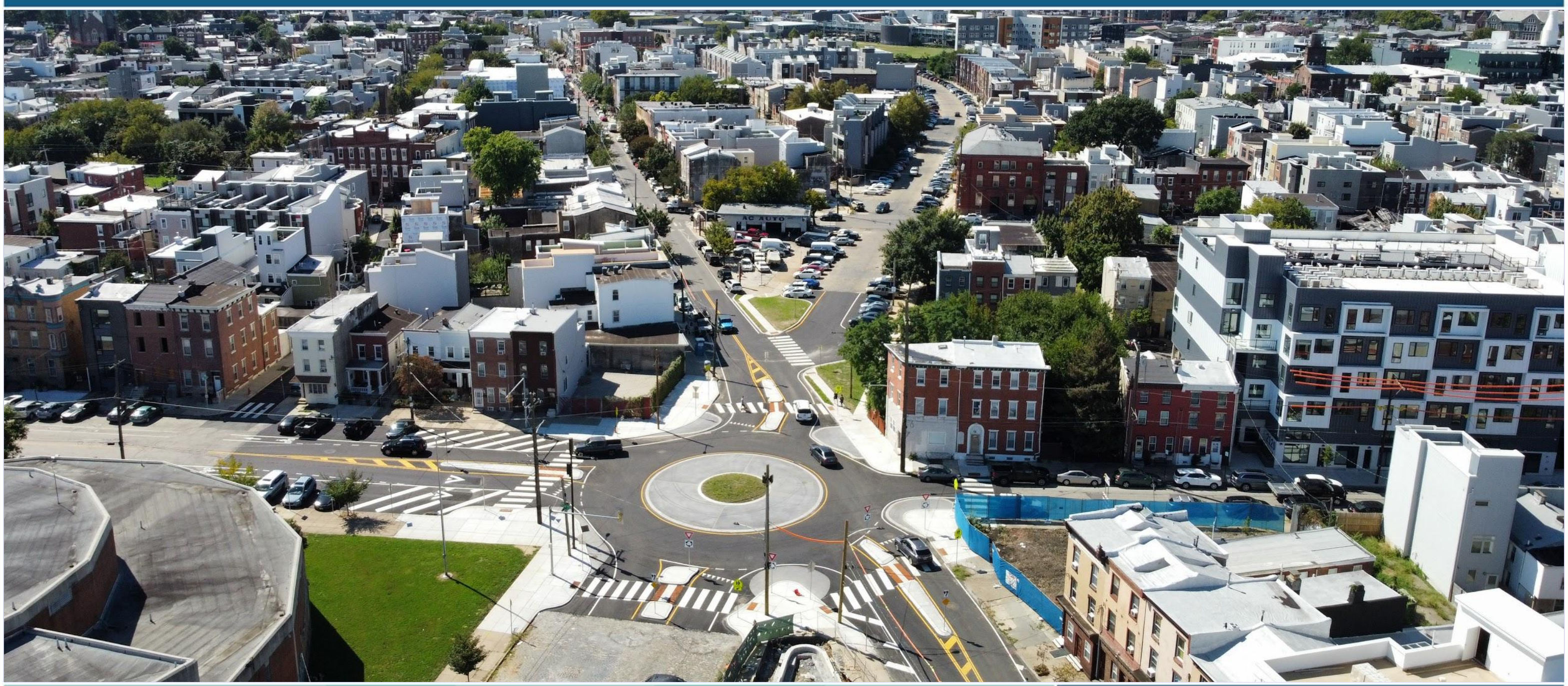
Arterial Typology and Speed Management Decision-Making Framework for the City of Philadelphia



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Cover photo credit: Justin Batchelor

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Executive Summary

Speed is the number one determinant of severity in a crash—as speed increases so does the probability of crash fatalities and serious injuries. Roadway engineering improvements offer the greatest opportunity to control speed and reduce crash severity. Local, regional, state, and federal zero crash deaths initiatives promote speed management as a critical tool for advancing safety goals. Implementing the right speed management techniques at the right locations provides localized safety benefits, contributes to area-wide crash reduction, and promotes a safer environment for vulnerable users—pedestrians, bicyclists, and transit users.

Conceived by PennDOT District 6-0, this safety-focused project, titled "Arterial Typology and Speed Management Decision-Making Framework for the City of Philadelphia" was designed to address the limitations of roadway functional classification. The approach was to redefine Philadelphia's arterial roads with new typologies that more accurately reflect Philadelphia's unique characteristics to allow scaled traffic calming per typology. Prior to this, many speed management strategies (especially vertical deflection) were avoided on state-owned arterials. In advancing their Vision Zero goals, City officials have had success using vertical deflection techniques on City-owned arterials to calm traffic, while state-owned arterials with nearly identical characteristics remained ineligible for similar treatments due to existing guidance.

The 2022 update to PennDOT's Design Manual (DM-2) offered an opportunity to re-think traffic calming guidance statewide and at the local level. The update expanded existing traffic calming guidance and included a provision permitting municipalities to create a traffic calming program and guidance catered to their unique or specific needs. This process must be data-driven and developed in partnership with the appropriate PennDOT District office, if it intends to impact state-owned roadways. It is under this provision that the "Arterial Typology and Speed Management Decision-Making Framework for the City of Philadelphia" builds on and in some cases, deviates from state guidance presented in the "Multimodal Traffic Calming" chapter of DM-2 in order to better suit the unique safety needs of Philadelphia.

Roadway characteristics, land use, and context, are the primary considerations when defining speed management needs and assigning appropriate speed management techniques. Drawing from the American Association of State Highway and Transportation Officials (AASHTO) Policy on Geometric Design of Highways and Streets manual—commonly referred to as the "Green Book", and considering Philadelphia's built environment and circulation needs, the resulting product is a data-driven approach for determining where speed management treatments are most appropriate on arterials in Philadelphia, for use on both local and state-owned facilities. This guidance is based on Philadelphia's characteristics as of 2022. Recognizing that roadway characteristics, land use, and context will change, the typologies should be updated as needed using the methodology described here, which was developed collaboratively among the study stakeholders. Also, the treatments included in this framework can be added to by PennDOT as new and innovative alternatives arise to ensure the framework remains contemporary.

With each application of this framework it is recommended that before and after transportation data be collected to understand real-world outcomes associated with the various typology and treatment combinations; this will promote more effective applications in the future. The treatments included in this framework can be piloted with temporary materials allowing for data collection which can inform the application of permanent installations.

This effort was guided by officials from PennDOT District 6-0, the City of Philadelphia, and PennDOT Central Office. In considering multiple iterations of this framework, the stakeholders responded to Philadelphia's unique urban context with a typology system that balances local circulation and regional connectivity, while prioritizing safety for all users.

Chapter 1:

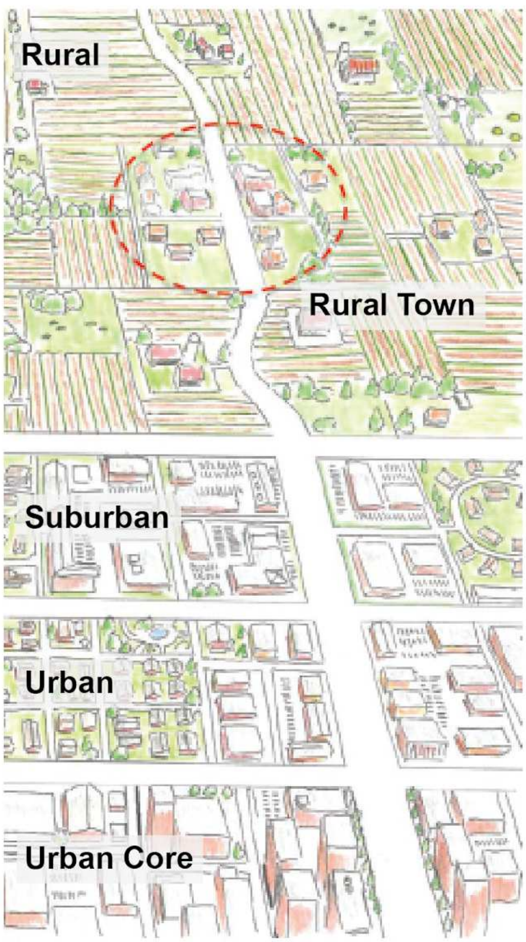
Methodology

Introduction

Relying on guidance from AASHTO's *Green Book* (2018), DVRPC developed a methodology in consultation with the stakeholder group to create typologies to dictate traffic calming treatments for Philadelphia's arterial network. This guidance reflects conditions in Philadelphia at the time of publication and should be revised as conditions change using the agreed upon methodology. In place of the traditional functional class definitions, the *Green Book* advises transportation planners to consider a framework based on two key elements: (1) the position of a roadway within the transportation network and the role it plays for transporting motor vehicles, and (2) the context the roadway operates in, including the surrounding environment and how it serves the local community. **Figure 1** illustrates this concept, showing an arterial road traveling through different contexts, including (from top to bottom) rural, rural town center (circled in red), suburban, urban, and urban core contexts.

This framework provided a direction, but not specifics for how to devise nuanced typologies for arterials in Philadelphia. DVRPC distilled the guidance into three key questions that could be addressed through an investigation of local land use and roadway infrastructure characteristics:

Figure 1: Arterial Road in Different Contexts



Source: NCHRP Report 855 (2018)

1. What speed management strategies are possible within the cartway of the arterial?
2. What land uses front along the street and how do they dictate which speed management strategies are appropriate?
3. At a citywide scale, how does the arterial fit into the overall transportation network? Is the priority for land access or vehicle mobility?

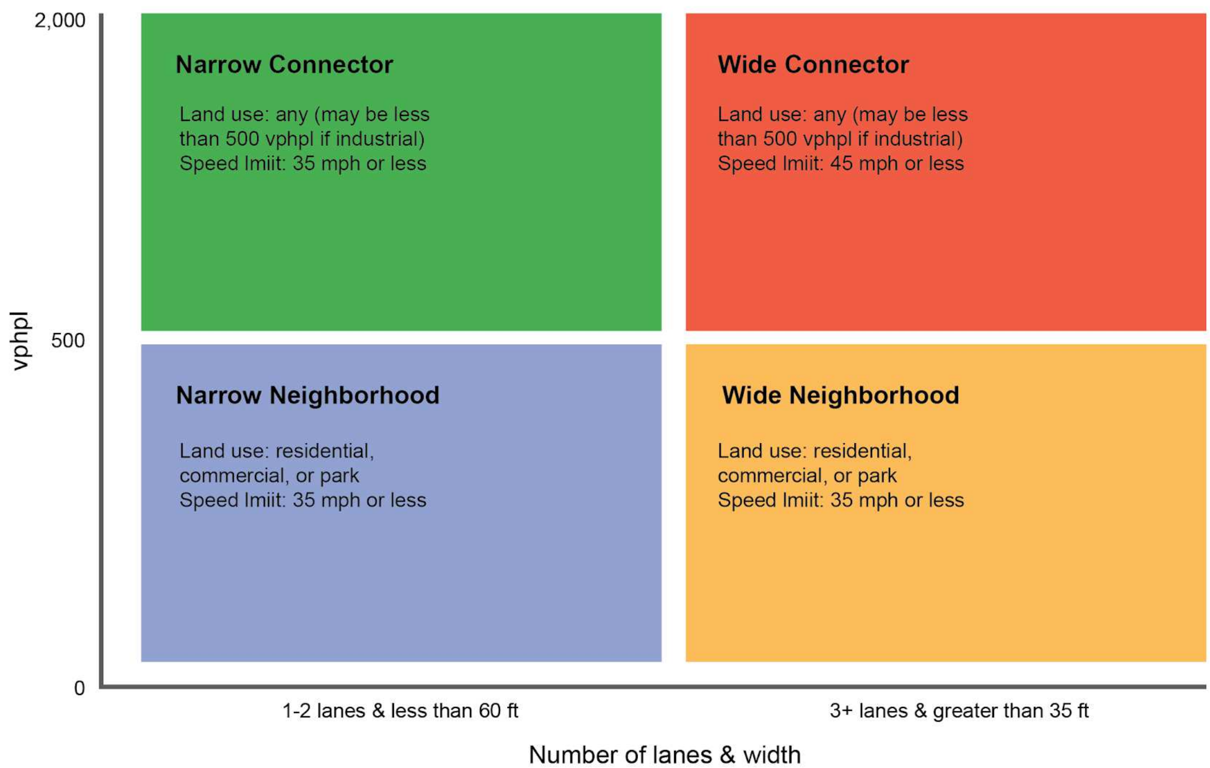
Answering each of these questions determined the parameters of the arterial typologies. They are distilled into (1) the physical characteristics of the roadway, (2) the adjacent land uses, and (3) the context of the roadway on an urban core-to-rural spectrum. The data analysis performed to assign each of these parameters are outlined below.

The outputs of this analysis resulted in nuanced but categorizable features for every arterial in Philadelphia. Through an iterative process with the stakeholder group, these features were adjusted in response to best practice research on the appropriateness of different types of traffic calming and considering the City of Philadelphia's current traffic calming practices. This resulted in four typologies that provide guidance to roadway owners in Philadelphia on what types of traffic calming to apply where needed that will not have an unduly detrimental impact on access or throughput. The four typologies are:

1. Narrow Neighborhood
2. Narrow Connector
3. Wide Neighborhood
4. Wide Connector

The four typologies are dictated by the roadway characteristics and land use parameters. **Figure 2** shows the four typologies on a matrix with volume (vehicles per hour per lane) on the vertical

Figure 2: Typologies Matrix



Source: DVRPC

axis and roadway width (by both feet and number of lanes) on the horizontal axis. Additional characteristics like adjacent land use and speed limit are listed with each typology.

Context is incorporated as an overlay, as outlined in the Guidance chapter. This guidance reflects conditions in Philadelphia at the time of publication and should be revised as conditions change using the agreed upon methodology. An example of a change that would prompt a review and possible revision is the conversion of an industrial land use into a residential development—a common re-use. Depending on the scale of such a land use change, the typology of the arterial serving this land use may change from connector to neighborhood. All such revisions should be addressed collaboratively among the stakeholders and reflected in appropriate mapping applications.

Selecting Arterials

To determine the scope of the network to be categorized into speed management-related typologies, DVRPC analyzed two distinct files:

1. PennDOT's Road Management System (RMS) data, and
2. The Philadelphia Streets Department's Centerline data.

Ultimately, 623 miles of roadway categorized as arterials were identified for inclusion in the project. Of these, 50 percent are PennDOT-owned and 50 percent are city-owned. This resulted in a total of 347 unique streets in Philadelphia. The following is a further breakdown of the methodology and categorization of the 623-mile arterial network.

Using the RMS layer, the project team began by isolating the 454 miles of roadway in Philadelphia considered a "Major Arterial" or "Minor Arterial" (FHWA functional class of 3 or 4) by PennDOT.[1] This includes roadways owned by PennDOT, as well as city-owned, Federal-aid roads. The RMS layer does not cover every road in Philadelphia. To ensure that roads also considered arterials by the Philadelphia Streets Department were not being excluded, we looked to their data for additional roadway mileage to include.

The Streets data was also limited to roads classified as "Major Arterial" or "Minor Arterial." These classifications do not correspond in every case to RMS classifications. There is a total of 625 miles of roadway classified as an arterial by Streets. Of this, 568 miles have corresponding RMS geometry. Most of this road mileage was already captured in the RMS roads isolated by functional class; however, 111 miles of RMS roadway classified as "Collector" or "Local" was considered an arterial by Streets. Therefore, these RMS segments were added to the network (less than one mile of roadway is classified as "Local").

Finally, 59 miles of roadway defined as an arterial in the Streets data had no corresponding RMS geometry. These road segments were not included in the analysis.

Binning Methodology

The process of assigning typologies required performing a range of analysis and quality control checks on the PennDOT RMS data, as well as bringing in additional datasets like DVRPC's land use data. The process for developing each of the key data points for assigning typologies are outlined below.

Physical Characteristics

Roadway width, number of lanes, and vehicles per hour per lane (vphpl) were based on PennDOT RMS data. This data is available by roadway segment, but many divided roadways are represented by parallel segments rather than a single segment. To address divided roadways where width only refers to one direction, segments were associated based on State Route Number and Sequence Number; the widths of segments with equivalent sequence numbers were summed and the sum assigned to both segments for typology setting. The same process was employed to calculate the number of lanes and vphpl.

Prior to finalizing the typology assignments, spot checks were performed on roads that were close to the threshold between "Wide" and "Narrow" as well as other edge cases to ensure they were accurately reflecting the width and number of lanes. This quality control process resulted in 47 adjustments to the width (more common) or number of lanes of a roadway segment.

To calculate the vphpl, the Annual Average Daily Traffic (AADT) data provided in the RMS data was summed if on a divided roadway, as described above. To convert AADT to vphpl, the following formula was used:

- vphpl = AADT/10/number of lanes

This formula is based on the rough estimate of peak hour traffic as 10 percent of total daily traffic, and then divided by the total number of lanes, regardless of the direction of travel.

Land Use

In order to assign land use to each segment, a 100 foot buffer was applied to each roadway segment and used to clip the adjacent land use frontages. This resulted in many different land uses along each roadway segment. **Figure 3** shows an example of clipped parcels along arterials. The total length of each land use type was calculated for each roadway segment. To further simplify the process, land use categories were refined to five categories (residential, commercial, institutional, industrial, and park), down from the original thirteen as these are the most relevant. The land use lengths were then summed by roadway segment to determine the predominant land use along the roadway.

[1] In order to avoid double-counting road miles of arterials split into east/west or north/south directions, odd-numbered segments were removed.

Figure 3: Assigning Land Use to Arterials

Source: DVRPC (2015)

In the final analysis, seven land use categories were used to describe the predominant use along a roadway segment ("Arterial Land Use Category" in Figure 3), including both "pure" (e.g. solely residential) and "mixed use" categories. The land use categories were defined as the following:

- **Park**: at least 90 percent of adjacent land use is park
- **Residential**: at least 70 percent of adjacent land use is residential
- **Commercial**: at least 50 percent of adjacent land use is commercial or institutional and less than 30 percent is residential
- **Industrial**: at least 30 percent of adjacent land use is industrial and less than 30 percent is residential
- **Mixed land uses**
  - Residential-Commercial: more than 30 percent residential and more than 30 percent commercial or institutional
  - Residential-Industrial: more than 30 percent industrial and more than 30 percent residential
  - Commercial-Industrial: more than 30 percent industrial and more than 30 percent commercial or institutional

Vacant land use was not a permitted category; it reverted to the most prevalent adjacent categories. Also, not every segment was categorized with the rules listed above; the rule of thumb was a land use category must be at least twice another to be the absolute category, otherwise the top two were selected as a mixed-use category.

Context

The issue of assigning a "context" category was one of the most challenging. In the initial analysis, DVRPC developed a measure of built-up area that could be cross-referenced with zoning classifications to develop a rough estimate of "urban" versus "urban core" that aligned with Green Book guidance. By joining property assessment data to census block data and removing open area lots like parks, a census block "floor area ratio" could be created for the city, with a threshold at 150 percent separating urban from urban core. This helped guide discussion in the stakeholder group. To be more responsive to expected land use changes and in recognition that simplified measures like 'built area' can be disconnected from the realities of land use activity in the urban core, the stakeholder group ultimately developed a more nuanced approach to identifying the urban core.

First, all census blocks within Center City from Spring Garden St. to South St., river to river, and University City (east of 38th St. and University Ave.) were included within the definition of urban core. Next, commercial corridor overlays developed and maintained by the Philadelphia City Planning Commission were added in, focusing on corridors characterized as “Pedestrian/Transit Corridor.” In addition, “Mixed Character” corridors were included if they were also considered a “Neighborhood Subcenter” or a “Neighborhood Center.”

Finally, the committee recognized the need for greater consideration of pedestrians near schools. Therefore, areas near to schools were included in the urban core overlay. Data from the City of Philadelphia was provided for the analysis. School locations were used to select the blocks which they were located within to create a new dataset containing each block that contained a school. Unusually large blocks were evaluated on a case-by-case basis to determine if the block was all school-related facilities such as sport fields. In addition, data on university parcels was obtained from OpenDataPhilly. A 50-foot buffer was put on this dataset to ensure that the parcels overlapped with the adjacent arterials.

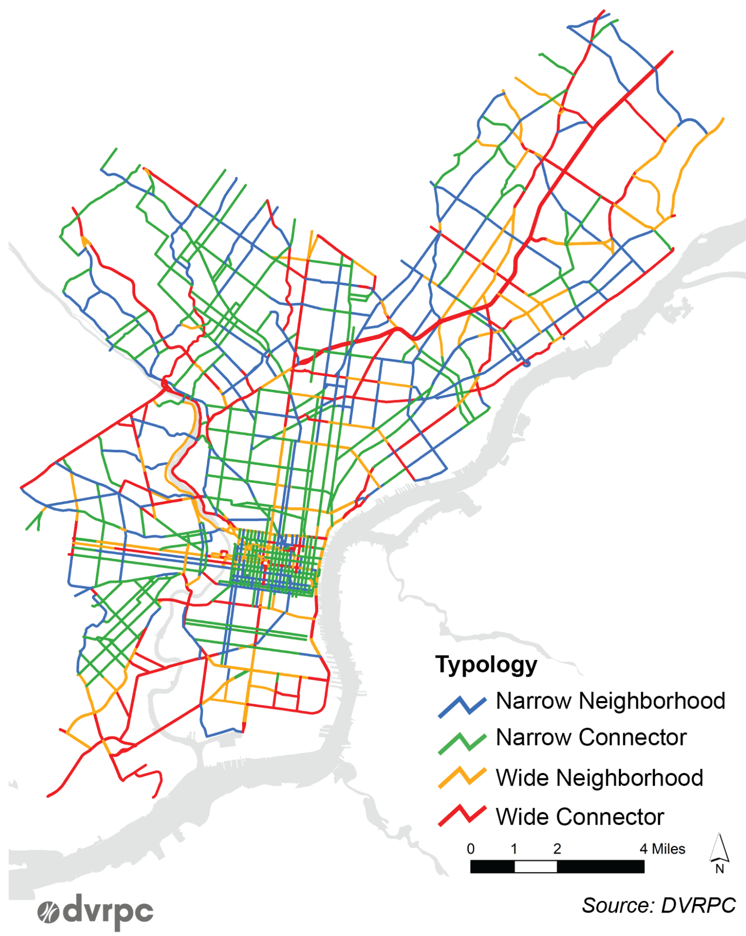
Guidance

How To Use This Chapter

Guidance

This chapter should be used in concert with the speed management typologies dataset, which is shown in **Figure 4**. Every arterial road segment in Philadelphia is assigned one of four typologies (Narrow Neighborhood, Narrow Connector, Wide Neighborhood, or Wide Connector). These typologies reflect context-sensitive characteristics of the arterial, summarized in **Table 1**. Each typology has a corresponding list of possible traffic calming treatments that are generally permissible on that type of arterial based on key considerations (primarily roadway geometry, land use, and estimated volume). The list of treatments is provided in **Table 2**.

Figure 4: Speed Management Arterial Typologies



Source: DVRPC

Determining Need

The guidance provided in this chapter will help to identify potentially applicable traffic calming strategies for arterials with a demonstrated speeding concern. The City of Philadelphia currently defines speeding as speeds of 10 mph or more over the legally posted speed limit. Additional key factors in determining the existence of a speeding concern include an overrepresentation of speeding-related crashes and highly elevated top-end speeds.

Treatments

Each treatment from the list of possible treatments must be evaluated individually for the target road segment. Relevant data points include:

- PennDOT estimated AADT
- DVRPC traffic counts
- Speed limit
- Road geometry
- Intersection density
- Transit/emergency route
- 85th percentile speed

The guidelines for evaluating specific treatments are provided as the last section of this chapter: Guidance by Treatment.

Table 1: Speed Management Typologies

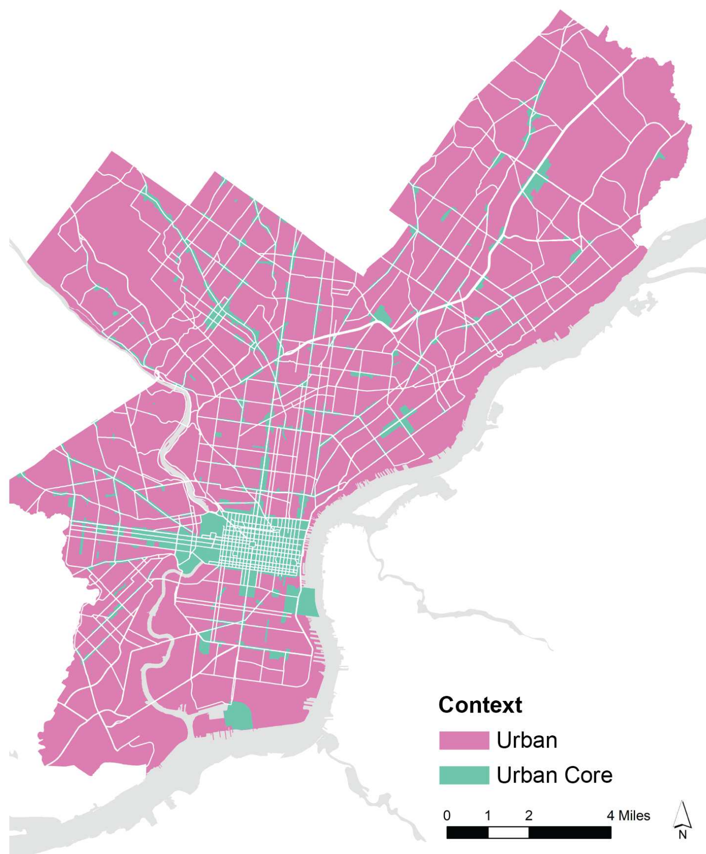
TYPOLOGY	SUMMARY
Narrow Neighborhood • Located in residential, commercial, or mixed-use land use contexts, including substantial residential uses. Narrower than typical arterials, similar to minor arterials or even collector streets • Up to 60 feet wide, however, if the number of lanes is limited. • Less than 500 vphpl during peak hours • Good candidates for "short profile" vertical deflection (see "Guidance by Treatment") to calm traffic where needed.	**Width:** 0-60 feet **Lanes:** 1-2 (may have 3 if road is less than 35 feet wide) **Land Use:** residential, commercial, park, mixed use including residential **Typical Volume:** 0-500 vphpl (peak hour) **Speed Limit:** 35 mph or less
Narrow Connector • Similar road geometry to Narrow Neighborhood roads • Conditions like the traffic volume and/or adjacent land use demand different approaches to traffic calming, such as considering "long profile" vertical deflection devices (see "Guidance by Treatment") • May have industrial or other auto-oriented adjacent land uses • Peak hour volumes are generally above 500 vphpl • **If a Narrow Connector road is located within the Urban Core overlay, treatments that would not otherwise be recommended may be considered.**	**Width:** 0-60 feet **Lanes:** 1-2 (may have 3 if road is less than 35 feet wide) **Land Use:** any **Typical Volume:** 500-1,750+ vphpl (peak hour); may be less for industrial and mixed commercial/industrial land use **Speed Limit:** 35 mph or less
Wide Neighborhood • Located in residential, commercial, or mixed-use land use contexts that include substantial residential uses • Generally wider than average with multiple lanes per direction • Due to lower volumes (less than 500 vphpl at peak hour), these roads may be good candidates for various types of vertical and horizontal deflection.	**Width:** 35+ feet, most are 60+ feet **Lanes:** 3+ (may have 2 if road is more than 60 feet wide) **Land Use:** residential, commercial, park, mixed use including residential **Typical Volume:** 0-500 vphpl **Speed Limit:** 35 mph or less
Wide Connector • Carry the greatest traffic volumes in the city, with both high lane volumes and large cross-sections • Generally wider than 60 feet and have multiple lanes per direction. • May be located in any land use type, but if they are located in an industrial area there is no minimum threshold for traffic volume • **As with Narrow Connector roads, if a Wide Connector road is located within the Urban Core overlay, treatments that would not otherwise be recommended may be considered.**	**Width:** 35+ feet, most are 60+ feet **Lanes:** 3+ (may have 2 if road is more than 60 feet wide) **Land Use:** any **Typical Volume:** 500-1,750+ vphpl at peak hour; may be less for industrial and mixed commercial/industrial land use **Speed Limit:** 45 mph or less

Urban Core Context

An urban core overlay is needed to interpret what treatments are appropriate for certain locations. The urban core was determined through a data-derived iterative process working with key stakeholders. It includes:

- Center City Philadelphia (Spring Garden Street to South Street, river to river) as well as parts of University City;
- Commercial corridors that have a pedestrian character (either alone or in conjunction with another character) as identified by the Philadelphia Department of Planning and Development; and
- Blocks with grade schools, colleges, and universities (included as a separate overlay that should receive urban core consideration).

Figure 5: Context Categories in Philadelphia



Source: DVRPC

Figure 5 shows the urban and urban core contexts mapped across Philadelphia.

Where a road segment is targeted for traffic calming with one of the two "Connector" typologies, and it passes into the urban core overlay, the list of possible treatments expands to include treatments that may be appropriate on the corresponding "Neighborhood" typology–this would ultimately be decided using engineering judgment. In these locations, the urban core designation indicates that greater latitude is justified for exceeding the guidance, particularly the recommended traffic volume ranges. This provision does not apply to the "Neighborhood" typologies because the urban core thresholds are already reflected in this typology.

Volume Ranges

Volume ranges are intended to ensure that the delay caused by traffic calming treatments doesn't result in a detrimental impact on Level of Service (LOS) during peak hours by significantly lowering travel speeds. Since most streets in the Urban Core already operate below target speeds at the peak hour, installation of traffic calming is unlikely to further reduce LOS at the peak hour. Meanwhile, installing traffic calming can greatly improve target speed-compliance at off-peak times when speeding is more likely and LOS levels have minimal delay.

Research

In the absence of definitive official guidance, the volume ranges used to differentiate between "Neighborhood" and "Connector" typologies were developed based on analysis of the impact that typical traffic calming measures would have on LOS to arterials, particularly vertical deflection. Research of the impact of speed cushions, tables, and humps on the volume of arterials before and after installation found a wide array of impacts suggesting that local context plays a significant role. One study identified the importance of considering throughput per lane at the peak hour, identifying an upper threshold of 750 vphpl as the upper threshold for maintaining LOS C on arterials with speed table installations in the local context.

Investigation of speed cushion installations on Philadelphia arterials with before and after volume counts identified four locations. AADT figures were converted to peak hour per lane using an assumed 10 percent peak hour volume. In three locations, volume reduction after installation was 8 percent or less including two locations with peak hour throughput of approximately 350 veh/ln. One location experienced a 29 percent reduction, from 582 veh/ln to 411 veh/ln. Further study of before and after vehicle counts and speeds is warranted to better understand the impact of vertical deflection on travel speed and throughput on Philadelphia streets.

The guidance provided in this document draws directly from research completed in 2020 for PennDOT evaluating traffic calming device spacing for urban arterials. The evaluation focused on speed cushion and speed slot installations, determining that speed cushions did not negatively impact throughput at specified spacings when traffic is less than 500 vphpl. These findings aligned with DVRPC's analysis of existing speed cushion installations in Philadelphia. Further, the analysis found that speed slot installations did not negatively impact throughput at specified spacings when hourly traffic is less than 1,750 veh/ln. Therefore, these thresholds were used to determine the cut-off between typologies. Further guidance on vertical deflection installation spacing is provided in the "Guidance by Treatment" section.

Guidance By Treatment

The following guidance provides recommended criteria for each speed management treatment identified in **Table 1**. This guidance should be used to help determine if the treatment is appropriate for a particular road segment. The guidance provides the best available data on the conditions under which the particular treatment will not create negative unintended outcomes on arterials, such as significant traffic diversion or dangerous driver maneuvering. **Table 2** presents the roadway typologies and corresponding speed management treatments from the universe of treatments included in this framework, including a filter for urban and urban core contexts. This table is meant to be the starting point for considering speed management treatments and not a replacement for careful consideration of the necessary data points. Also, the treatments included in this framework can be added to by PennDOT and the stakeholder group as new and innovative alternatives arise to ensure the framework remains up-to-date.

Treatment Data Points

- Recommended Volume Range: identifies the volumes for which the speed management treatment is most ideal because it will not cause significant diversion or degrade LOS.
- Recommended Target Speed Range: identifies the range of operating speeds that could be desired and expected on roads where the treatment is installed.
- Road Geometry: identifies factors like the number of lanes, intersection density, and whether the treatment is appropriate at the midblock and/or an intersection.
- Emergency & Transit Route Compatibility: indicates if the treatment is appropriate on these facilities[2]. Further guidance on ensuring compatibility with emergency routes is available in PennDOT's Design Manual 2's Traffic Calming chapter. In most instances, it is important to consult with transit and emergency response vehicle operators on the design of the treatment to ensure it does not hinder their operations, but in some limited cases a treatment is listed as "not recommended" or "permitted" if it is very likely to hinder operations or very unlikely to, respectively.
- Additional Guidance: related considerations provided per typology where appropriate.

As previously noted, this guidance is not exhaustive and should be considered in conjunction with the "Traffic Calming" chapter from PennDOT's DM-2, giving priority to the guidance provided here where it contradicts DM-2. More detail on each treatment is available in DM-2 as well as a screening matrix for traffic calming treatments and desired outcomes.

[2] The City of Philadelphia does not maintain a list of emergency routes.

Table 2: Speed Management Treatments by Typology

Table 2 is intended as a quick reference tool to identify potential speed management strategies by typology. Strategies must be evaluated on an individual basis by location using the guidance provided in this document.

	Narrow Neighborhood	Narrow Connector		Wide Neighborhood	Wide Connector	
		Urban	Urban Core		Urban	Urban Core
Vertical Deflection						
Speed hump	◐	○	◐	○	○	○
Speed cushion	●	○	◐	●	○	◐
Speed table	●	◐	●	●	○	◐
Speed slot	●	◐	●	●	◐	◐
Raised crosswalks	●	◐	◐	●	○	◐
Raised intersection	●	◐	◐	●	○	◐
Horizontal Deflection						
Single and multilane roundabouts	◐	◐	◐	◐	◐	◐
Mini roundabout	◐	◐	◐	○	○	○
Neighborhood traffic circle	●	○	◐	○	○	○
Gateway	●	●	●	○	○	○
Curb extension	●	●	●	●	●	●
Pedestrian median islands	◐	◐	◐	●	●	●
Hardened centerline	◐	◐	◐	●	●	●
Chicanes	●	○	◐	○	○	○
Road Configuration						
Parallel parking	●	●	●	●	●	●
Angled parking	◐	◐	◐	◐	◐	◐
Protected bicycle lane	●	●	●	●	●	●
Road diet with center turn lane	○	○	○	●	◐	●
Road diet with standard bike lane	◐	◐	◐	●	◐	●
Travel lane narrowing	●	◐	●	●	◐	●
Transverse soft rumble strips	●	●	●	●	●	●

Table Symbology

● *typically appropriate* ◐ *occasionally appropriate* ○ *rarely appropriate*

Source: DVRPC

Vertical Deflection

These traffic calming devices are presented in two broad categories: “short profile” vertical deflection devices and “long profile” vertical deflection devices. The “short profile” category includes both speed humps and speed cushions, which are generally 10–12 feet long and have a lower traversing design speed. The “long profile” category includes speed tables and speed slots, which are generally 20–22 feet long and have a higher traversing design speed. Raised crosswalks and raised intersections are addressed separately, as they do not fit neatly into either category.

The design speed of a roadway with either type of vertical deflection devices will be greatly influenced by the spacing of the devices; some guidance is provided, but engineer’s discretion is needed as placement is highly context sensitive. In addition, the slope of the vertical taper also greatly influences design speed; this guidance presumes the traversing platform is 3-inches above the roadway and a 1:8 slope gradient on the tapers. If the traversing platform of the vertical deflection element is more than 3 inches above the roadway, the taper should be adjusted accordingly, or the design speed will be lower.

Short profile vertical deflection

This category includes both speed humps and speed cushions. Both treatments have a similar design profile with a traversing distance of approximately 12 feet. Speed humps present a continuous edge running perpendicular to the direction of travel, while the perpendicular edge of a speed cushion treatment is interrupted to allow wider axle vehicles to pass unimpeded. This makes speed cushions more appropriate for transit, truck, and emergency routes.

1. Speed hump

DM-2[3] description: *A speed hump is a raised traffic calming device located midblock in the roadway to slow vehicular traffic and reduce speeds on the roadway through vertical deflection. Typically, speed humps are 12–14 feet long and 3–4 inches high. The spacing of speed humps typically determines the speed at which motorists can drive. For example, a spacing of approximately 250–500 feet tends to achieve an 85th percentile operating speed between 25 and 30 mph.*

Philadelphia-specific recommendations:

- **Recommended volume range**: 0–500 vphpl[4]
    - In the *urban core* context, the volume threshold may be higher than 500 vphpl or inapplicable all together depending on the design profile of the speed hump and according to engineering judgment
- **Recommended target speed range:** 20–30 mph[5]
- **Road geometry**: Midblock
    - Spacing should be 400’ for 25–30 mph target speed[6]
- **Emergency & transit route compatibility**: Discouraged
        - Consider a speed cushion instead
- **Additional guidance**:
    - A demonstrated speeding concern, such as:
        - Speeding-related crash trend
        - 85th percentile and/or top-end speeds exceed the speed limit and are in the fatal range for most hit pedestrian crashes (>35 mph)
    - If pre-installation 85th percentile speeds exceed 45 mph, supplemental traffic calming is needed to ensure safe installation[7]

[3] PennDOT, Design Manual 2 (Draft).
[4] “Evaluation of Traffic Calming Device Spacing for Urban Arterials.”
[5] Ibid.
[6] Ibid.
[7] FHWA, Traffic Calming e-Primer.

2. Speed cushion

DM-2*[8] *description: *Speed cushions have similar dimensions and applications as a speed hump, and are typically 3 inches high, 6 feet wide, and 7–14 feet long. Speed cushions consist of two or more raised areas placed laterally across a roadway with space between the raised areas to provide access for most wider axle emergency vehicles to cross with minimal disruption.*

Philadelphia-specific recommendations:

- **Recommended volume range:** 0–500 vphpl
    - In the *urban core* context, the volume threshold may be higher than 500 vphpl or inapplicable altogether depending on the design profile of the speed cushion and according to engineering judgment
- **Recommended target speed range:** 20–30 mph
- **Road geometry:** Midblock
    - Spacing should be designed as follows:
        - 400’ for 25–30 mph target speed
- **Emergency & transit route compatibility:** Permitted
- **Additional guidance:**
    - A demonstrated speeding concern, such as:
        - Speeding-related crash trend
        - 85th percentile and/or top-end speeds exceed the speed limit and are in the fatal range for most hit pedestrian crashes (>35 mph)
    - If pre-installation 85th percentile speeds exceed 45 mph, supplemental traffic calming is needed to ensure safe installation

Example of a speed cushion on N. 5th St. in Philadelphia. Source: DVRPC

Long profile vertical deflection

This category includes both speed tables and speed slots. Both treatments have a similar design profile with a traversing distance of approximately 22 feet. Speed tables present a continuous edge running perpendicular to the direction of travel, while the perpendicular edge of a speed slot treatment is interrupted to allow wider axle vehicles to pass unimpeded. This makes speed slots more appropriate for transit, truck, and emergency routes.

1. Speed table

DM-2*[9] *description: *Speed tables have similar dimensions and applications as a speed hump, but with the exception that they have a flat top designed to accommodate the wheelbase of a passenger car, generally 10-feet long. Speed tables are typically 22 feet long with a 10-foot plateau and 6-foot taper on either side. If a speed table is designated as a crosswalk, it is known as a raised crosswalk.*

Philadelphia-specific recommendations:

- **Recommended volume range**: 0–1,750 vphpl[10]

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[8] PennDOT, Design Manual 2 (Draft).

[9] Ibid.

[10] “Evaluation of Traffic Calming Device Spacing for Urban Arterials.”

- In the *urban core* context, the volume threshold may be higher than 1,750 vphpl or inapplicable altogether depending on the design profile of the speed table and according to engineering judgment
- **Recommended target speed range:** 20–35 mph[11]
- **Road geometry**: Midblock (if at intersection, see "Raised Crosswalk")
  - Spacing should be designed as shown in **Table 3**:[12]

Table 3: Speed Table Spacing Recommendations

Target Speed	0 to 500 vphpl	500 to 750 vphpl	750 to 1,000 vphpl	1,000 to 1,250 vphpl	1,250 to 1,500 vphpl	1,500 to 1,750 vphpl
25 MPH	250'	250'	250'	250'	>400'	>400'
30 MPH	250'	300'	350'	400'	450'	450'
35 MPH	350'	400'	500'	550'	600'	600'

- **Emergency & transit route compatibility:** Discouraged
  - Consider a speed slot instead
- **Additional guidance:**
  - A demonstrated speeding concern, such as:
    - Speeding-related crash trend
    - 85th percentile and/or top-end speeds exceed the speed limit and are in the fatal range for most hit pedestrian crashes (>35 mph)

2. Speed slot

Description (not in DM-2): *Speed slots have similar dimensions and applications as a speed table, typically 22 feet long with a 10-foot plateau and 6-foot approaches on either side. Speed slots consist of two or more raised areas placed laterally across a roadway with space between the raised areas to provide access for most wider axle emergency vehicles to cross with minimal disruption.*

Philadelphia-specific recommendations:

- **Recommended volume range:** 0–1,750 vphpl[13]
  - In the *urban core* context, the volume threshold may be higher than 1,750 vphpl or inapplicable all together depending on the design profile of the speed slot and according to engineering judgment
- **Recommended target speed range:** 20–35 mph[14]
- **Road geometry:** midblock
  - Spacing should be designed as shown in **Table 4**:[15]

Example of a speed slot on Cobbs Creek Pkwy in Philadelphia. Source: DVRPC

[11] "Evaluation of Traffic Calming Device Spacing for U
[12] Ibid.
[13] Ibid.
[14] Ibid.
[15] Ibid.

Table 4: Speed Slot Spacing Recommendations

Target Speed	0 to 500 vphpl	500 to 750 vphpl	750 to 1,000 vphpl	1,000 to 1,250 vphpl	1,250 to 1,500 vphpl	1,500 to 1,750 vphpl
25 MPH	250’	250’	250’	250’	>400’	>400’
30 MPH	250’	300’	350’	400’	450’	450’
35 MPH	350’	400’	500’	550’	600’	600’

- **Emergency & transit route compatibility:** Permitted
- **Justification of need:**
  - A demonstrated speeding concern, such as:
    - Speeding-related crash trend
    - 85th percentile and/or top-end speeds exceed the speed limit and are in the fatal range for most hit pedestrian crashes (>35 mph)

Raised crosswalk

DM-2[16] description: *Raised crosswalks are a vertical traffic calming treatment similar to speed tables applied at pedestrian crossing locations. Raised crosswalks elevate a crosswalk from street level to sidewalk level, thereby improving visibility and awareness of pedestrians, reducing vehicle speeds, and improving pedestrian comfort and safety. Typical approach ramps are 5–7 feet with a top flattened width of 10 feet and a total length of 20–24 feet. Raised crosswalks combine the benefits of a speed hump with enhanced visibility for pedestrian crossings.*

Philadelphia-specific recommendations:

- **Recommended volume range**: 0–1,750 vphpl
  - In the *urban core* context, the volume threshold may be higher than 1,750 vphpl or inapplicable altogether depending on the design profile of the raised crosswalk and according to engineering judgment
- **Recommended target speed range**: 20–35 mph[17]
- **Road geometry**: Intersection or midblock locations where crosswalk exists or is warranted; maximum two lanes without a median island or stop control
  - Raised intersections are preferred at intersections, though raised crosswalks may be considered on a case-by-case basis
- **Emergency & transit route compatibility**: Design profile of the treatment should be selected in consultation with bus and emergency vehicle operators[18]

Example of a raised crosswalk on Arch St. in Philadelphia. Source: DVRPC

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[16] PennDOT, Design Manual 2 (Draft).
[17] Ibid.
[18] PennDOT, Design Manual 2 (Draft).

- **Additional guidance:**
    - A demonstrated speeding concern, such as:
        - Speeding-related crash trend
        - 85th percentile and/or top-end speeds exceed the speed limit and are in the fatal range for most hit pedestrian crashes (>35 mph)

Raised intersection

DM-2[19] description: *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, typically 3–6 inches above street grade and typically uses brick or other textured materials. Raised intersections combine the benefits of speed humps and raised crosswalks, resulting in improved pedestrian visibility, safety, reduced vehicle speeds, and driver awareness. Raised intersections are also referred to as raised junctions, intersection humps, or plateaus.*

Philadelphia-specific recommendations:

- **Recommended volume range**: 0–1,750 vphpl[20]
    - In the *urban core* context, the volume threshold may be higher than 1,750 vphpl or inapplicable altogether depending on the design profile of the raised intersection and according to engineering judgment
- **Recommended target speed range**: 20–35 mph[21]
- **Road geometry**: Any signalized or all-way stop-controlled intersection[22]
- **Emergency & transit route compatibility**: Design profile of the treatment should be selected in consultation with bus and emergency vehicle operators[23]
- **Additional guidance**:
    - A demonstrated speeding concern, such as:
        - Speeding-related crash trend
        - 85th percentile and/or top-end speeds exceed the speed limit and are in the fatal range for most hit pedestrian crashes (>35 mph)

Example of a raised intersection on S. Broad St. in Philadelphia. Source: DVRPC

Horizontal Deflection

Single and multi-lane roundabouts

DM-2 description: *A roundabout is an intersection control form where traffic entering the circulatory roadway yields to circulating vehicles (this is different from a traffic circle—refer to NCHRP Report 672, page 1–3 for the description of a traffic circle). … A roundabout is included as a traffic calming measure because the geometric design of a roundabout can change the operating character of a roadway and slow speeds. Roundabouts can be effective if implemented in conjunction with other traffic calming features to reinforce a change in environment: for example, as a gateway treatment where higher-speed facilities transition to*

[19] Ibid.
[20] Ibid.
[21] Ibid.
[22] Ibid.
[23] Ibid.

lower-speed facilities with pedestrian presence. A roundabout typically has a non-traversable central island which can be landscaped with ground cover, street trees, or flowers.

Philadelphia-specific recommendations:

- **Recommended volume range**: 0–25,000 AADT (single-lane), 0–60,000 AADT (multi-lane)[24]
- **Recommended target speed range**: Any urban arterial speed
- **Road geometry**: Replaces signalized intersection; may require additional right-of-way
- **Emergency & transit route compatibility**: Design profile of the treatment should be selected in consultation with bus and emergency vehicle operators[25]
- **Additional guidance**:
    - Must follow FHWA guidance on modern roundabout design

Example of a roundabout on Frankford Ave. in Philadelphia. Source: DVRPC

Mini roundabout

DM-2[26] description: *A mini-roundabout is a smaller roundabout typically used in an urban environment with operating speeds of 30 mph or less. The central island of a mini-roundabout is fully traversable.*

Philadelphia-specific recommendations:

- **Recommended volume range**: 0–15,000 AADT[27]
    - In the *urban core* context, the volume threshold may be higher or inapplicable altogether according to engineering judgment
- **Recommended target speed range**: any urban arterial speed
- **Road geometry**: intersections' approaches must be one lane per direction[28]
- **Emergency & transit route compatibility**: Design profile of the treatment should be selected in consultation with bus and emergency vehicle operators[29]
- **Additional guidance:**
    - Must follow FHWA guidance on modern roundabout design
    - Left-turn movements difficult for transit vehicles[30]
    - Should utilize traversable center island (unlike single-lane roundabout)

Neighborhood traffic circle

Description (not in DM-2): *Neighborhood traffic circles consist of a raised central island at the intersection of two typically lower-volume, local roads. They lack the channelization of roundabouts and, in some cases, even permit left turns in front of the circle.*

Philadelphia-specific recommendations:

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24 FHWA Traffic Calming e-Primer.
25 PennDOT, Design Manual 2 (Draft).
26 Ibid.
27 Ibid.
28 FHWA Traffic Calming e-Primer.
29 PennDOT, DM-2 (Draft).
30 Ibid.

- **Recommended volume range:** 0–3,500 AADT[31]
    - In the *urban core* context, the volume threshold may be higher or inapplicable altogether according to engineering judgment
- **Recommended target speed range:** 20–30 mph[32]
- **Road geometry**: Intersections; since it lacks approach controls (splitter islands), this treatment is only appropriate on roads with a single lane approach per direction (not appropriate on one-way, two-lane roads)
- **Emergency & transit route compatibility**: Design profile of the treatment should be selected in consultation with bus and emergency vehicle operators[33]
- **Additional guidance**:
    - Left-turn movements may be difficult for transit vehicles[34]

Gateway

DM-2[35] description: *Gateways are used as entrance treatments that use physical and textural changes to provide identity to an area. They include features such as curb cuts, raised crosswalks, signs, textured pavement, street furniture, and/or landscaping to narrow the apparent width of the roadway and potentially reduce the operating speed of motorists. Gateways indicate an entrance to a special area that may require lower speeds or higher pedestrian activity, and they are useful where roadways transition to areas with slower-speed environments, such as residential neighborhoods, school zones, or shared streets.*

Philadelphia-specific recommendations:

- **Recommended volume range**: None[36]
- **Recommended target speed range**: Any urban arterial speed
- **Road geometry**: Marking a change in speed limit or land use; typically on a narrow street where it intersects a wide road or vice versa
- **Emergency & transit route compatibility**: Permitted
- **Additional guidance**:
    - Limited access transition gateway: a range of strategies can be employed to slow vehicles exiting off-ramps on to the city grid, including:
        - Soft transverse rumble strips
        - Signage
        - Automated enforcement
        - Roundabouts
        - Curb extensions and pedestrian median islands do not narrow travel lanes below 11’

Curb extension

DM-2 description: *Curb extensions narrow the width of a roadway visually and physically through the expansion of the sidewalk and curb, usually to the edge of the on-street parking lane. A curb extension can be implemented at an intersection or a midblock location. Other names for intersection curb extensions include “bulb outs” or “bump outs.” The purpose of a curb extension is to reduce the 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.*

Philadelphia-specific recommendations:

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[31] FHWA Traffic Calming e-Primer.
[32] Ibid.
[33] PennDOT, Design Manual 2 (Draft).
[34] Ibid.
[35] Ibid.
[36] Ibid.

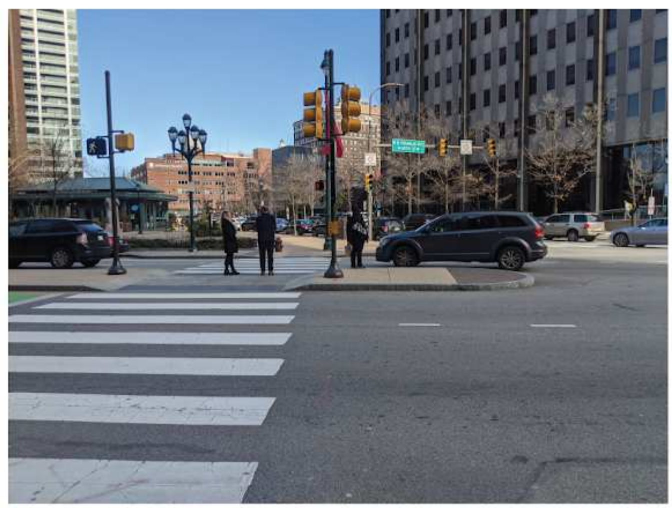
- **Recommended volume range**: None[37] (0–6,000 AADT if lane narrowing)[38]
    - In the *urban core* context, the volume threshold may be higher or inapplicable altogether according to engineering judgment
- **Recommended target speed range**: Any urban arterial speed[39]
- **Road geometry**:
    - At intersections, the street must have on-street parking or a shoulder and may have any number of lanes
    - At midblock, the street must have on-street parking or a shoulder and no more than two lanes unless a median island is present[40]
- **Emergency & transit route compatibility**: Permitted
    - Consult with bus and emergency vehicle operators where intersecting street is part of a bus/emergency route
- **Additional guidance**:
    - Philadelphia Streets Department focuses intersection installations at:[41]
        - Long crossings, especially at unsignalized locations
        - Transit stops
        - High pedestrian generators where vehicles encroach on crosswalks or fail to yield to pedestrians
        - Designated school crossing guard location
        - “Safe Routes to School” locations
        - Intersections with restricted corner sight distance (e.g., illegal parking?
    - Temporary solutions may use paint and posts, such as a corner wedge[42]

Pedestrian median islands

DM-2[43] description: *Pedestrian median refuge islands provide added protection for pedestrians and bicyclists crossing at an intersection or midblock. 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, seniors, children, and others less able to cross the street in a single stage.*

Philadelphia-specific recommendations:

- **Recommended volume range**: None; encouraged over 9,000 AADT[44]
- **Recommended target speed range**: Any urban arterial speed; encouraged at high-end speeds (35 mph+)[45]
- **Road geometry**: Two-way street, minimum 60 ft width recommended; intersection or midblock[46]



Example of a pedestrian median island on the Ben Franklin Pkwy in Philadelphia.
Source: DVRPC

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[37] Ibid.
[38] NACTO
[39] FHWA Traffic Calming e-Primer.
[40] PennDOT, Design Manual 2 (Draft).
[41] Traffic Calming Policies & Guidelines, City of Philadelphia, Department of Streets, Traffic Engineering Division (2014).
[42] NACTO
[43] PennDOT, Design Manual 2 (Draft).
[44] FHWA, Proven Safety Countermeasures.
[45] Ibid.
[46] PennDOT, Design Manual 2 (Draft).

- **Emergency & transit route compatibility**: Design profile of the treatment should be selected in consultation with bus and emergency vehicle operators.
- **Additional guidance**: None

Hardened centerline

Example of a hardened centerline on N. Broad St. in Philadelphia. Source: City of Philadelphia

Description (not in DM-2): *Hardened centerlines consist of delineators that extend along the centerline up to, and sometimes beyond, the crosswalk. They force left-turning vehicles to make a more perpendicular turn, thereby calming traffic at the intersection.*

Philadelphia-specific recommendations:
- **Recommended volume range**: None
- **Recommended target speed range**: Any urban arterial speed
- **Road geometry**: At intersections, on two-way streets (slows left turning traffic)[47]
- **Emergency & transit route compatibility**: Design profile of the treatment should be selected in consultation with bus and emergency vehicle operators.
- **Additional guidance**: This treatment is not included in the traffic calming chapter of DM-2, more guidance is available in NACTO's guidebook, "Don't Give Up at the Intersection" (2019)

Chicanes

DM-2[48] description: *Chicanes narrow the width of a street using a series of alternating curves, staggered parking, or alternating curb extensions. They lower speeds by requiring motorists to shift laterally through narrowed travel lanes, and they provide opportunities to increase public space, including additional sidewalk and greenspace. Medians may be used at deflection points to prevent speeding motorists from disregarding roadway markings. Chicanes are also referred to as lane offsets, serpentines, reversing curves, or twists.*

Philadelphia-specific recommendations:
- **Recommended volume range**: 0–3,500* AADT[49]
    - * Recommended volume range for chicanes is for all roadways, regardless of context or design profile; **in the urban core context**, the volume threshold may be much higher or inapplicable altogether depending on the design profile of the chicane and according to engineering judgment
- **Recommended target speed range:** 20–35 mph
- **Road geometry**: Maximum 2 lanes[50]
- **Emergency & transit route compatibility**: Not recommended
- **Additional guidance:** None

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47 NACTO
48 PennDOT, Design Manual 2 (Draft).
49 Ibid.
50 Ibid.

Road Configuration

On-street parking (parallel & angled)

DM-2[51] description: *On-street parking effectively narrows the roadway travel lanes by adding side friction to the travel flow, and it may be used to encourage traffic calming. On-street parking may be allocated on alternate sides of a roadway to create a chicane effect, and it must be occupied with parked vehicles to effectively promote traffic calming. On-street parking may be parallel, front-in, or front-out angled parking… Additionally, on-street parking may be combined with other treatments, such as curb extensions, midblock chokers, chicanes, or road diets to have a greater traffic calming impact.*

Example of back-in angle parking on N. 2nd St. in Philadelphia.
Source: DVRPC

Philadelphia-specific recommendations:

- **Recommended volume range**: None
- **Recommended target speed range**: Any urban arterial speed[52]
- **Road geometry**: Minimum 18 ft cartway width for one side parking or 26 ft cartway width for two-sided parking[53]
- **Emergency & transit route compatibility**: Permitted
- **Additional guidance**: Most effective for speed management if on both sides of a narrow road[54].

Road diet

DM-2[55] description: *A road diet involves removing vehicle lanes from a roadway and reallocating the extra space for other uses or modes, including bicycle infrastructure, wider sidewalks, landscaping, on-street parking, and transit facilities. Road diets are also known as "lane reductions" and "roadway reconfigurations." The most common road diet configuration is the conversion of an undivided four-lane roadway to a three-lane undivided roadway made up of two through lanes and a center two-way left-turn lane.*

Philadelphia-specific recommendations:

- **Recommended volume range**: 0–25,000 AADT[56]
- **Recommended target speed range**: Any urban arterial speed[57]
- **Road geometry**: Wide roads
- **Emergency & transit route compatibility**: Permitted

Example of a road diet with a protected bike lane on Race St. in Philadelphia.
Source: DVRPC

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[51] PennDOT, Design Manual 2 (Draft).
[52] FHWA Traffic Calming e-Primer.
[53] Traffic Calming Policies & Guidelines, City of Philadelph Division (2014).
[54] PennDOT, Design Manual 2 (Draft).
[55] Ibid.
[56] FHWA Traffic Calming e-Primer.
[57] PennDOT, Design Manual 2 (Draft).

- See "Travel lane narrowing" guidance below to ensure remaining lanes meet minimum width
- **Additional guidance**:
  - Road diets should include lane narrowing and/or reduction through the addition of a center turn lane (4-to-3, 4-to-5, 2-to-3, 5-to-3, etc.), with or without a bike lane
  - If a bike lane is included, consult with the bicycle design chapter of DM-2 or in NACTO's guidebook, "Urban Bikeway Design Guide" (2013) for guidance

Travel lane narrowing

DM-2[58] description: *Lane width is an important element of street design. Lane widths delineate space for vehicles, buses, trucks, bicycles, and parked vehicles within a street cross-section. The travel lane width of a roadway influences driver comfort, operations of the roadway, and the likelihood of crashes. …Research has shown wider travel lanes are correlated with higher vehicle speeds, while narrow 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.*

Philadelphia-specific recommendations:
- **Recommended volume range**: None
- **Recommended target speed range**: Any urban arterial speed; if arterial target speed is 30 mph or less, 10 ft lanes are preferred[59]
- **Road geometry**: None
- **Emergency & transit route compatibility:**
  - Truck and transit routes should be 11 feet, all others should be 10-foot travel lanes
  - Wider lanes may be required on truck and transit routes at curves, where turning vehicle geometry requires it
- **Additional guidance**: None

Transverse soft rumble strips

DM-2[60] description: *Double thick thermoplastic transverse pavement markings have been successful in slowing traffic in diverse areas such as school zones, hospitals, approaches to severe curves, and stop signs. These markings typically consist of five transverse, 6-inch-wide stripes, installed 2 feet on center, repeated every 100 feet. Depending on conditions, three to five sets of clusters are installed per approach. It is estimated that each cluster reduces approach speeds by 1–3 mph. As vehicles travel over these thermoplastic markings the noise and vibration alert the driver. It may be inappropriate to use this application in locations with nearby residents due to the noise generated.*

Philadelphia-specific recommendations:
- **Recommended volume range**: None
- **Recommended target speed range**: None
- **Road geometry**: None
- **Emergency & transit route compatibility**: Permitted
- **Additional guidance**: May not be appropriate in "Neighborhood" typologies due to noise issues caused by vehicles traveling over the rumble strips[61]

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58 Ibid.
59 PennDOT, Design Manual 2 (Draft).
60 Ibid.
61 Ibid.

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Arterial Typology and Speed Management Decision-Making Framework for the City of Philadelphia

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Abstract: This document provides guidance in conjunction with the “Traffic Calming” chapter of the Pennsylvania Department of Transportation’s Design Manual-2 (DM-2) which outlines the traffic calming process for local jurisdictions. Through a data-driven analysis and in partnership with PennDOT District 6-0 and the City of Philadelphia, arterial typologies were developed to aid with identifying speed management strategies appropriate for the City of Philadelphia’s arterial road network. The guidance provided is intended to augment and, in some cases, supersede guidance provided by DM-2.

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