traffic crossings, reducing speed, and enhancing mobility for all users.

Road diets have demonstrated a 3 to 5 mph speed reduction in 85$^{th}$ percentile speeds.

Studies show a 19 to 47% reduction in overall crashes when a road diet converts a four-lane facility to a three-lane facility. A road diet that incorporates elements of a Complete Street may also reduce collisions. Generally, road diets have shown a crash reduction of approximately 2%.

### Design

Refer to Chapter 8.5.1, *Design Elements*, for more specific Road Diet design information.

**Exhibit 18.5.71 Design Features and Typical Design Criteria of Lane Reductions and Road Diets**

| TRAFFIC-CALMING MEASURE DESIGN FEATURES | TYPICAL DESIGN CRITERIA |
|---|---|
| **DIMENSIONS** | • Roadway widths are described in Chapters 3 and 4.<br>• Median design information is in Chapter 3. |
| **CROSS SLOPE** | • Generally, the highest point of the converted cross section is located at the center of the median or two-way, left-turn lane.<br>• Cross slope design details are in Chapter 3. |
| **BICYCLE FACILITIES** | • Road diets that incorporate bicycle lanes must provide a minimum of 4 ft with no curb and gutter. Wider bicycle lanes should be considered when feasible.<br>• Bicycle facilities may require additional attention within transition zones (entering and existing road diet segment.)<br>• Refer to Chapter 14 for more information about the design of bicycle facilities. |
| **LOCATION** | • Applicable on roadway segments of varying lengths.<br>• May be considered where road space may better be allocated to other modes, including bicycles, pedestrians, transit, or additional street furniture. |
| **ON STREET PARKING** | • Refer to Chapter 19, *Parking Facilities*, for the design of on street parking. |
| **CROSS SECTION TRANSITIONS** | • May require transitions entering and exiting the road diet segment. The design of these transitions is a function of the width of the lane to be dropped and the posted or design speed at lane-drop locations.<br>• Taper lengths can be found in Chapter 3. |

### Design Considerations and Context

Refer to Chapter 8, *Road Diets*, Section 8.5, for more specific design considerations of Road Diets.

- **Area context.** Factors such as driveway access, transit and emergency routes, location of intersections, and operational characteristics of a corridor should be evaluated when considering a road diet. The FHWA and AASHTO established qualities that should be met when considering a road diet, including providing lasting community value and safe facilities, as well as preserving environmental, scenic, aesthetic, and historic values of the area.
- **Speeds.** When designing road diets, the design should match vehicle speeds to the context of surrounding land uses and road users.

- **Turning movements.** The volume and patterns of turning movements should be assessed when considering road diet conversions.
- **Service vehicles.** Roads that have a high volume of frequently stopping or slow-moving vehicles may not be well suited for a road diet. Queueing may result as delivery trucks, transit vehicles, and other service trucks stop along the roadway and prevent vehicles from passing. Applying curb management techniques may address frequently stopping or slow-moving vehicles.
- **Sight distance.** Road diets can be designed to improve sight distance for mid-block, left-turning drivers at entrances. Refer to Section 8.6.1.
- **Access management.** Access management should be analyzed during road diet conversions to mitigate site access issues. Access management considerations include potential conflicts with transit stops, driveway access use, property access, sidewalk continuity, and bicycle accommodations. Consolidating access points may simplify multimodal interactions and conflicts.
- **Maintenance.** Landscaping should only be incorporated into traffic-calming devices where clear maintenance responsibilities have been established. PennDOT typically requires a maintenance agreement with municipalities for maintenance responsibilities.
- **Materials.** Short-term materials, such as flex-posts, planters, and other street furniture, may be used as interim treatment options.

## 18.5.20 – Yield to Pedestrian Channelizing Devices

### Description and Purpose

Yield to Pedestrian Channelizing Devices (YTPCD), R1-6 signs, offer a low-cost, effective solution for locations that have either an intersection with a documented car/pedestrian crash history or where pedestrians have difficulty crossing the street or roadway because motorists fail to yield to them lawfully.

The signs are designed to remind motorists of Pennsylvania law requiring the operator of a vehicle to yield the right-of-way to a pedestrian crossing a roadway within any marked crosswalk or unmarked crosswalk at an intersection where there are no traffic controls or traffic controls are not in operation. The designer can refer to Pennsylvania Statute *Title 75, Section 3542 (a)* for details.

YTPCD have both temporary and permanent applications. The temporary application is defined in this chapter. For details regarding permanent applications, the designer can refer to Publication 236*, Handbook of Approved Signs*.

### Typical Application

The following eligibility criteria pertain to the temporary installation of YTPCD:

1) The units are intended for mid-block crossings or non-signalized intersections. However, if used at intersections, they must be placed slightly in advance of and as close to the crosswalk as feasible without interfering with the turning radius of motor vehicles.
2) Where YTPCD are considered, all crosswalks must be marked (i.e., no unpainted crosswalks). High visibility, continental crosswalks are recommended and preferred.
3) YTPCD are not intended as a permanent installation for traffic-calming purposes and should only be placed in the roadway during peak pedestrian activity. Experience using YTPCD in Pennsylvania indicate motor vehicles become accustomed to the presence of YTPCD and the installation becomes less effective at enhancing safety over time.

### Design Considerations and Context

- **Using YTPCD as a gateway treatment.** YTPCD may be used alone by placing them on the double-yellow centerlines in the roadway or used as part of a gateway treatment. A gateway treatment can be constructed using a combination of three elements:
  - YTPCD mounted in the roadway on a temporary curb base.
  - YTPCD flush mounted on a curb in a median island or curb extension.
  - Flexible delineator post mounted on the white lane line.
- **Context and location.** YTPCD should not be used at an intersection approach that includes a stop control, either by sign or signal. It is for use at crosswalk locations where there are no traffic controls or traffic controls are not in operation.
- **Determining potential locations.** Potential locations for usage are determined by two methods.
  - Documented pedestrian crash locations in municipalities with significant numbers of pedestrian crashes.
  - High pedestrian-activity locations or locations near trip generators where motorists do not yield to pedestrians in crosswalks, resulting in community safety issues.

## 18.5.21 – Other

There are other engineering tools and techniques that can be used to achieve traffic-calming objectives. The toolbox includes the following other traffic-calming measures:

- 18.5.22 – Traffic Signal Timing and Phasing Modifications

- 18.5.23 – Automated Enforcement
- 18.5.24 – Leading Pedestrian Interval
- 18.5.25 – Intersection Control Spacing

## 18.5.22 – Traffic Signal Timing and Phasing Modifications

### Description and Purpose

Traffic signal timing and phasing modifications can achieve traffic-calming goals that support the balanced movement of pedestrians, bicyclists, transit, and vehicles.

The designer can consider alterations to signal cycle length, signal phasing, and signal coordination. Signal timing parameters such as clearance intervals, detection location, and detection settings may also be altered to achieve safety related improvements at signalized intersections.

### Design Considerations and Context

- **Shorten signal cycle lengths.** Shorter cycle lengths can minimize delay for all users and increase turnover at an intersection.
- **Minimize signal phases.** Where possible, minimizing signal phases can decrease wait times for all users. Providing additional phases has safety benefits for high vehicular-turning movements but may lead to increasing the signal cycle length. In urban areas, vehicular turn restrictions should be considered at key locations.
- **Prioritize walking, bicycling, and transit movements.** Signal priority techniques, such as leading pedestrian intervals, bicycle signals, and transit signal priority, are examples of tools used to establish priority for desired modes along a corridor.
    - Leading pedestrian intervals can be implemented to prioritize pedestrian movements at an intersection with a high volume of vehicle turning movements. Leading pedestrian intervals allow pedestrians to begin crossing the intersection before the turning vehicles receive a green indication.
    - Transit signal priority is a technique for coordinating transit headways for consistent transit routes.

    The designer can refer to Chapter 14 for information on bicycle signals.
- **Time signals to maintain desired travel speed.** Coordinated signal timing techniques can be used to maintain a specified travel time or average speed along a corridor. Low vehicle progression speeds can create a pedestrian-and-bicycle-friendly environment. Off-peak or weekend volumes should be considered when developing timing plans.

- **Use fixed time signalization versus actuated signalization.** In urban areas, fixed signals provide consistent and predictable opportunities for pedestrians to cross the street. Providing pedestrian recall at a signal can provide pedestrian phases every cycle, while still allowing vehicle demand to extend the green time beyond the pedestrian minimum time.
- **Meet accessible design regulations.** PROWAG and ADA regulations and guidelines can be met by incorporating audible indicators and pushbuttons (where applicable).

## 18.5.23 – Automated Enforcement

### Description and Purpose

Automated enforcement is a tool used by states and agencies to reduce vehicles running red-lights and speeding, as both behaviors are major contributing factors to fatal crashes. Automated enforcement supplements traditional enforcement operations (in which violations are detected, identification information about the vehicle and driver is recorded, and citations are issued by mail). Both speed cameras and red-light-running cameras enable police to focus resources on other enforcement needs. Review Title 75 provisions to ensure compliance with the regulations.

For additional guidance and information regarding the implementation of red-light camera systems or speed enforcement camera systems, the designer can refer to *Red Light Camera Systems: Operational Guidelines* and *Speed Enforcement Camera Systems: Operational Guidelines* developed by the FHWA and the NHTSA. In addition, NCHRP's *Report 729: Automated Enforcement for Speeding and Red Light Running* provides guidelines for the operation of automated enforcement programs.

**Exhibit 18.5.72 Advantages and Disadvantages of Automated Enforcement**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Research indicates a reduction in speeds can be attributed to the implementation of automated enforcement, although the estimated reduction is difficult to quantify.<br>• Improves safety by reducing speeding and speed related crashes. (Crashes occurring at lower speeds tend to be less severe.)<br>• Allows police enforcement to reallocate resources to other needs.<br>• Obtains quantifiable data on speed and red-light violations. | • May require further research into traffic flow changes and crash mitigation to non-enforced routes or segments. |

### Effectiveness

Studies documented in NHTSA's project, *Automated Enforcement: A Compendium of Worldwide Evaluations of Results,* reported reductions in speeds with automated speed enforcement. The estimated reduction is difficult to quantify due to the many factors associated with speeding and confounding factors related to differences in study designs.

Studies evaluated in NHTSA's project also reported a decrease in estimated injury crashes, all crashes, or speed-related crashes at project sites with automated speed enforcement. While key studies show a significant reduction in estimated crashes, only a few studies were well-controlled. The effects of regression to the mean, confounders, specific site characteristics, and behavior shifts (such as taking alternate routes) on the reduction in estimated crashes cannot be stated with certainty.

Factors contributing to red-light running include driver behavior, intersection design and operation, vehicle characteristics, and weather. Studies have shown evidence that red-light running camera systems improve safety at signalized intersections with high red-light running activity.

A variety of studies report a reduction in crash severity. Similarly, other reports document that red-light running camera systems contributed more to decreasing fatal, injury, angle and left-turn crashes than to decreasing property-damage-only or rear-end crashes. Crashes caused by red-light running tend to be more severe than other crashes that occur at signalized intersections.

### Design Considerations and Context

- **Supplement to traditional tools.** Automated enforcement should supplement traditional engineering, enforcement, and education countermeasures, not just replace these measures.
- **Program qualities.** Beyond providing public transparency and awareness, automated enforcement offers other key program qualities. Their implementation is motivated by safety considerations, with legislation that provides the authority to operate the program. Further, automated enforcement is developed to be repeatable and monitored to evaluate performance and operation. As a result, automated enforcement can be deployed in locations such as on a high-injury network, or near school zones.

## 18.5.24 – Leading Pedestrian Interval

### Description and Purpose

At signalized intersections with pedestrian signal indications, a leading pedestrian interval is a period of typically 3 to 7 seconds where the walk signal is provided to pedestrians in advance of vehicles receiving a green signal indication. The interval enables pedestrians to begin crossing an intersection to establish their presence in the crosswalk.

According to MUTCD, leading pedestrian intervals should be at least three seconds and timed to allow pedestrians to cross one lane of traffic or to be visible to vehicles before they receive a green indication. The duration of a green interval sometimes extends the pedestrian clearance time to provide turning drivers additional time to make turns after pedestrians completely cross the intersection.

**Exhibit 18.5.73 Leading Pedestrian Interval Typical Application**

| LEADING PEDESTRIAN INTERVAL TYPICAL APPLICATION | |
|---|---|
| **TRAFFIC VOLUMES** | At a signalized intersection with high left-or-right-turning volumes. |
| **INTERSECTION OR ROADWAY SEGMENT TYPE** | At a signalized intersection. |
| **CONTEXT: LAND USE AND AREA** | In areas with high pedestrian activity. |

**Exhibit 18.5.74 Advantages and Disadvantages of Leading Pedestrian Intervals**

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Improves pedestrian safety (increases pedestrian visibility within the intersection, reduces pedestrian-vehicle crashes, and increases likelihood of vehicles yielding to pedestrians).<br>• Low-cost improvement - can be incorporated into existing signal timing. | • May increase vehicle delay at signalized intersections operating at capacity.<br>• Reduces green time for vehicle movements. |

### Effectiveness

The leading pedestrian interval is one of FHWA's Proven Safety Countermeasures based on the proven effectiveness of the safety improvement. This traffic-calming measure provides a 13% reduction in pedestrian-vehicle crashes at intersections.

One study demonstrated that the implementation of leading pedestrian intervals at ten intersections in Pennsylvania reduced pedestrian-vehicle collisions by up to 60%.

### Design

MUTCD, *Pedestrian Intervals and Signal Phases* section, provides guidance and support about these measures. These include:

- Providing leading pedestrian intervals at intersections with high pedestrian volumes and high conflicting turning vehicle volumes.
- Using accessible pedestrian signals if intervals are implemented.
- Only applying leading pedestrian intervals when accessible features are also present, to avoid confusion.
- Prohibiting turns across the crosswalk during the interval.

The designer can refer to *NCHRP 812, Signal Timing Manual, Second Edition*, *Section 6.1.6.6 Additional Guidance on Pedestrian Intervals – Leading Pedestrian Interval*, for additional guidance.

### Design Considerations and Context

- **Located at signalized intersections.** Leading pedestrian intervals can be implemented at intersections with current or desired high pedestrian volumes or intersections with long crossing distances.

- **Curb extensions.** Leading pedestrian intervals can be coupled with curb extensions to improve pedestrian visibility at intersections with conflicts, such as high left-or-right-turn volumes and reduce the amount of signal cycle time needed to complete the crossing.
- **Pedestrians with visual restrictions.** An audible signal should accompany the interval to accommodate pedestrians with visual restrictions.
- **Use of accessible pedestrian signals.** Accessible pedestrian signals should be considered.

## 18.5.25 – Intersection Control Spacing

### Description and Purpose

Intersection control spacing impacts mobility, access, and connectivity within a network. Intersections should be analyzed as a part of a network rather than as an isolated feature and should be designed to result in operating speeds consistent with driver expectations and the function of the roadway.

NCHRP's *Report 613, Guidelines for Selection of Speed Reduction Treatments at High-Speed Intersections,* discusses the transition area between intersections and segments where drivers need to react and adjust their speed. The report also describes the intersection influence area as comprising geometric and operational areas. The geometric area includes typical section changes such as tapers for adding or dropping lanes. The operational area includes queuing, merging, lane changing, and acceleration and deceleration.

### Design Considerations and Context

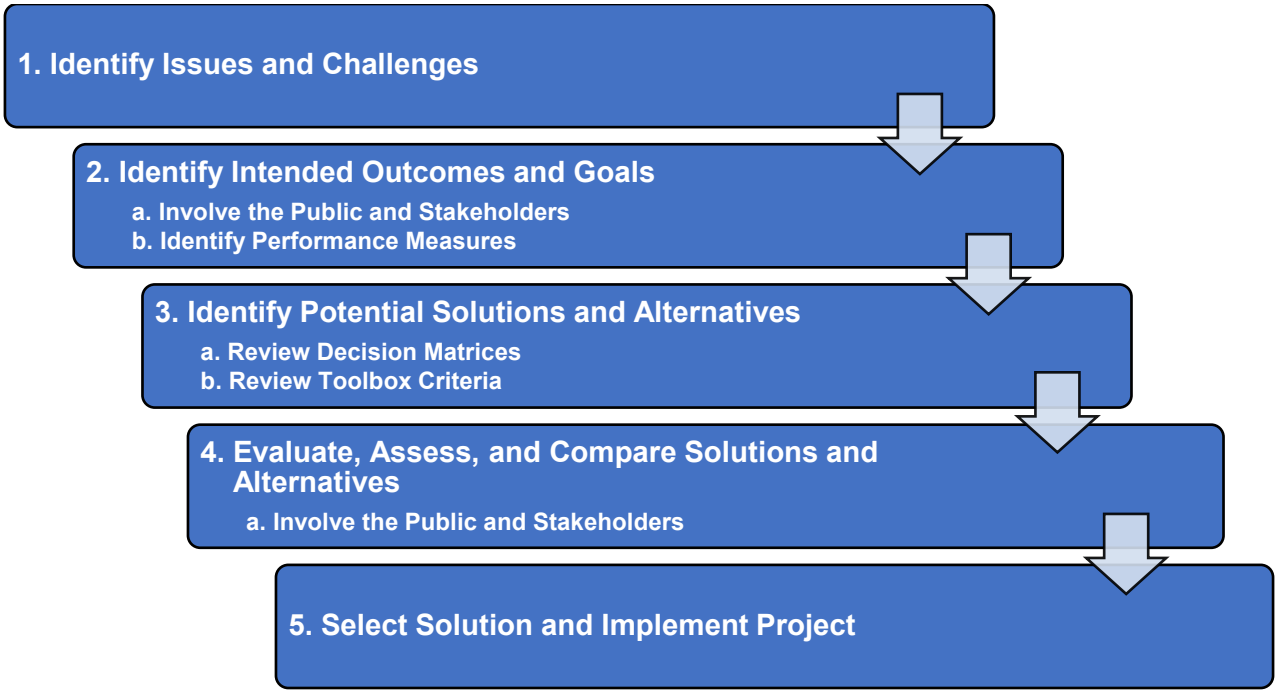
- **Traffic control type.** Driver operating speeds will vary with different traffic control types, due to various driver tasks required.
- **Long blocks between intersections.** Higher speeds tend to be associated with longer distances between intersections. Introducing elements of traffic control friction, such as vertical deflection, along long blocks can serve to calm traffic.
- **Large speed differentials.** When vehicle queues extend beyond an intersection or outside an intersection's approach sight distance, speed differentials along a segment can increase. This, in turn, increases the potential for severe crashes. When the difference in 85$^{th}$ percentile speeds exceed 10 to 15 mph in transition areas, crashes tend to be more severe. The relationship between speed and crash frequency is less clear.
- **Roadway characteristics.** Roadway and intersection geometric design characteristics, such as intersection spacing, travel lane width, turn lanes, and sight distance, can impact travel speed.

- **Pedestrian access.** The average intersection spacing for walkability is a maximum distance of 660 ft; less than 400 ft is desirable.
- **Transition area.** Intersection locating with respect to tangent segment could influence speeds.

## Appendix 18A Traffic-Calming Study and Approval Process

Implementing a traffic-calming measure should be based on an established process. The process should start with the identification of a problem or issue within a given project or site context and continue through the implementation of an individual measure or series of measures. This procedure is for State highways, a local road with state or federal funding, or a federal aid roadway. PennDOT approval is not required prior to the installation of traffic-calming measures on a local road with local funding. See 67 Pa Code §212.5. Processes vary in their formal structure, but all effective decision-making incorporates the following key components displayed in **Exhibit 18.A.1**.

**Exhibit 18.A.1 Traffic-Calming Study and Approval Flow Chart**




As outlined in Chapter 2, the context will determine the design speed of a roadway. The context of the roadway could be defined through the planning process, the evaluation and review of existing conditions and proposed data, the involvement of stakeholders and the public, and data-driven analyses or processes.

A local authority can further define the context within its area through a data-driven screening process. This process allows a local authority to define and classify facilities under a more detailed and specific lens, potentially enhancing the resulting project. General approaches may include retrofitting existing roadway facilities with traffic-calming measures or designing new projects where geometrics and context lower speeds and criteria are aligned with design speed.

Traffic Engineering Form TE-125 is a step-by-step guide for documenting the project process and determining an appropriate traffic-calming measure. Documentation is an essential part of codifying all the research, outreach, and engineering judgments made during a project. A standardized traffic engineering form will also ensure consistency in how traffic-calming devices are deployed in Pennsylvania.

## 18A.1 – Tort Liability Considerations

Risk management best practices include keeping adequate documentation of engineering design decisions and assumptions made throughout a project. Elements that counteract potential liability concerns include the following:

- Public involvement.
- Documentation of design decisions made throughout a project.
- Documentation of the issues to address and the goals of the project.
- Design development that accommodates all users.
- Design development consistent with driver expectations.
- Provisions for adequate maintenance of the project features.
- Record retention.

Tort liability is addressed in Chapter 1; design documentation and exceptions are discussed in Chapter 2. Details pertaining to documentation and the process of design exceptions are outlined in Publication 10X, Design Manual Part 1X, *Appendices to Design Manuals 1, 1A, 1B AND 1C*, (DM-1X) *Appendix P,* Design Exceptions.

## 18A.2 – Identify Issues and Challenges

An engineering evaluation should be conducted when concerns about speed or safety arise. The evaluation may involve site observations, speed studies, conflict monitoring, community input, and available crash data and analysis information. The engineering evaluation should quantify and document the context considerations, such as existing site and project conditions, community feedback, environmental impacts, policy, and constraints.

The determination of traffic-calming measures might consider:

- Speeding issues, as documented through a speed evaluation of vehicles exceeding the posted speed limit or the operating speed intended for the context of the roadway.
- Concerns regarding speeding, poor visibility and impeded sightlines, and pedestrian safety.

- Crash data that documents pedestrian or bicyclist crashes, higher-than-expected vehicular crashes, intersection safety concerns, or specific crash types related to speeding.
- Land uses and context classification of an area that warrant implementation of traffic calming.

## 18A.3 – Identify Intended Outcomes and Goals

Once specific issues are identified, the stakeholders and community should be involved in developing the objectives and goals of traffic calming through implementation of priority concepts.

Outcomes and goals to increase the safety of users may include the following:

- Improve visibility for all modes of transportation.
- Reduce vehicle operating speeds.
- Reduce crash frequency and severity.
- Reduce crossing distance.
- Decrease all road users' exposure to crash risk.
- Increase pedestrian safety and comfort.
- Reduce conflict points.
- Improve visibility for pedestrians.
- Improve line of sight for pedestrians.
- Enhance multimodal connectivity and access.

## 18A.3.a – Involve the Public and Stakeholders

PennDOT's *Design Manual 1 (DM-1)* states that opportunities should be provided for more participation from agencies and the public at an early stage of the project and should continue throughout the duration of the project.

The designer can refer to *PennDOT Connects* and *DM-1* for best practices related to public involvement and stakeholder coordination. Avenues for soliciting feedback from stakeholders and the public include public comment periods, meetings and workshops, and online surveys.

## 18A.3.b – Identify Performance Measures

Once issues, challenges, outcomes, and goals are identified, performance measures should be developed to provide a framework for weighing alternatives and measuring progress. Performance measures can be linked to assessments of speed control, crash data, modal split, traffic volumes, and existing site-condition reviews.

## 18A.4 – Identify Potential Solutions and Alternatives

Once the issues are understood and the goals of the project are determined, the next step is to identify and prioritize solutions and alternatives to address the challenges. Maintenance considerations and public or stakeholder involvement should be a part of the decision-making process.

To find the optimal solution, the designer should assess the impacts of implementing traffic-calming measures and identify improvement opportunities. The designer should explore:

- The potential solutions and the variety of alternatives that can achieve the goals within the given constraints.
- The advantages and disadvantages of certain traffic-calming measures, and how project-specific performance measures and goals can be used in weighing solutions.

The path to implementing a traffic-calming measure may include education, enforcement, turn prohibitions, speed feedback signs, and pavement markings.

These tasks involve:

- **Education.** Advise and inform the public about the issues and challenges relating to safety and speed management within the transportation network for all transportation modes and users. Provide resources through community engagement efforts.
- **Enforcement.** Traffic and speed enforcement can be focused on key locations through data-driven processes to alter the behavior of drivers.
- **Turn prohibitions.** Implementing turn-prohibition signs (e.g., No Turn On Red signs, No Left Turns signs) may be useful in addressing operational concerns, safety implications, or cut-through traffic impacts. Installing signs to eliminate driver movements in full-time or restricted-time intervals may meet the goals of the project.
- **Speed feedback signs.** Installing speed feedback signs provides drivers with real-time information about how fast they are traveling and may encourage them to slow down.
- **Pavement marking solutions.** Implementing pavement markings to visually narrow the roadway to slow speeds, also known as roadway narrowing. Installing speed limit pavement marking legends to reinforce the speed limit.

## 18A.4.a – Preliminary Screening of Traffic-Calming Measures

Designers can use Exhibit 18.4.1 and Exhibit 18.4.2 to screen appropriate traffic-calming measures for a project. **Exhibit 18.4.1** shows the typical applicability of various traffic-calming measures to intended outcomes. **Exhibit 18.4.2** shows the five context classifications and posted speed ranges and the applicability of each traffic-calming measure within each context and each posted speed range.

## 18A.4.b – Review Toolbox Criteria

After a preliminary screening of traffic-calming measures, the next step is to review the toolbox criteria in Section 18.5, *Toolbox of Traffic-Calming Measures and Design Guidelines*, of this chapter for further details.

The criteria further narrow solutions and consider the advantages and disadvantages of potential traffic-calming measures by assessing impacts and opportunities, considering costs, and weighing outcomes.

## 18A.5 – Evaluate, Assess, and Compare Solutions and Alternatives

Evaluating, assessing, and comparing traffic-calming measures is an iterative process. The designer should consider applying multiple treatments within a network or area to achieve goals.

The design should provide efficiency in project implementation and identify low-cost solutions where applicable or effective, as well as descriptions or reasons why other considerations should be evaluated before undertaking a traffic-calming measure.

## 18A.5.a – Involve the Public and Stakeholders

The community can help identify concerns and can be involved in the solution process. The designer should incorporate the community vision and values in the selection of project alternatives and solutions. Designers should continue coordinating with affected stakeholders, such as residents and community members, public works, or PennDOT Maintenance, to discuss snowplowing or other challenges, such as drainage, utility, and other engineering implications.

The designer can refer to *PennDOT Connects*, DM-1, and Publication 295, *Transportation Project Development Process – Public Involvement Handbook,* for best practices for public involvement and stakeholder coordination.

Collaboration and partnership with PennDOT and other agencies throughout the duration of the project will help to ensure the success of traffic-calming measures on state-owned roadways or local roads on the Federal Aid System.

Early PennDOT Connects coordination with the Planning Region(s) and PennDOT District Staff, may help to identify planning concepts for a candidate project decision making process. Conversations with District staff in Design and Maintenance may also help to identify discretionary or Regional Long Range Transportation Program (LRTP) Funding opportunities for near and long-term solutions.

## 18A.6 – PennDOT Approval, Selection of Solution, Implementation of Project

PennDOT approval is required, prior to the installation of traffic-calming measures on a State highway, a local road with state or federal funding, or a federal aid roadway. PennDOT approval is not required prior to the installation of traffic-calming measures on a local road with local funding. See 67 Pa Code §212.5.

PennDOT approval of the selection and implementation of a traffic-calming project requires the following elements:

- Completed Form TE-125 (Traffic Calming Measure Engineering and Traffic Study) with appropriate signatures.
- HOP issuance (state-owned roadways only).
- Maintenance agreements.

Form TE-125 is to receive municipal approval, District Traffic Engineering approval if the project is a state roadway, and Assistant District Executive-Design Approval if the project is a PennDOT project.

Traffic calming is an evolving practice and data regarding certain traffic-calming measures is limited. Collecting before and after data on traffic-calming projects on both state and local roadways in Pennsylvania will help the department improve our policies and design criteria. Information on existing site conditions and intended outcomes will be documented using Traffic Engineering Form TE-125. It is strongly recommended to conduct a post-implementation analysis to: (1) assess the effect on measurable conditions including 85th percentile speeds and observed crashes; and (2) determine to what extent the intended outcomes were achieved. The findings should be reported to PennDOT Bureau of Operations for consideration and policy updates as applicable.

## Appendix 18B Maintenance and Ownership

The justification for a traffic-calming device can originate as a stand-alone need for a specific location or as an integral part of a roadway project. Several different entities may be responsible for the various planning, design, construction, and maintenance stages of traffic calming.

When a local authority originates a project on a state road, close communication between the District and the local authority throughout the planning stage is recommended. The design and construction should be administered through PennDOT's Highway Occupancy Permit (HOP) program. Traffic calming can be integrated into the project scope, with PennDOT providing local support on the planning, justification, design, and construction. On a PennDOT construction project, PennDOT may issue an HOP to the local authority or complete a maintenance agreement identifying what aspects of traffic calming is the responsibility of the local authority Should the Permittee choose to make any future modifications to the traffic-calming measure, an HOP application must be submitted to PennDOT for review. **Exhibit 18.B.1** shows a typical breakdown of the responsibilities of local authorities and PennDOT.

**Exhibit 18.B.1 Roles and Responsibilities of Local Authority and PennDOT**

| Task | Local Authority | PennDOT |
|---|---|---|
| **Preliminary Assessment** | | |
| Process review | x | 1 |
| Site investigation | x | 1 |
| Data collection | x | 1 |
| Study development | x | 1 |
| Public and stakeholder involvement | x | |
| Municipal concurrence, associated cost, and future maintenance | x | |
| **Application Submission** | | |
| Traffic-calming process adherence – conduct outreach with all stakeholders and coordinate with PennDOT Traffic Unit for determination and pre-approval | x | 1 |
| **Department Application Review** | | |
| HOP submission process adherence – approve, deny or request additional information from the local authority | | x |

| | | |
|---|---|---|
| HOP issuance | | x |
| Plan sheets development | x | 1 |
| Construction plans and specifications development | x | 1 |
| **Construction** | | |
| Construction | x | 1 |
| Inspection | x | 1 |
| As-built drawings | x | 1 |
| **Maintenance** | | |
| Budgeting | x | |
| Response and preventative maintenance | x | |
| Design modifications | x | |

x = Entity responsible for task.
1 = The Department would generally perform this function for Department construction projects on state highways, but local authorities may be responsible for a share of the costs.

## Appendix 18C: Form TE-125

TE-125 (11-24)

# TRAFFIC-CALMING MEASURE ENGINEERING AND TRAFFIC STUDY

**PLEASE TYPE OR PRINT ALL INFORMATION IN BLUE OR BLACK INK**

pennsylvania
DEPARTMENT OF TRANSPORTATION
www.dot.state.pa.us

## STEP 1: IDENTIFY CHALLENGES AND ASSESS ISSUES

### A – LOCATION INFORMATION

| | |
|---|---|
| COUNTY: | MUNICIPALITY: |
| STREET NAME: | |
| STATE ROAD #: | LOCAL ROAD #: |
| STUDY AREA: SEGMENT: OFFSET: | TO SEGMENT: OFFSET: |
| LOCATION: | TO LOCATION: |

### B – REFERENCE INFORMATION

| | |
|---|---|
| REFERENCE: Chapter 212 | SECTION(S): §212.9 Traffic Calming |
| REFERENCE: Design Manual 2 | SECTION(S): Chapter 18 Traffic Calming |
| REFERENCE: PUB 46 Traffic Engineering Manual | SECTION(S): |
| REFERENCE: | SECTION(S): |

### C – STUDY ELEMENTS

**FROM PUBLICATION 212 APPENDIX:**

| | | | | |
|---|---|---|---|---|
| ❑ Crash Analysis (1) | ❑ Gap study for school children (7) | ❑ Roadside Development (13) | ❑ Speed Data (17) | ❑ Other: _____ |
| ❑ Alternate Route (3) | ❑ Geometric Review (8) | ❑ Roadside Obstructions (14) | ❑ Traffic Signals (19) | ❑ Bicycle Volumes (X) |
| ❑ Arr./Dep. hrs of students (5) | ❑ Parallel Streets (9) | ❑ School Route Plan (15) | ❑ Type of Highway (21) | |
| ❑ Capacity Analysis (6) | ❑ Pedestrian Volumes (12) | ❑ Sight Distance (16) | ❑ Intersection Delay (22) | |

### D – EXISTING CONDITIONS DESCRIPTION

1. Is there a documented speeding problem? ❑ YES ❑ NO ❑ N/A

85th Percentile Speed: _____ Posted Speed: _____ Target Speed: _____

Remarks:

2. Have there been observed conflicts with vulnerable users or documented crashes? ❑ YES ❑ NO ❑ N/A

Remarks:

3. Are pedestrian/bicycle facilities present (i.e., sidewalks, curb ramps, crosswalks, pedestrian signals, trail, roadway)? ❑ YES ❑ NO ❑ N/A

Remarks:

4. Are pedestrian facilities near the site? ❑ YES ❑ NO ❑ N/A

Remarks:

5. Has the land use context been defined per Design Manual 2? ❑ YES ❑ NO ❑ N/A

Remarks:

6. Has the functional street classification been defined? ❑ YES ❑ NO ❑ N/A

Remarks:

## STEP 2: IDENTIFY INTENDED OUTCOMES OR GOALS FOR THE PROJECT

### E – OUTCOME IDENTIFICATION

Identify outcomes/goals of traffic calming implementation to address site challenges.

- Reduced vehicle operating speed ❑ YES ❑ NO ❑ N/A
- Reduced crash frequency/severity ❑ YES ❑ NO ❑ N/A
- Reduced crossing distance ❑ YES ❑ NO ❑ N/A
- Decreased pedestrian exposure ❑ YES ❑ NO ❑ N/A
- Increased pedestrian safety and comfort ❑ YES ❑ NO ❑ N/A
- Reduced conflict points ❑ YES ❑ NO ❑ N/A
- Improved visibility of pedestrians ❑ YES ❑ NO ❑ N/A
- Improved line of sight for pedestrians ❑ YES ❑ NO ❑ N/A
- Enhanced multimodal connectivity and access ❑ YES ❑ NO ❑ N/A
- _____ ❑ YES ❑ NO ❑ N/A
- _____ ❑ YES ❑ NO ❑ N/A
- _____ ❑ YES ❑ NO ❑ N/A
- _____ ❑ YES ❑ NO ❑ N/A
- _____ ❑ YES ❑ NO ❑ N/A

### F – OUTREACH EFFORTS

Has contact and discussion concerning traffic calming been made with the following groups/organizations?

- Municipality (s) ❑ YES ❑ NO ❑ N/A
- Transit Organization (s) ❑ YES ❑ NO ❑ N/A
- School District (s) ❑ YES ❑ NO ❑ N/A
- Public Meeting (s) ❑ YES ❑ NO ❑ N/A
- Emergency Services ❑ YES ❑ NO ❑ N/A
- Advocacy Groups ❑ YES ❑ NO ❑ N/A
- County Maintenance Service Providers ❑ YES ❑ NO ❑ N/A
- Other (s) ❑ YES ❑ NO ❑ N/A

Remarks/Comments from outreach efforts (specify which groups/organizations were involved in outreach efforts):

## STEP 3: IDENTIFY POTENTIAL SOLUTIONS AND ALTERNATIVES

### G – SITE INFORMATION FOR POTENTIAL ALTERNATIVES

| DATE DATA COLLECTED: | PERSON CONDUCTING STUDY: | TITLE: |
|---|---|---|
| | | |

1. Traffic Volumes (ADT): .....

Remarks:

2. Posted Speed Limit (MPH): .....

Remarks:

3. Street Functional Classification: .....

Remarks:

4. Crash History: .....

Remarks:

5. Parking Information (i.e. Location, Capacity, Use, etc.): .....

Remarks:

6. Operating Speed (MPH): .....

Remarks:

7. Grade (percent) .....

Remarks:

8. Roadway Geometry (i.e. Curves, Intersection, Segment Type, etc.) .....

Remarks:

9. Number of Travel Lanes .....

Remarks:

10. What is the context, Land Use, and Area of the site/project? .....

Remarks:

11. What are the impacts on the project area and surrounding roadway network? .....

Remarks:

a. Is there a Transit Route/Transit Stops or Emergency Vehicle Route in the site/project vicinity? ..... ❑ YES ❑ NO

Remarks:

b. Have the impacts to larger vehicles been considered? ..... ❑ YES ❑ NO

Remarks:

c. Have noise impacts been considered ..... ❑ YES ❑ NO

Remarks:

### Step 3.1 - Preliminary Screening of Traffic-Calming Measures using Decision Matrices

1. Intended Outcomes of Traffic Calming Implementation, shows which intended outcomes are typically applicable with the implementation of various traffic-calming measures.
2. Posted Speed and Roadway Classification, shows the five context classifications and posted speed ranges along the top of the matrix. This matrix shows the applicability of each traffic-calming measure within each context and posted speed range.

### Step 3.2 – Review Toolbox Criteria for potential Traffic-Calming Measures

## STEP 4: EVALUATE, ASSESS, AND COMPARE ALTERNATIVES

### H – EVALUTATION OF PROPOSED ALTERNATIVES

- Weighing the Advantages and Disadvantages associated with potential traffic-calming measures – document traffic-calming measure effectiveness in achieving intended outcomes.

- Considering Tradeoffs: safety, accessibility, cost, maintenance, multiple users, vehicles, and other modes of transportation.

**STEP 5: RECOMMENDATION OF A SOLUTION**

## I – RECOMMENDATION AND JUSTIFICATION OF PROPOSED SOLUTION

## J – APPROVALS FOR PENNDOT PROJECTS

Comments:

**Completed by:**

| Name: | Agency/ Consultant: | Date: |
|---|---|---|
| | | |

**MUNICIPAL APPROVAL**
(Required for Local Roads)

| Reviewed and Approved By (Print): | Title: | Date: |
|---|---|---|
| | | |

Reviewed and Approved By (Signature):

**DISTRICT TRAFFIC ENGINEERING APPROVAL**
(Required for State Roadways)

| Reviewed and Approved By (Print): | Title: | Date: |
|---|---|---|
| | | |

Reviewed and Approved By (Signature):

**ASSISTANT DISTRICT EXECUTIVE-DESIGN APPROVAL**
(Required for Arterials and State Roads with Posted Speeds over 35 MPH; HDTD involvement required in the approval process)

| Reviewed and Approved By (Print): | Title: | Date: |
|---|---|---|
| | | |

Reviewed and Approved By (Signature):