Traffic Calming Protocol Manual

MUNICIPALITY OF ANCHORAGE TRAFFIC DEPARTMENT

MARCH 2001

TRAFFIC CALMING PROTOCOL MANUAL

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ABBREVIATIONS AND ACRONYMS

AAC ..... Agency Advisory Committee
AASHTO..... American Association of State Highway & Transportation Officials
ADA .....Americans with Disabilities Act
ADOT&PF .....Alaska Department of Transportation and Public Facilities
ADT..... average daily traffic
AFD .....Anchorage Fire Department
AMATS ..... Anchorage Metropolitan Area Transportation Study
APD .....Anchorage Police Department
ASD .....Anchorage School District
CFR ..... Code of Federal Regulations
DOWL ..... DOWL Engineers
FCC .....Federal of Community Councils
FHWA .....Federal Highway Administration
ITE..... Institute of Transportation Engineers
min.....minimum
mph..... miles per hour
MOA.....Municipality of Anchorage
MUTCD .....Manual of Uniform Traffic Control Devices
NATC .....Neighborhood Advisory Traffic Committee
OSHP.....Official Street and Highways Plan
perm..... permanent
R ..... radius
ROW .....Right-of-Way
TCPM .....Traffic Calming Protocol Manual
temp .....temporary
TYP ..... typical
U.S. .....United States
v:h.....vertical:horizontal
vpd..... vehicles per day
VSDB .....Variable Speed Display Board

1.0 INTRODUCTION AND OBJECTIVES

This Traffic Calming Protocol Manual (TCPM) was developed for the Municipality of Anchorage (MOA), Traffic Department. The TCPM is intended to function as a planning and design manual for engineers, planners, developers, and local residents who have an interest in traffic calming within the MOA and desire to know more about the proper applicability, geometric design, planning and public involvement, procedures, and effectiveness of traffic calming improvements.

Institute of Transportation Engineers' (ITE), *Traffic Calming State-of-the-Practice* (Ewing, 1999) defines traffic calming as follows: "Traffic calming involves changes in street alignment, installation of barriers, and other physical measures to reduce traffic speeds and/or cut-through volumes in the interest of street safety, livability, and other public purposes." The ITE definition does not include non-engineering measures that modify street appearance to affect vehicle speeds nor does it mollify residents that perceive a traffic volume or speed problem. Examples of these non-engineering measures include roadside tree and flower planting, increased traffic enforcement, and neighborhood traffic safety campaigns.

An Agency Advisory Committee (AAC) was established to support and guide the development of this TCPM. The AAC included representatives from Community Planning, Anchorage Fire Department (AFD), Anchorage Police Department (APD), MOA Street Maintenance, Anchorage School District (ASD), MOA Traffic Department, and the Federation of Community Councils (FCC).

This manual was assembled in consultation with Mr. Reid Ewing from Rutgers University and with various MOA departments and employees who volunteered their efforts to assist us in better understanding the issues and concerns regarding traffic calming in Anchorage. This manual borrows heavily from the experiences of the MOA through their initiatives and experiences in Fairview and Mountain View during the 1990s, as well as from the *Delaware Traffic Calming Manual* (Ewing, 2000) and ITE's *Traffic Calming State-of-the-Practice* (Ewing, 1999).

Beginning in the 1990s, traffic calming has been employed in Anchorage with significant success. The first projects were focused on two neighborhoods (Fairview and Mountain View) that were experiencing economical challenges as well as high levels of street crime relative to other areas of the MOA. Both neighborhoods were originally laid out in a rather large grid pattern with long, straight, wide streets running north-south and east-west. Between 1995 and 2000, a significant traffic calming program was undertaken in Anchorage's Fairview neighborhood that was aimed at reducing cut-through traffic, reducing trafficking of illegal substances, making policing easier, and reducing traffic volumes and speeds on residential streets and collectors. These capital improvements in Fairview resulted in renewed life in the community, an increased sense of pride and neighborhood livability, and a safer environment for this highly pedestrian-dependent neighborhood. The measured improvements in Fairview manifested themselves in increased property values, reduced crime rates, and a more vibrant and family-oriented community.

In 1998 and 1999, the MOA worked with the community of Mountain View to devise a framework plan for traffic calming improvements and modifications to address some of their problems and challenges. Although some of the same treatments were borrowed from Fairview, they were typically arranged in different configurations to address different problems and challenges. Those improvements were primarily constructed in 2000 with some carryover into 2001.

The applicability of this TCPM is primarily suited to residential streets and low volume neighborhood collectors. Some states and local governments have developed complex algorithms that are used to numerically determine the applicability of traffic calming. Some of these algorithms include an analysis of traffic speeds, accidents, volumes, residential voting results, and other such quantitative parameters to determine if traffic calming can be used to solve a certain problem. After much consideration and discussion, the AAC determined that the success of Anchorage's past endeavors in traffic calming have centered around being able to temper the quantitative analytical process with an area-wide approach rather than intersection-by-intersection or street-by-street. Under this approach, much of the decision-making power is left

in the hands of the MOA Traffic Engineer and his/her staff working in concert with the community to address both qualitative and quantitative criteria and issues.

2.0 APPLICABILITY AND PROCEDURES

This manual and the guidelines it contains apply to all streets and highways under the MOA's jurisdiction. This includes all existing and new subdivision streets that are or will be maintained by the MOA and are candidates for traffic calming.

This manual does *not* apply to streets under State of Alaska Department of Transportation and Public Facilities (ADOT&PF) control nor to private streets under the control of neighborhood associations. Traffic calming on these streets is the responsibility of the entities maintaining them.

This manual does *not* mandate traffic calming on existing streets under MOA control. If residents, local officials, or others initiate traffic calming, the MOA will follow the guidelines contained herein with some approved exceptions. This manual also does *not* mandate traffic calming on new subdivision streets to be turned over to the MOA. Nevertheless, if private developers choose to consider traffic calming measures (something the MOA encourages), they will be subject to the application, geometric, and signing and marking guidelines contained in this manual.

Even with standardization of traffic calming in the MOA, design flexibility will remain. This TCPM sets forth guidelines rather than rigid policies. The MOA reserves the right to deviate from these guidelines in special cases at the discretion of the MOA Traffic Engineer. The guidelines provide flexibility in that they offer options rather than dictating single design solutions.

This chapter establishes procedures for traffic calming in the MOA for deciding when, where, and how to calm its streets. The MOA will follow the procedures outlined in this chapter.

2.1 Steps in the Process

A traffic calming program may be *reactive* (responding to citizen requests for action) or *proactive* (with MOA staff identifying problems and initiating action prior to complaints, accidents, and other negative consequences of traffic through neighborhoods). A traffic calming program may make *spot* improvements, street-by-street, or may plan and implement improvements on an *area-wide* basis with multiple streets treated at the same time. Figure 1 shows the typical process that a traffic calming project will usually follow.

2.1.1 Project Initiation

Anyone can suggest or recommend that traffic calming improvements be considered at a particular location or neighborhood. However, the MOA prefers traffic calming requests come through associations or community councils representing the broad interests of the community or neighborhood. The MOA will encourage individuals to work through their community councils rather than initiating projects on their own. Projects shall be initiated by submitting a formal letter of request or community council resolution to the MOA Traffic Engineer.

2.1.2 Project Selection

2.1.2.1 Screening

The MOA will make an initial determination of eligibility for traffic calming under the MOA Application Guidelines detailed later in this manual (see Table 5). Traffic volume and speed data will be gathered (if not already available) for the streets in question. Streets must be at a functional classification level eligible for traffic calming (neighborhood collector or below per the Official Street and Highways Plan [OSHP]) and have a daily volume and 85th percentile speed within the eligible ranges shown in Table 5. The same volume and speed information will subsequently be used by the MOA to rate projects for funding priority.

2.1.2.2 Priority Rating

The MOA will rate eligible traffic calming projects and, on a fiscal year basis, rank them for funding priority. The highest ranked projects will be programmed for installation subject to available funding.

Traffic calming improvements will be funded primarily out of Anchorage Roads and Drainage Service Area bonds, which are subject to the approval of the voters each year. Developers or homeowners' associations may also partially or fully privately fund traffic calming. All traffic calming projects, even those privately funded, must meet all process and substantive requirements outlined in this manual.

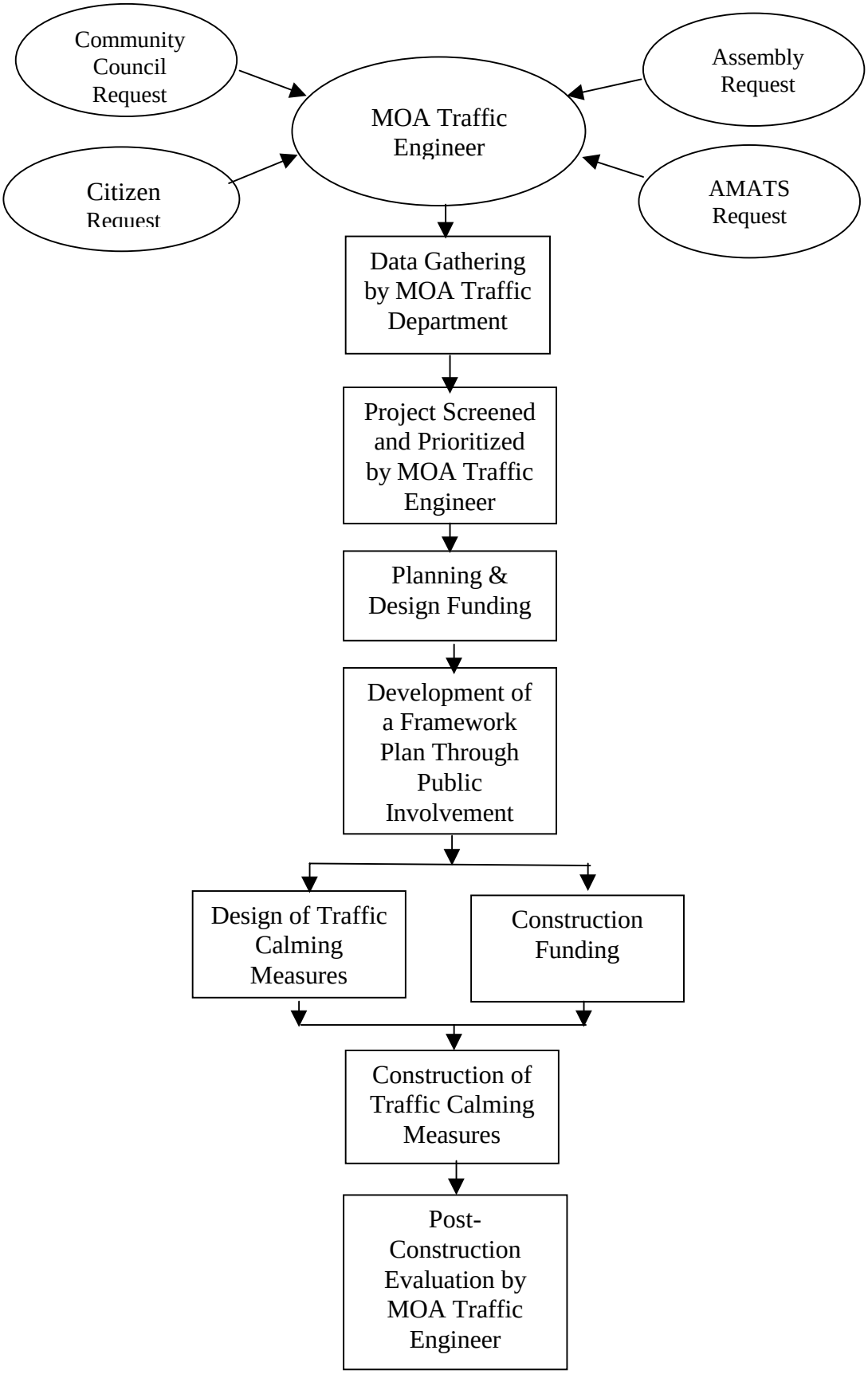


Figure 1: Traffic Calming Flow Chart

2.1.3 Plan Development

2.1.3.1 Impact Area

In consultation with the party requesting traffic calming, the MOA will define the impact area of projects for purposes of plan development and public approval. This area shall encompass all streets proposed for traffic calming, all streets only accessible via such streets, and all streets likely to be significantly impacted by diverted traffic. A significant impact is defined as an increase of more than 100 vehicles per day (vpd) on any residential street and more than 600 vpd on any collector street[1].

The impact area will ordinarily be larger for volume control measures than for speed control measures and larger for severe speed control measures such as speed humps than for mild measures such as center island narrowings. In defining the impact area, the MOA will consult volume impact information contained in the ITE's *Traffic Calming State-of-the-Practice*. In the absence of better estimates, the MOA will use average percentage reductions in traffic volumes on traffic calmed streets as reported by ITE and will assign the corresponding diverted traffic to neighboring streets in order to determine if the significance threshold is met. The final decision regarding what streets will be impacted rests with the discretion of the MOA Traffic Engineer. Volume impacts of some common traffic calming measures as reported by ITE are reproduced in Table 1.

1 R. Ewing, *Traffic Calming State-of-the-Practice*, Institute of Transportation Engineers, Washington, D.C., 1999.

Table 1: Volume Impacts of Common Traffic Calming Measures

Measure	Average Percent Reduction in Traffic Volume
Speed Humps	20%
Speed Tables	12%
Traffic Circles	5%
Narrowings	10%
Full Closures	44%
Half Closures	42%
Diagonal Diverters	35%
Source: R. Ewing, *Traffic Calming State-of-the-Practice*, Institute of Transportation Engineers, Washington, D.C., 1999.	

2.1.3.2 Neighborhood Traffic Committee

For each funded project, the MOA may establish a Neighborhood Advisory Traffic Committee (NATC) to assist in the preparation of a traffic calming framework plan for the impact area. The entire impact area shall be equitably represented on the NATC. Committee members may include the original petitioners for traffic calming, residents appointed by the local community council, citizens volunteering at an initial public meeting, business owners within the impact area, and any other members deemed essential by the MOA for balanced representation. Representatives of emergencies services, the school district, the bicycling community, refuse collection services, and any transit providers shall be offered membership on the NATC.

2.1.3.3 Traffic Calming Framework Plan

The MOA will prepare a traffic calming framework plan with input from the NATC. The planning process will include a training component for committee members receiving their first exposure to traffic calming. Traffic calming options and impacts will be described. Advantages and disadvantages of different measures will be explained. Visual media will be used to help members visualize the options available to them.

Plan development will be accomplished through a close coordination with the NATC, through a workshop at which the MOA presents a preliminary plan for NATC review and refinement, or through any other process that will actively engage the NATC. From the experiences of past projects in Anchorage, this degree of public/MOA interaction is critical for plan success. An example of the traffic calming framework plan that was prepared as part of the Mountain View Transportation Study (DOWL, 1998) is shown in Figure 2.

2.1.3.4 Public Workshop

Once a plan is developed, the MOA will hold a public workshop (may be combined with a community council meeting) to solicit comments. The plan may be modified based on the feedback received. The final plan will be available to all households and businesses located within the impact area.

2.1.4 Trial

At the MOA Traffic Engineer's discretion, traffic calming framework plans may be implemented on a trial basis subject to impact evaluation during the trial period. Trial installations may be warranted when implementing complex area-wide plans where traffic diversion potential is difficult to predict. Trial installations may also be warranted when deploying novel traffic calming measures as when vertical measures with unconventional profiles are first used. For example, the MOA owns temporary speed humps that will be used at the discretion of the MOA Traffic Engineer for trial periods to determine the suitability of possible traffic calming locations.

The fact that installation is on a trial basis does not mean that unsightly materials may be used. The national experience suggests the importance of aesthetics for public acceptance.

2.1.5 Implementation

The MOA will design and construct traffic calming measures in accordance with geometric, aesthetic, signing, and marking guidelines contained in this manual.

The MOA will maintain the constructed portions of traffic calming measures. However, the

maintenance of landscaped areas within traffic calming measures will, in some cases, become the responsibility of others.

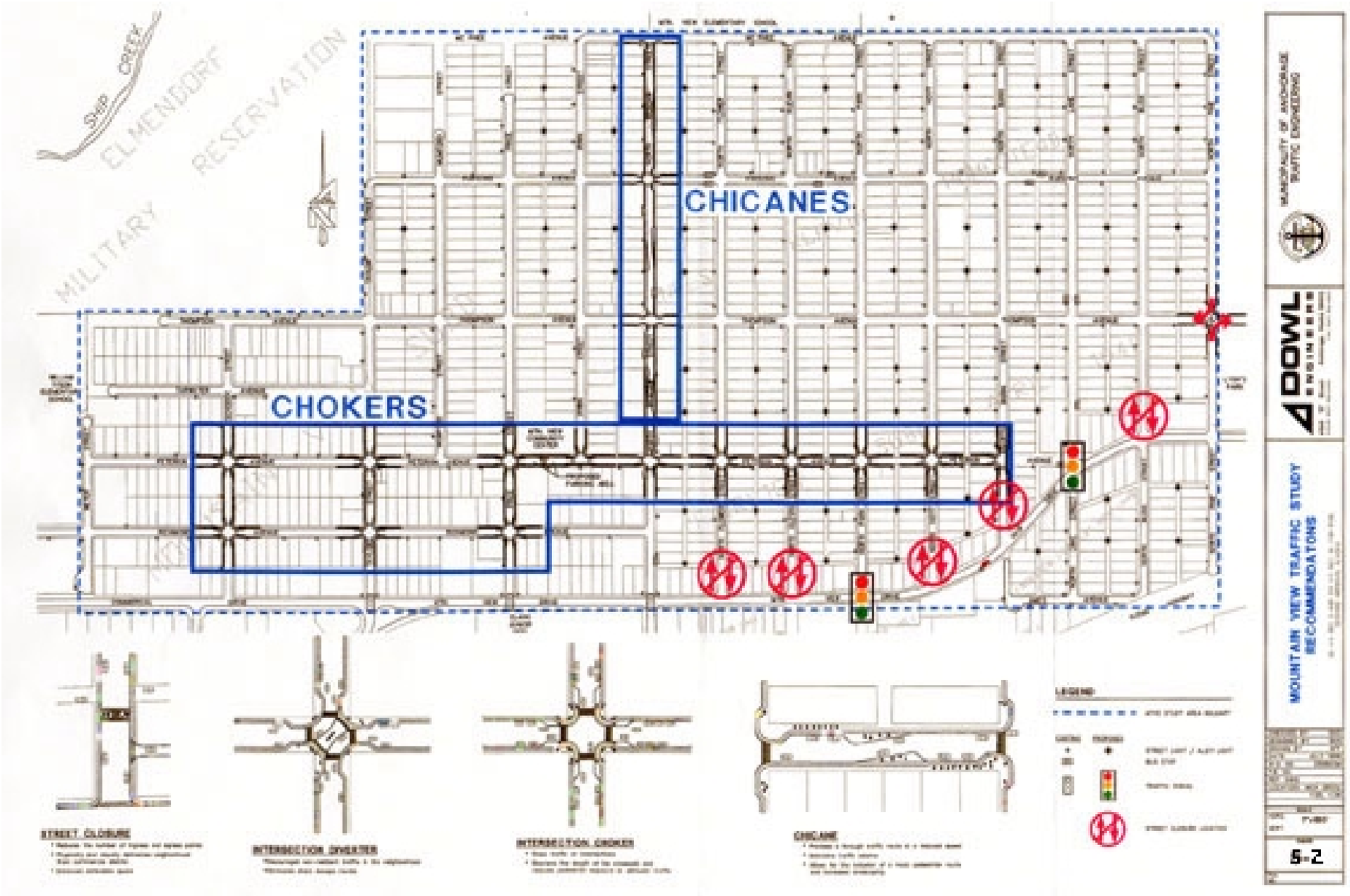


Figure 2: Example of Traffic Calming Plan

The MOA will assess the performance of traffic calming measures roughly six months after permanent installation in order to learn from each project and acquire impact data for use in subsequent budget and project priority deliberations. Typically, speed and volume measurements will be taken to permit before and after comparisons. Accident and resident satisfaction survey data may also be gathered.

3.0 REGULATORY AND RESOURCE AGENCY CONCERNS

3.1 General

Based on the experience of past traffic calming projects, certain basic concerns of various agencies will be used to evaluate the appropriate installation of traffic calming measures in the MOA. Individual agency's concerns are listed in this report to assist petitioners in selecting traffic calming devices that have the greatest chance of being approved/accepted.

3.2 Specific Agency Concerns

3.2.1 Municipality of Anchorage Planning

The MOA Department of Planning considers the following issues when reviewing proposed traffic calming initiatives:

- compatibility with Anchorage 2020 Comprehensive Plan,
- compatibility with Anchorage Trails Plan,
- use of traffic calming as a tool to create neighborhood identity,
- consideration of land use and zoning in development of transportation plans, and
- adequate public and agency involvement.

3.2.2 Emergency Services

The AFD and the APD evaluate the following issues when reviewing traffic calming initiatives:

- adequate curb radii to accommodate emergency vehicles,

- efforts to minimize response time impacts, and
- the quantity and unobstructed access to fire hydrants.

3.2.3 Street Maintenance

The MOA Street Maintenance Department evaluates the following issues when reviewing traffic calming initiatives:

- adequate curb radii to accommodate maintenance vehicles,
- adequate space to turn around on closed streets,
- available space for snow storage,
- vertical delineation of modified and non-linear curb locations,
- impacts on time/effort required to clear snow,
- adequate drainage, and
- resolution of right-of-way (ROW) encroachments.

MOA Parks and Beautification is part of the Street Maintenance Department and is primarily concerned that traffic calming projects include a program for landscape maintenance that utilizes neighborhood resources to the extent practicable and that new landscaping be maintenance friendly.

3.2.4 Solid Waste Services

Solid waste services is primarily concerned with providing adequate curb radii that will not hinder turning movements.

3.2.5 Transit Service

People Mover is primarily concerned with the following:

- maintaining adequate turning radii for buses,
- maintaining the quantity and locations of bus stops, and

- improving boarding pads where practicable.

3.2.6 Anchorage School District

The ASD has the following concerns when evaluating traffic calming initiatives:

- adequate curb radii to accommodate school buses,
- pedestrian traffic safety,
- delineation of pedestrian routes,
- consideration of school locations during traffic calming framework plan formation, and
- unobstructed access for bus routes.

3.2.7 Utility Companies

Utility companies are primarily concerned that traffic calming devices minimize obstructions to existing utilities so that future maintenance and repairs will not be hindered.

4.0 TRAFFIC CALMING TOOLBOX

Traffic calming involves identifying the nature of traffic problems on a given street or in a given area and then selecting traffic calming measures capable of solving identified problems. The measures come from a toolbox of possibilities. If the problem is cut-through traffic on local streets, one set of measures may be indicated. If the problem is speeding on streets whose abutting land uses are adversely affected, another set may be indicated. If the problem is a high rate of collisions, a third set may be indicated.

The process of selecting appropriate tools is described previously in this report (see Section 2). This section specifies which traffic calming measures are eligible for use on Anchorage streets of different OSHP classifications with different traffic characteristics. The resulting *Application Matrix* is meant to be advisory only. It does not constitute a set of warrants or minimum requirements but rather a set of recommendations that can be overridden in specific cases by engineering judgment and MOA approval.

4.1 Toolbox of Traffic Calming Measures

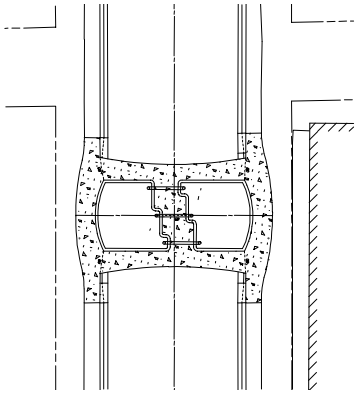
Schematic plans and photographic examples of different traffic calming measures are presented in Figures 3 through 18. This set of measures constitutes the MOA's traffic calming toolbox. The traffic calming toolbox is divided into four categories:

1. volume control measures,
2. vertical speed control measures,
3. horizontal speed control measures, and
4. narrowings.

4.1.1 Volume Control Measures

Volume control measures consist of modifications that reduce the quantity of vehicles that use a specific roadway. Typical measures include full street closures, half street closures, forced turn islands, and diverters.

Full street closures are barriers placed across a street to completely close the street to through traffic usually leaving only sidewalks open. Examples of full street closures include *hammer heads, cul-de-sacs, and dead-ends.* Closure barriers may consist of landscaped islands, walls, gates, side-by-side bollards, or any other obstructions that leave an opening smaller than the width of a passenger car.



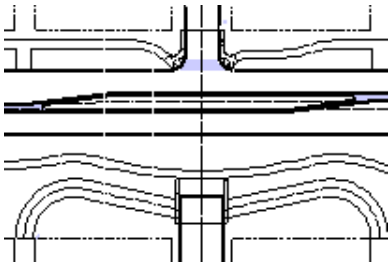


Figure 3: Closure Examples

Half closures are barriers that block travel in one direction for a short distance on otherwise two-way streets. They are also sometimes called *partial closures* or *one-way closures*. When two half closures are placed across from one another at an intersection, the result is a *semi-diverter* that blocks through movement on a cross street.

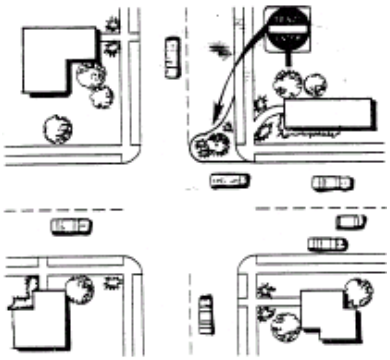


Figure 4: Half Closure Example

Diagonal diverters are barriers placed diagonally across an intersection blocking through movement. They are also called *full diverters* and *diagonal road closures. Median barriers* are raised islands located along the centerline of a street and continuing through an intersection to block through movement at a cross street. They are also referred to as *median diverters* or occasionally as *island diverters. Forced turn islands* are raised islands on approaches to an intersection that block certain movements. They are sometimes called *forced turn channelizations, pork chops,* or in their most common incarnation, *right turn islands.*

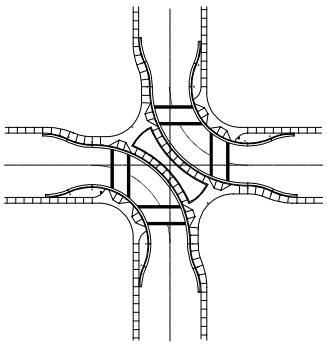


Figure 5: Diagonal Diverter Example

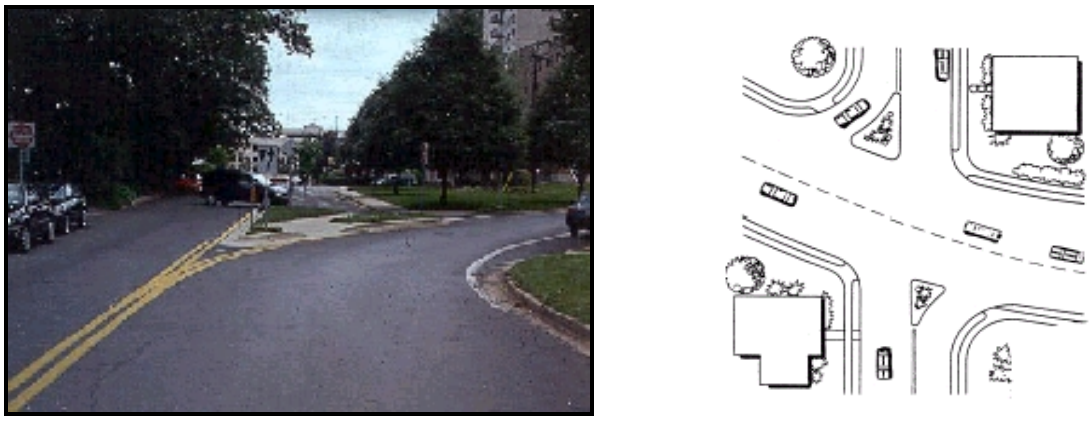


Figure 6: Forced Turn Island Example

4.1.2 Vertical Speed Control Measures

Vertical speed control measures are elevated segments of roadway that require vehicles to slow down. Typical measures include speed humps/bumps, speed tables, raised crosswalks, and raised intersections.

Speed humps are rounded raised areas placed across the road. They are also referred to as *undulations.* The standard or Watts profile hump, developed and tested by Britain's Transport and Road Research Laboratory, is the most common speed control measure in the United States (U.S.). It is the only speed control measure, at present, for which ITE provides design and application guidance.

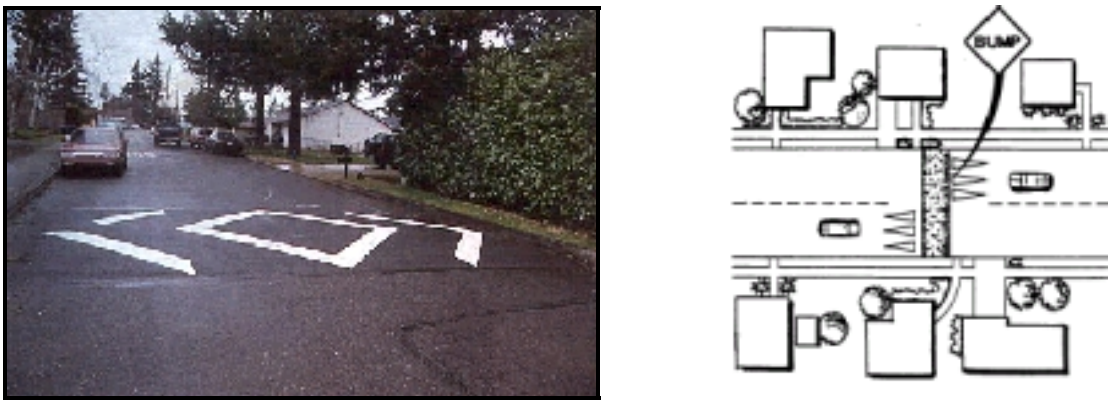


Figure 7: Speed Hump Example

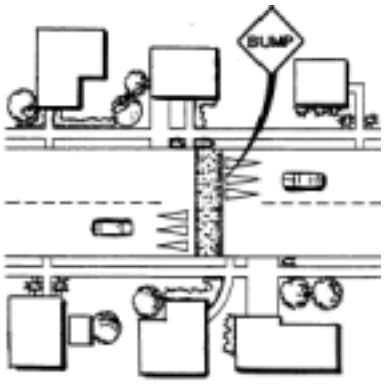


Figure 8: Temporary Speed Hump Example

Speed tables are flat-topped speed humps often constructed with a brick or other textured materials on the flat section. They are also called *trapezoidal humps, plateaus,* and if marked for pedestrian crossing, *raised crossings or raised crosswalks.* Speed tables are typically long enough for the entire wheelbase of a passenger car to rest on top. Their long flat fields give speed tables higher design speeds than humps.

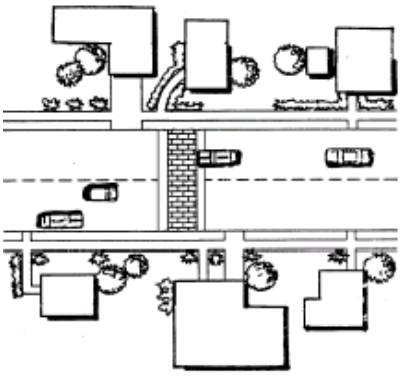


Figure 9: Speed Table Example

Raised intersections are flat raised areas covering entire intersections with ramps on all approaches and often with brick or other textured materials on the flat section. They are also called *raised junctions* or *intersection humps.* They usually rise to sidewalk level or slightly below to provide a "lip" for the visually impaired. They make entire intersections, crosswalks and all, pedestrian territory.

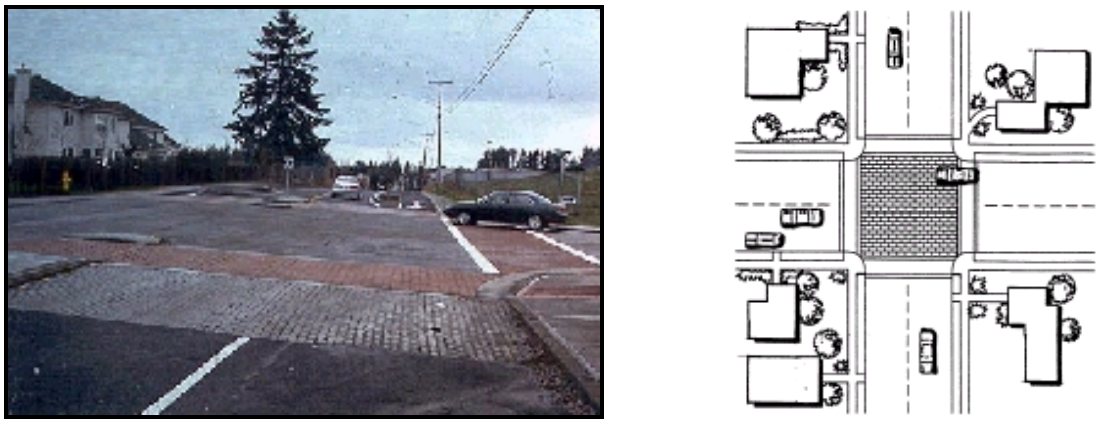


Figure 10: Raised Intersection Example

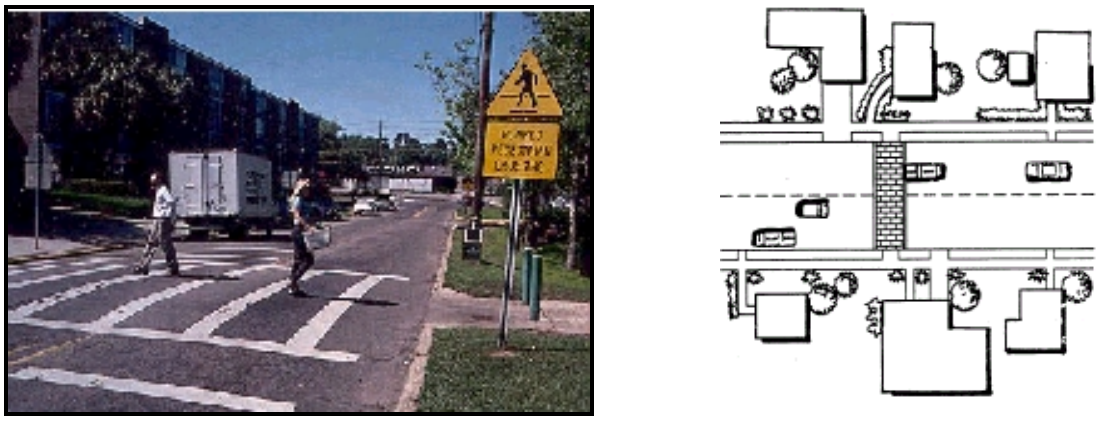


Figure 11: Raised Crosswalk Example

4.1.3 Horizontal Speed Control Measures

Horizontal speed control measures alter the typical straight line traveled way of a specific roadway in an effort to reduce speed. Typical measures include mini traffic circles, roundabouts, lateral shifts, and chicanes.

Mini traffic circles are raised islands placed in intersections around which traffic circulates. They are sometimes called *intersection islands.* They are usually circular in shape and landscaped in their center islands, though not always. They often have outer rings (called truck aprons) or conical shapes (with "lips") that are mountable so large vehicles can circumnavigate their small curb radii.

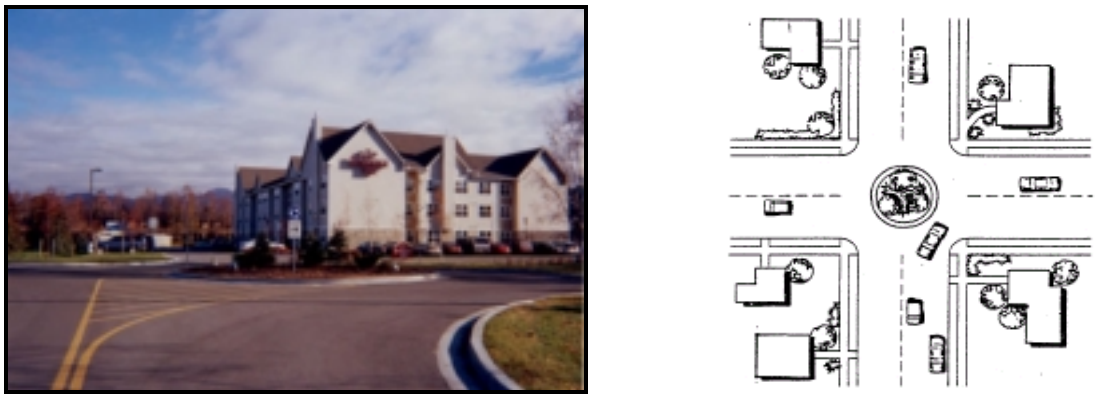


Figure 12: Traffic Circle Example

Roundabouts, similar to mini traffic circles in that traffic circulates around center islands, are used at higher volume intersections to allocate ROW among competing movements. Roundabouts in the U.S. are found primarily on arterial and collector streets, often substituting for traffic signals or all-way stops. They are larger than mini traffic circles, are designed for higher speeds, and have raised splitter islands to channel approaching traffic to the right.

Figure 13: Roundabout Example

Lateral shifts are curb extensions on otherwise straight streets that cause travel lanes to bend one way and then bend back the other way in the original direction of travel. They are occasionally referred to as *axial shifts*, *staggerings*, or *jogs*. Lateral shifts, with just the right degree of horizontal curvature, are one of the few measures that can be used on collectors where high traffic volumes and high posted speeds preclude more abrupt measures.

Chicanes are curb extensions that alternate from one side of the street to other forming s-shaped curves. They are also referred to as *deviations, serpentines,* and *reversing curves.* *Realigned intersections* are changes in alignment that convert "T" intersections with straight approaches into curving streets meeting at right angles. A straight shot along the top of the "T" becomes a turning movement. Realigned intersections are sometimes called *modified intersections.*

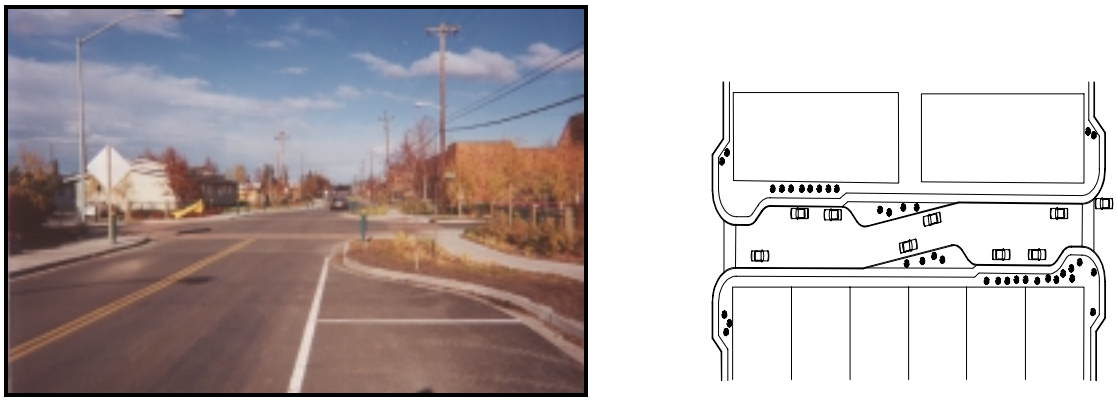


Figure 14: Chicane Example

4.1.4 Narrowings

Narrowings, as the name implies, are short roadway segments that are narrower than the typical roadway section. Typical narrowings include neckdowns, chokers, and island narrowings.

Neckdowns are curb extensions at intersections that reduce roadway width curb-to-curb. They are sometimes called *nubs, bulbouts, knuckles,* or *intersection narrowings.* If coupled with crosswalks, they are referred to as *safe crosses*. Placed at the entrance to a neighborhood, often with textured paving between them, they are called *gateways*. Their effect on vehicle speeds is limited by the absence of pronounced vertical or horizontal deflection. Instead, their primary purpose is to "pedestrianize" intersections.

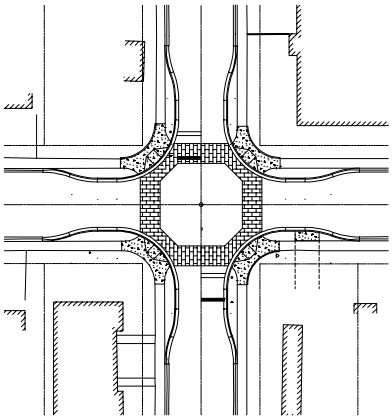


Figure 15: Neckdown Example

Chokers are curb extensions or edge islands at midblock that narrow a street at that location. In different configurations, they are called *midblock narrowings, midblock yieldpoints,* and *pinch points.* If marked as crosswalks, they are also called *safe crosses*. Chokers can leave the street cross section with two lanes, albeit narrower lanes than before, or take it down to one lane. In the MOA, only two-lane chokers are permitted on two-way streets.

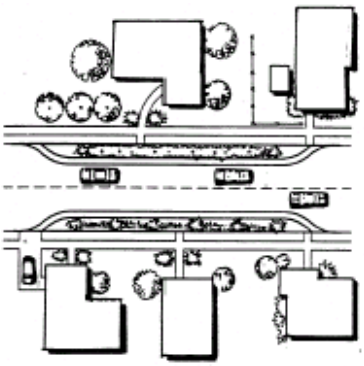


Figure 16: Two-Lane Choker Example

Center island narrowings are raised islands located along the centerline of a street that narrow the street at that location. They are also called *midblock mediates, median slow points,* and *median chokers.* Placed at the entrance to a neighborhood, often with textured paving on either side, they are called *gateways.* They may be nicely landscaped to provide visual amenity and neighborhood identification as well as modest speed reduction.

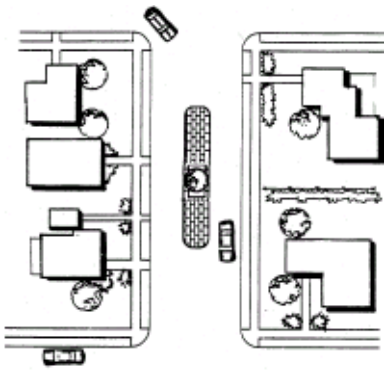


Figure 17: Center Island Narrowing Example

4.1.5 Combined Measures

The search for the optimal traffic calming measure may lead to various combinations of measures at single slow points. A standard traffic circle cannot control speeds on the top of a "T" intersection, so curb extensions may be added on the approaches to achieve some horizontal deflection. A choker cannot control speeds in the absence of opposing traffic, so speed humps may be added in the gap between the curb extensions. Individual measures can be combined in any number of ways to customize the design improvement to site-specific conditions.

4.2 Effectiveness and Impacts of Traffic Calming Measures

As noted previously, traffic calming involves matching engineering measures to specific traffic problems. From the toolbox of measures just described, the MOA attempts to choose the most cost-effective and conservative measure that will do the job. Table 2 summarizes the effectiveness of each traffic calming measure and other non-engineering measures based on typical traffic calming objectives.

Table 2: Summary of the Effectiveness of Traffic Calming and Non-Engineering Measures
(Adapted from *Neighborhood Traffic Control*, North Central Section ITE, 1994)

TRAFFIC CALMING TOOL BOX	Volume Reduction	Speed Reduction	Safety Improvement	Pollution Reduction	Access Restriction	Emergency Access	Maintenance Problems	Level of Violation	Community Acceptance	Cost
Full Closures	◒	●	◒	●	●	●	●	n/a	○	●
Half Closures	◒	◒	◒	< >	●	●	○	○	○	●
Diverters	◒	◒	◒	< >	●	●	●	n/a	○	●
Speed Bumps/Humps/Raised Crosswalks/Raised Intersections	◒	●	○	○	○	●	◒	n/a	○	◒
Traffic Circles/Roundabouts	○	◒	◒	○	○	●	◒	n/a	○	●
Neckdowns/Chockers	◒	○	◒	○	○	○	○	n/a	●	●
Chicanes/Lateral Shifts	◒	◒	◒	○	○	○	○	n/a	○	●
NON ENGINEERING MEASURES										
Increased Enforcement	○	●	◒	○	○	○	○	n/a	●	◒
Variable Speed Display	○	●	◒	○	○	○	○	n/a	●	○
Watch for Children	○	○	○	○	○	○	○	n/a	●	○
Pavement Markings	○	○	○	○	○	○	○	n/a	●	○
Street Narrowing	○	◒	◒	○	○	○	○	n/a	○	◒
Turn Restrictions	●	◒	◒	< >	●	○	○	○	○	○
Basket Weave Stop Signs	○	◒	●	○	○	○	○	○	●	○
Yield Signs	○	◒	○	○	○	○	○	◒	●	○
Do Not Enter	◒	○	◒	< >	●	○	○	◒	○	○
Speed Limit Changes	○	○	○	○	○	○	○	●	●	○
Parking Restrictions	○	○	●	○	○	○	○	○	○	○
All Way Stop	○	◒	◒	○	○	○	○	◒	●	○
One Way Streets	◒	○	◒	○	●	○	○	○	○	○

K ○ Low, Unlikely, No
E ◒ Mid, Moderate, Possible
Y ● High, Likely, Yes
< > Traffic Shift
n/a Not applicable

To assist in selecting the appropriate traffic calming measure, this section summarizes speed, volume, and collision impacts of different traffic calming measures. Impact data are taken from *Neighborhood Traffic Control*, North Central Section of ITE, 1994 and from ITE's *Traffic Calming State-of-the-Practice*, which draws on hundreds of before and after studies to derive average values and standard deviations. The speeds reported are midpoint speeds after traffic calming. Collision impacts are reported with and without adjustments for decreases in traffic volumes after traffic calming measures are installed. On average, all of the different traffic calming measures reduce speeds, volumes, and collisions. However, only certain measures do so to a statistically significant degree.

Sample averages, while no substitute for detailed analyses of proposed treatments, can be used to initially screen traffic calming measures for further consideration. Tables 3 and 4 summarize the speed and volume impacts of various traffic calming measures.

Table 3: Speed Impacts Of Traffic Calming Measures

	Sample Size	**Average Speed After Traffic Calming (standard deviation from the average), mph**	**Average Change in Speed with Traffic Calming (standard deviation from the average), mph**	**Average Percent Change in Speed with Traffic Calming (standard deviation from the average), %**
12-foot Humps	179	27.4 (4.0)	-7.6 (3.5)	-22 (-9)
14-foot Humps	15	25.6 (2.1)	-7.7 (2.1)	-23 (6)
22-foot Tables	58	30.1 (7.7)	-6.6 (3.7)	-18 (8)
Longer Tables	10	31.6 (2.8)	-3.2 (2.4)	-9 (7)
Raised Intersections	3	34.3 (6.0)	-.3 (3.8)	-1 (10)
Circles	45	30.2 (4.3)	-3.9 (3.2)	-11 (10)
Narrowings	7	32.3 (2.8)	-2.6 (5.5)	-4 (22)
Half Closures	16	26.3 (5.2)	-6.0 (3.6)	-19 (11)
Diagonal Diverters	7	27.9 (5.2)	-1.4 (4.7)	-0 (17)

Source: R. Ewing, *Traffic Calming State-of-the-Practice*, Institute of Transportation Engineers, Washington, D.C., 1999.

Table 4: Volume Impacts Of Traffic Calming Measures

	Sample Size	Average Change in Volume with Traffic Calming (standard deviation from the average), vpd	Average Percent Change in Volume with Traffic Calming (standard deviation from the average), %
12-foot Humps	143	-355 (591)	-18 (24)
14-foot Humps	15	-529 (741)	-22 (26)
22-foot Tables	46	-415 (649)	-12 (20)
Circles	49	-293 (584)	-5 (46)
Narrowings	11	-263 (2178)	-10 (51)
Full Closures	19	-671 (786)	-44 (36)
Half Closures	53	-1611 (2444)	-42 (41)
Diagonal Diverters	47	-501 (622)	-35 (46)
Other Volume Controls	10	-1167 (1781)	-31 (36)

Source: R. Ewing, *Traffic Calming State-of-the-Practice*, Institute of Transportation Engineers, Washington, D.C., 1999.

4.2.1 Full and Half Closures

The impact of a full or half street closure on traffic volume is immediate and drastic. A full closure typically reduces the traffic volume to that generated by the land uses abutting the closed street. The most effective street closures have a vertical element(s) to alert drivers from a distance that the road is closed or partially closed. There should also be one or more adjacent streets with sufficient capacity to handle displaced traffic.

Speed reduction is likewise drastic, reducing the speeds to that of a typical dead-end residential street. Speeding is more likely to occur on a half closure than on a full closure.

Full and half closures substantially increase traffic safety on the closed roadway. This is primarily due to the reduced volumes and reduced speeds that result on the closed roadway. Also, there is a safety increase to the collector or arterial that was previously the outlet of the closed roadway. Entering and/or exiting traffic is eliminated at the closed or half closed street and that traffic is typically relocated to an intersection that is better equipped to accommodate the turning movements. Studies show that although a closed roadway displaces a certain amount

of traffic, the tendency is for traffic volume to widely disperse thereby relieving the burden from a single alternate roadway.

Reduced access to the neighborhood should be evaluated thoroughly prior to construction of a closure or half closure. The closed or partially closed streets should not typically be streets that are serving as access to neighborhood traffic generators such as churches, community centers, or parks. Enforcement will likely be necessary at half closures to prevent traffic from entering the prohibited street through the opposing lane.

If cut-through traffic is a concern, the surrounding collectors and arterial roadways should be investigated to determine if there are traffic conditions that are encouraging cut-through traffic. Cut-through mitigation other than volume control measures should be evaluated as part of the planning effort. For example, cut-through traffic on a residential road may be the result of deteriorated level of service on an adjacent arterial that could be resolved by increasing capacity on that arterial. Capacity upgrades would reduce travel time thereby encouraging motorists to stay on the arterial rather than cutting through the residential neighborhood.

A closed street typically experiences a significant reduction in noise and an increase in air quality. However, that noise and air pollution is relocated to adjacent streets.

4.2.2 Diverters

Diverters reduce through volume traffic by diverting it to other streets. The typical objective of diverters is to route cut-through traffic to collectors or arterials. Diverters can have a substantial impact on traffic volumes depending on the percentage of cut-through traffic versus local traffic. Speeds are reduced adjacent to the diverter intersection, but there are only minimal speed reductions at the midblock. Safety benefits of diverters are achieved by diverting cut-through traffic and by reducing accidents at the diverter intersection through elimination of all conflict points.

There are no realistic impacts on noise or air quality that result from diverters.

4.2.3 Speed Humps

Speed humps are some of the most common traffic calming measures in existence in the U.S. and consequently have had numerous studies that have documented their impact on traffic speeds and volumes. (Raised crosswalks and raised intersections are considered modified forms of speed humps and will accomplish similar objectives with similar impacts on traffic safety, speeds, and volumes.) One such study was performed by the City of Portland and is reported in *City of Portland Speed Bump Peer Review* (Kittleson and Associates, 1998). In generating that report, Portland evaluated over 500 speed humps and arrived at the following conclusions.

Traffic Speeds

- Speed humps are an effective tool in reducing travel speeds to be consistent with posted speed limits. They are very effective in reducing the speeds of the fastest drivers and slightly effective (2 mph) in reducing speeds on parallel untreated streets.

- On average, speed humps reduced 85th percentile travel speeds by about 7 mph after speed humps were installed. Average speed over the speed humps was about 25 mph (see Figure 18).

- After the study streets were treated with speed humps, 20 percent of motorists on average were traveling at speeds greater than 25 mph compared to 60 percent before.

- Overall, approximately 13 percent of motorists traveled more than 10 mph over the speed limit before installation of speed humps compared to two percent afterwards (see Figure 19).

- The study revealed that residents' perceptions about speed hump impacts on speed were consistent with the documented speed impacts.

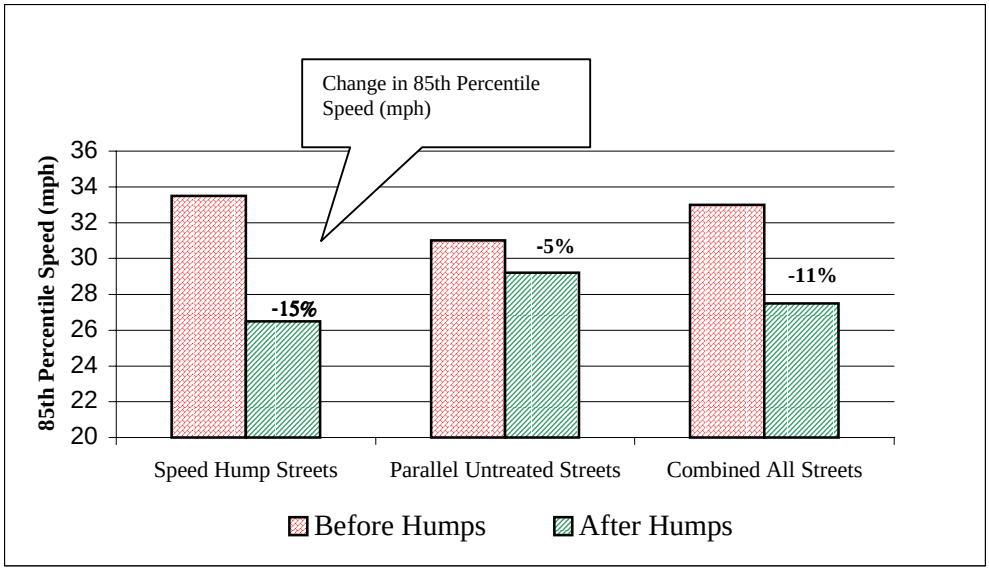


Figure 18: Effect of Speed Humps on 85th Percentile Speeds
(*City of Portland Speed Bump Peer Review*, Kittelson and Associates, 1998)

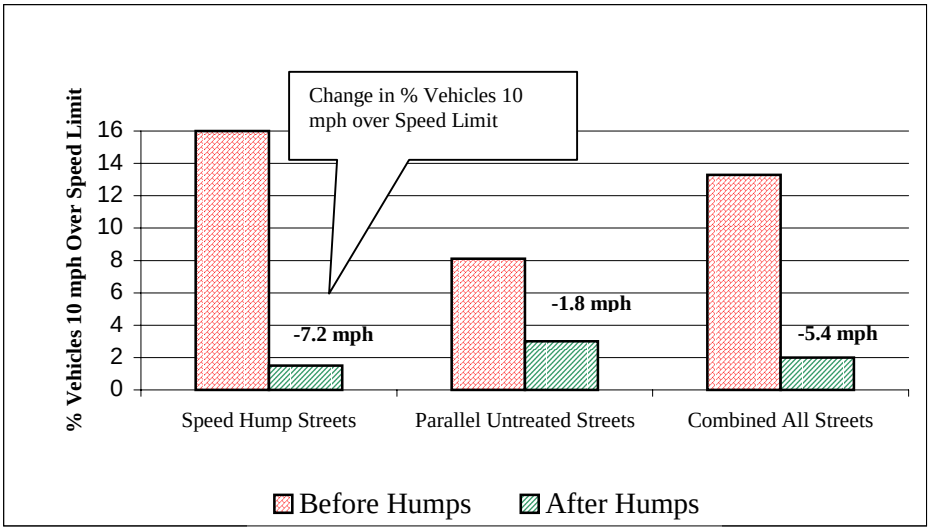


Figure 19: Effect of Speed Humps on Percent Vehicles 10 mph or More Over Speed Limit

(*City of Portland Speed Bump Peer Review*, Kittelson and Associates, 1998)

Traffic Volumes

- Traffic volumes tend to decrease on streets with speed humps (see Figure 20). The amount of volume reduction depends on the amount of speed reduction and availability of alternate routes.

- On streets treated with speed humps (14-foot), the average traffic volume reduction was 33 percent. After installing longer speed humps (22-foot), traffic volumes decreased by an average of 21 percent.

- On average, parallel untreated streets experienced slight increases in traffic volume (about four percent). Thus, the study indicated that only a small portion of the traffic diverted to the parallel untreated streets.

- The results of the public opinion survey showed that 64 percent of the respondents who lived on streets treated with speed humps perceived a reduction in traffic volumes. This perception matches the documented reduction in traffic volumes on treated streets.

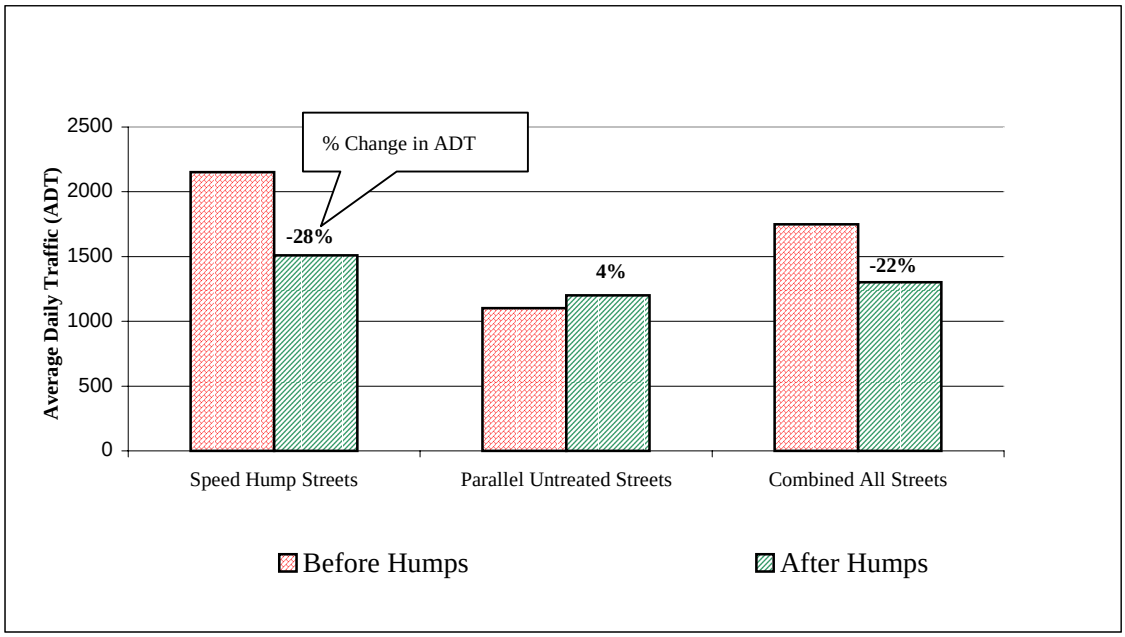


Figure 20: Effect of Speed Humps on Traffic Volumes
(*City of Portland Speed Bump Peer Review*, Kittelson and Associates, 1998)

The *City of Portland Speed Bump Peer Review* also included a safety evaluation of the streets that had been treated with speed humps. That analysis showed that crash frequency decreases after the installation of speed humps, primarily as a result of reduced traffic volumes on the treated streets. More specifically, the Portland data indicated the following.

Vehicle Crashes

- With installation of speed humps, the incidence of crashes on treated streets decreased an average of 39 percent (see Figure 21).

- The crash rate (annual crashes per average daily traffic [ADT]) decreased on treated streets an average of 5 percent after speed humps were installed.

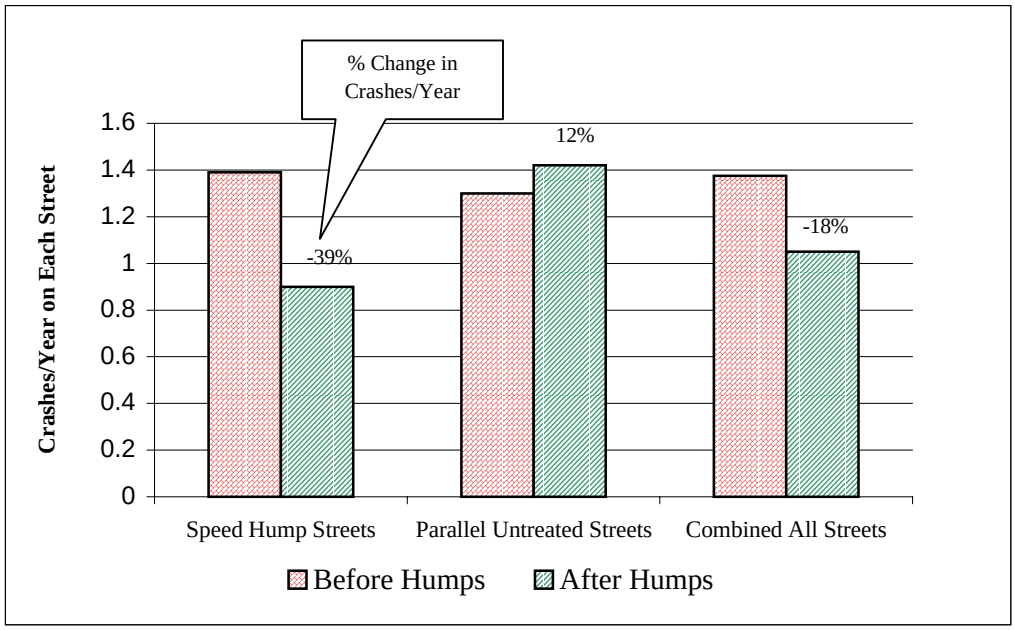
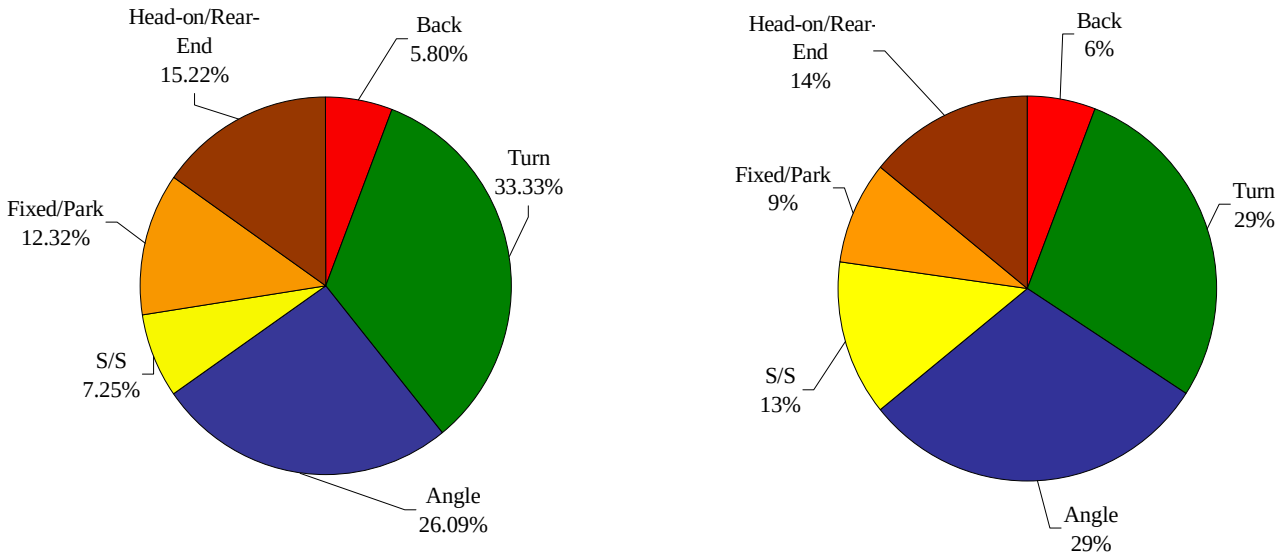


Figure 21: Effect of Speed Humps on Crash Frequency
(*City of Portland Speed Bump Peer Review*, Kittelson and Associates, 1998)

- There was no measured change in crash type caused by the installation of speed humps (see Figure 22). However, the incidence of injury crashes on treated streets decreased by 46 percent.

- Overall, residents of streets treated with speed humps perceived an increase in traffic safety.



Before Speed Humps **After Speed Humps**

Figure 22: Effect of Speed Humps on Crash Type
(*City of Portland Speed Hump Peer Review*, Kittelson and Associates, 1998)

4.2.4 Traffic Circles/Roundabouts

Traffic circles and roundabouts have the following general impacts on traffic safety and operations.

- They will likely have minimal impacts on traffic volumes. Sometimes they can increase traffic volumes by attracting motorists seeking reduced delay compared to stop controlled intersections. On the other hand, some vehicles may be diverted to adjacent roadways to avoid the central and splitter islands.

- Speed near the intersection is reduced unless there was previously a stop sign in that direction; in which case, the speed near the intersection will increase.

- Depending on accident patterns, there could be a decrease in accidents by reducing the likelihood of angle accidents. Otherwise, there will probably not be a significant impact on traffic safety.

- There are no realistic impacts to air quality or noise resulting from traffic circles or roundabouts.

- Traffic circles and roundabouts can reduce the amount of on-street parking near the intersection.

- Snow plowing is slowed as maintenance personnel must circumnavigate the central island.

4.2.5 Chicanes and Lateral Shifts

Chicanes and lateral shifts fall under the category of curvilinear construction and typically have the following general impacts on traffic safety and operations:

- They typically have little or no effect on traffic volumes unless there is a reduction in the number of lanes.

- Curvilinear construction of uniform width typically has little or no impact on traffic speeds unless there is a reduction in the shy distance to instigate slower speeds.

- There is little or no effect on noise and air quality.

- There is often a substantial decrease in the amount of on-street parking (usually about a 2/3 reduction). This can be either an advantage or a disadvantage depending on the site conditions and neighborhood issues.

- Studies are inconclusive regarding whether or not there is an increase or decrease in the number of accidents occurring on chicanes and lateral shifts. The safety of curvilinear construction is heavily dependant on designing vertical elements that provide visual cues to motorists regarding the alignment of the road without restricting horizontal visibility.

- Snow maintenance is typically slowed by curvilinear reconstruction.

- Provide landscape areas that enhance aesthetics.

4.2.6 Neckdowns and Chokers

Neckdowns and chokers are roadway narrowing techniques that have the following general impacts on traffic safety and operations.

- They typically have little or no effect on traffic volumes unless there is a reduction in the number of lanes.
- Roadway narrowings have a minimal impact on traffic speeds unless there is a severe restriction in the shy distance to instigate slower speeds.
- There is little or no effect on noise and air quality.
- Roadway narrowings can reduce the amount of on-street parking near the intersection or at the choke point.
- Potential for improved pedestrian safety due to improved visibility of crossing point, shorter crosswalks, and no on-street parking near the crosswalk.
- Snow maintenance is typically slowed by roadway narrowings and roadway design should include vertical elements such as bollards to assist the snow plow operators in identifying the location of curb extensions.
- Provide landscape areas that enhance aesthetics and define neighborhood entries.

4.3 Non-Engineering Measures

As shown in Table 2, there are other non-engineering measures that fall outside the definition of traffic calming as established by ITE. These measures are often requested by residents who are looking for ways to reduce traffic speeds and volumes in their neighborhoods but are unaware of more effective traffic calming measures. A study of the following non-engineering measures was performed by the North Central Section of ITE. (The analysis and conclusions of their report titled *Neighborhood Traffic Control* is the basis for the analysis herein.)

- Increased Enforcement
- Variable Speed Display
- Signage and Striping Modifications

4.3.1 Increased Enforcement

Increased enforcement involves the effective use of public safety/police personnel to encourage reduced speeds in residential areas. Enforcement procedures usually involve the use of radar to identify speeders for subsequent ticketing of speed violators. Increased enforcement has little or no effect on traffic volumes. However, studies have shown that enforcement operations can result in appreciable speed reductions, though speeds are usually reduced only as long as the enforcement is sustained.

With respect to safety, the number of accidents is generally reduced and overall safety is improved during periods of increased enforcement. If sustained enforcement is present, there could be significant improvements in reduced speeds and traffic safety.

Studies have generally shown that people speeding in neighborhoods tend to be local residents. The same studies show residents support and encourage enforcement on “their” street but negatively react when enforcement results in citations to local residents. Generally, this results in reduced police interest in enforcement.

Impacts of enforcement can have a longer lasting effect when enforcement is repetitive on a non-routine basis. Use of personnel for speed enforcement is typically not a high priority for police departments. Manpower time and wages can be costly for this type of speed reduction technique.

4.3.2 Variable Speed Display

A variable speed display board (VSDB) typically consists of a trailer mounted to a combined display board and wired to a radar unit that is aimed at passing motorists. It dynamically displays the driver’s travel speed as well as the speed limit to alert motorists of their speed compared to the posted speed limit. It is typically used to target times of the day when enforcement is needed

as well as to educate the public as to whether there is or is not a speeding problem. VSDBs have little or no effect on traffic volumes.

Lower speeds are observed when the device is present. The unit can also be used to target police enforcement times if a problem is evident. Generally, the effect on speed reduction is fleeting. Typically, speed reduction is significant during the few days that the VSDB is present and then speeds gradually return to normal. VSDBs are a relatively low cost approach to reducing speeds in the short term and are most effective when used as a precursor to target locations for longer term measures.

4.3.3 Signage and Striping

All of the remaining non-engineering measures can be lumped into the category of modifications to signage and/or striping. The most common include the following:

- pavement markings,
- watch for children signs,
- street narrowing through pavement marking,
- turn restriction signs,
- basket weave stop signs,
- yield signs,
- do not enter signs,
- speed limit changes,
- parking restriction signs/striping,
- all-way stops, and
- one-way streets.

Typically, all of these signing and striping modifications have little or no effect on traffic volumes. Only in cases where there is a convenient alternative route will there be more than slight reductions in traffic volumes. With regard to speed, there is often an initial reduction in speed immediately after installation of the signage or striping modifications; but, in the long term, there is typically no appreciable reduction in speeds for any of the non-engineered

measures. Even in the case of all-way stops and basket weave stop signage (alternating direction two-way stop control on every other block), speeds are reduced only immediately adjacent to the stop signs. On the remainder of the street, there is typically no speed reduction, and often speeds will increase as motorists try to make up for lost time.

The winter environment in Anchorage also reduces the effectiveness and increases the maintenance costs of non-engineered measures. Striping modifications are not effective during winter months due to snow/ice cover. Furthermore, striping typically requires routine maintenance every one to three years to counter the rapid wear that results from the large number of studded tire vehicles in Anchorage. Snow and ice cover also builds up at stop sign intersections due to increased braking, thereby resulting in increased road maintenance costs.

4.4 Application Guidelines

4.4.1 Relationship to Roadway Functional Classification

Moving down the roadway functional hierarchy in the MOA from arterials that mainly serve through traffic to collector streets that mainly serve through traffic to residential streets, the set of appropriate traffic calming measures expands.

At this point in the U. S., traffic calming programs are heavily focused on local residential streets. Applications seldom extend up the functional hierarchy beyond collector streets and seldom apply to nonresidential streets other than those serving as main shopping streets.

4.4.2 Relationship to Traffic Volumes and Speeds

The application guidelines establish maximum volumes and speeds for different measures (see Table 5). Beyond these volumes and speeds, little improvement occurs from a traffic safety and/or traffic efficiency standpoint. The guidelines for posted speeds refer to the speed limits on the streets themselves. Lower advisory speeds may be posted at traffic calming measures.

There are no minimum traffic volumes or speeds for any of these measures. Rather, the MOA will exercise discretion when prioritizing projects that gives weight to traffic volumes and speeds, along with other factors, in deciding which projects most warrant funding.

4.4.3 Summary of Guidelines

The following summarize the guidelines in Table 5.

- The range of applicable traffic calming measures is greater for lower functional classes and greatest for subdivision streets.

Table 5: Application Guidelines

Traffic Calming Application Guidelines			
Traffic Calming Measure	**Street Classification**		**Other Restrictions**
	Neighborhood Collectors	**Local Streets**	
Volume Control Measures			
Full Closures	No	May be suitable	
Half Closures Diagonal Diverters Forced Turn Islands	No	500-5,000 vpd ≥ 25% non-local traffic	
Vertical Speed Control Measures			
Speed Humps	Daily volume ≤ 5,000 vpd Posted speed ≤ 25 mph Not on primary emergency routes or bus routes		Grade ≤ 8%
Speed Tables Raised Crosswalks Raised Intersections	Daily volume ≤ 10,000 vpd Posted speed ≤ 25 mph Not on primary emergency response routes		Grade ≤ 8%
Horizontal Speed Control Measures			
Traffic Circles	Daily volume ≤ 5,000 vpd Posted speed ≤ 25 mph		Grade ≤ 10%
Roundabouts (one circulating lane)	Daily volume ≤ 15,000 vpd Posted speed ≤ 25 mph	No	Grade ≤ 6%
Lateral Shifts	Daily volume ≤ 20,000 vpd Posted speed ≤ 25 mph		
Two-Lane Chicanes Realigned Intersections	Daily volume ≤ 5,000 vpd Posted speed ≤ 25 mph		Grade ≤ 8%
One-Lane Chicanes (Two-Way operation)	Daily volume ≤ 2,000 vpd Posted speed ≤ 25 mph		
Narrowings			
Neckdowns Center Island Narrowings Two-Lane Chokers	Daily volume ≤ 20,000 vpd Posted speed ≤ 25 mph		
One-Lane Chokers (Two-Way operation)	Daily volume ≤ 2,000 vpd Posted speed ≤ 25 mph		
Combined Measures	Subject to limitations of component measures		

- Volume control measures are deemed appropriate for subdivision streets only. Even in subdivisions, they have limited application compared to speed control measures.

- Among speed control measures, speed humps, mini traffic circles, and chicanes are applicable to the lowest traffic volumes and speeds. Speed tables are applicable to intermediate volumes and speeds and roundabouts, lateral shifts, and narrowings are applicable to somewhat higher volumes and speeds though not to the very highest volume and speed conditions.

5.0 GEOMETRIC DESIGN

Guidance on a typical geometric design is presented for each type of traffic calming measure and, in most cases, the range of acceptable design alternatives is specified in this section.

5.1 General Guidance

Geometric design is based primarily on the desired crossing speed at slow points. This is the "design speed" of the slow points themselves. Once this speed is set, appropriate spacing of slow points can be determined based on target speeds midway between such points. For typical geometric designs, design speeds are provided for each traffic calming measure or can be estimated using the formulas and tables provided herein.

Ordinarily, crossing speeds at slow points will be no more than *5 miles per hour (mph) below* the posted speed limit (though with advisory speed signs, greater differences may be acceptable). Also, as a rule, midpoint speeds will be no more than *5 mph above* the posted speed limit. The speed differential on a given stretch of roadway is thus limited to 10 mph in the interest of traffic safety, noise control, fuel conservation, and driver acceptance.

Geometric design is also based on the dimensions of vehicles in the traffic stream. For most typical designs, a single unit truck is the "design vehicle." If the road is a bus route, the design vehicle will be a bus. Geometrics of slow points are set such that a single unit truck (or bus) can negotiate them with relative ease (albeit at a lower speed than a passenger car which has room to spare and can cross slow points at the full design speed).

When a single unit truck is the design vehicle, larger trucks and buses are accommodated in different ways, for example, with mountable overrun areas. While large vehicles will be forced to cross slow points at a crawl speed, this appears reasonable given the relatively few such vehicles using the streets in question—neighborhood collectors or below in the functional hierarchy. Freeways and arterials, which carry the bulk of the heavy vehicle traffic, are ineligible for traffic calming under *Application Guidelines* in Chapter 5.

5.2 Volume Control Measures

5.2.1 Full Closures

Given the fact that full closures can be designed in so many ways, no typical design is included in this TCPM. It is noted that unless otherwise approved by the Municipality, a closure must be accompanied by a cul-de-sac, hammerhead, or other method to enable vehicles to turn around. Furthermore, the design of closures should prevent the ability of motorists to drive around the closure or to use private property as a cut-through.

5.2.2 Half Closures

The typical half closure has two geometric features designed to encourage compliance with the one-way restriction (see Figure 23). First, the curb extension or edge island extends more than a car length along the roadway. Motorists traveling the wrong way through the half closure are doing so for an uncomfortable distance. Second, the curb extension or edge island extends all the way to the centerline of the street or beyond on a wide street. This leaves a relatively tight opening for wrong-way traffic.

To further enhance compliance with the one-way designation, half closures should be located at intersections. Once through traffic is already traveling down a street in the restricted direction, there is a strong tendency to continue through a half closure. On an exception basis, the MOA will consider half closures at midblock locations where commercial land uses transition to residential and the commercial uses require unrestricted access in both directions.

Along bicycle routes, the preferred design is a bicycle pass-through lane through the half closure. When bicycle lanes are bordered on both sides by vertical curbs, their channel widths shall be four to five feet wide to provide clearance for bicyclists but narrow enough to exclude automobiles.

A contra-flow bicycle lane should be installed adjacent to the motor vehicle lane when a half closure is formed by a curb extension rather than an edge island or if the half closure must have a wider opening in the restricted direction for emergency access purposes. The opening shall not be wider than 16 feet unless otherwise approved by the MOA Traffic Engineer. When designed extra wide to accommodate turning emergency vehicles, it may be advisable to have a bicycle contra-flow lane to discourage wrong-way movement of motor vehicles.

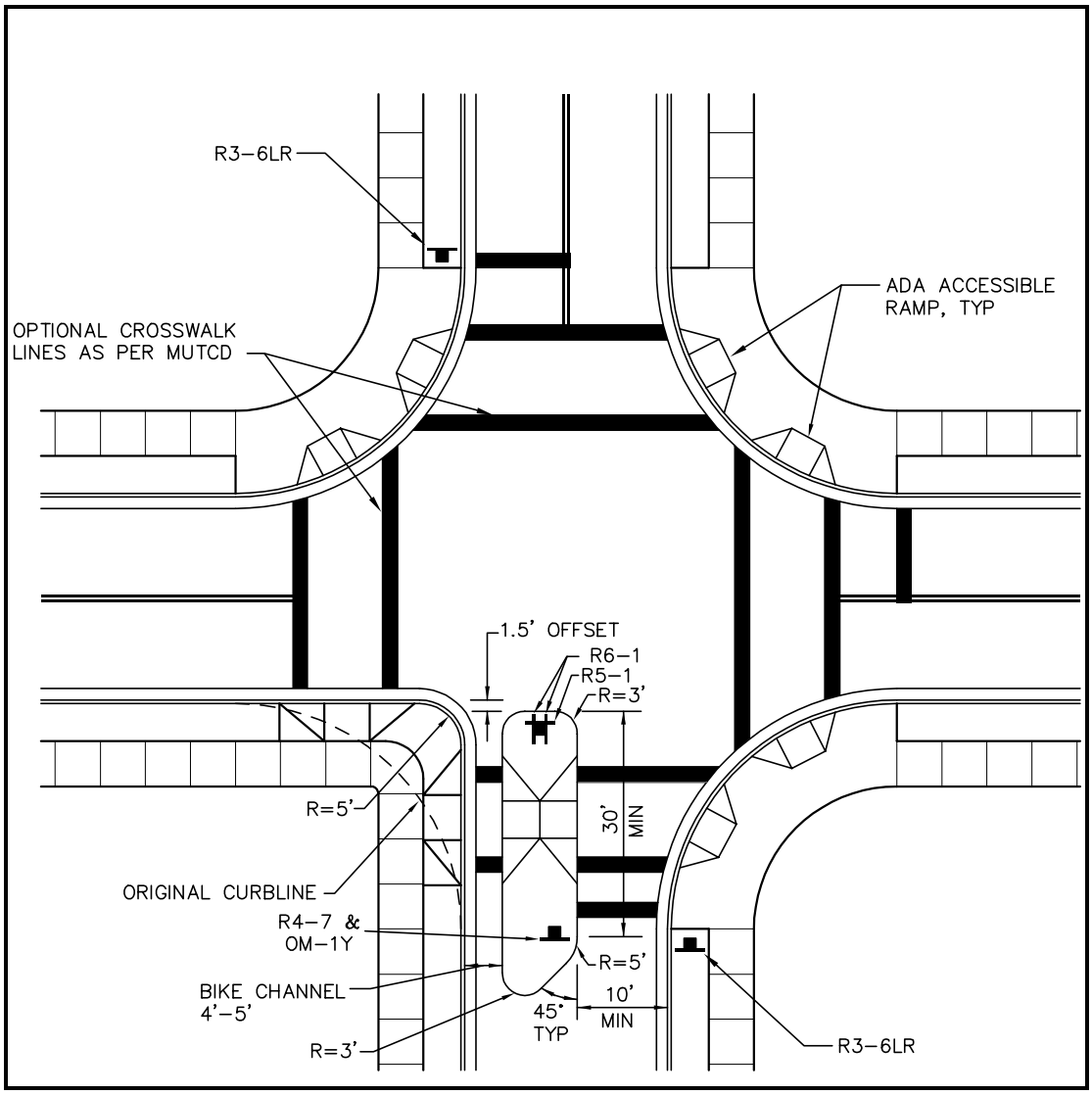


Figure 23: Typical Half Closure

5.2.3 Other Volume Control Measures

Diagonal diverters and forced turn islands are also authorized for use in the MOA subject to *Application Guidelines* in Chapter 5. They present few design issues as they are simple barriers blocking one or more movements at an intersection. The MOA typical designs (see Figures 24 and 25) have the following features:

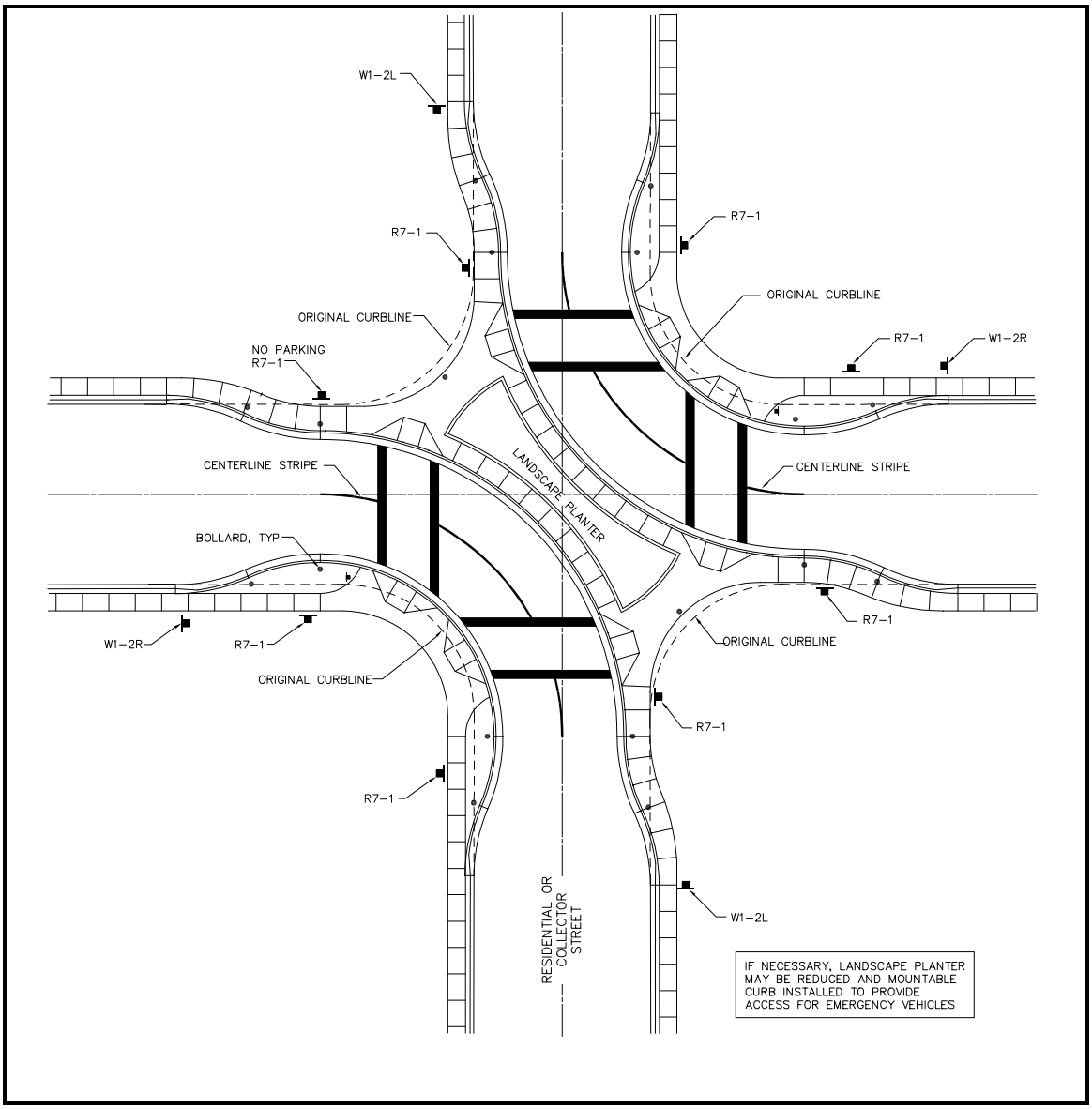
(1) Diagonal diverters and forced turn islands will have clear widths sufficient for single unit trucks (or buses if a transit route) to make turns at treated intersections without encroaching into opposing lanes.

(2) Diagonal diverters will have openings five feet to six feet wide, sufficient for bicyclists to pass through barriers but not for motorists to do so. Alternatively, diagonal diverters may have curb ramps up to the sidewalk at the corners. Such ramps must meet the Americans with Disabilities Act (ADA) *Standards for Accessible Design*, 28 CFR Part 36, Appendix A.

(3) Diagonal diverters will be landscaped for aesthetic reasons and also to reinforce the idea that barriers are not to be traversed. On an exception basis, bollards may be used instead of landscape materials. Where traversal by emergency vehicles is anticipated, a clear width of at least ten feet shall be left free of landscaping and bollards.

(4) Diagonal diverters will have barrier-type curbs to discourage unauthorized vehicles from traversing them. Curb heights as high as six inches may be used to allow emergency vehicles to mount and cross barriers without encouraging the same by private vehicles.

(5) Forced turn islands will be sharply angled toward the right on the approach to discourage wrong-way movement. At pedestrian crossing points, islands shall either have pedestrian cut-throughs at-grade or ADA compliant ramps and plateaus.



Note: If driveways are located in close proximity to the diverter, stop signs (R1-1) may be required at the approach to the diverter as directed by the MOA Traffic Department.

Figure 24: Typical Diagonal Diverter

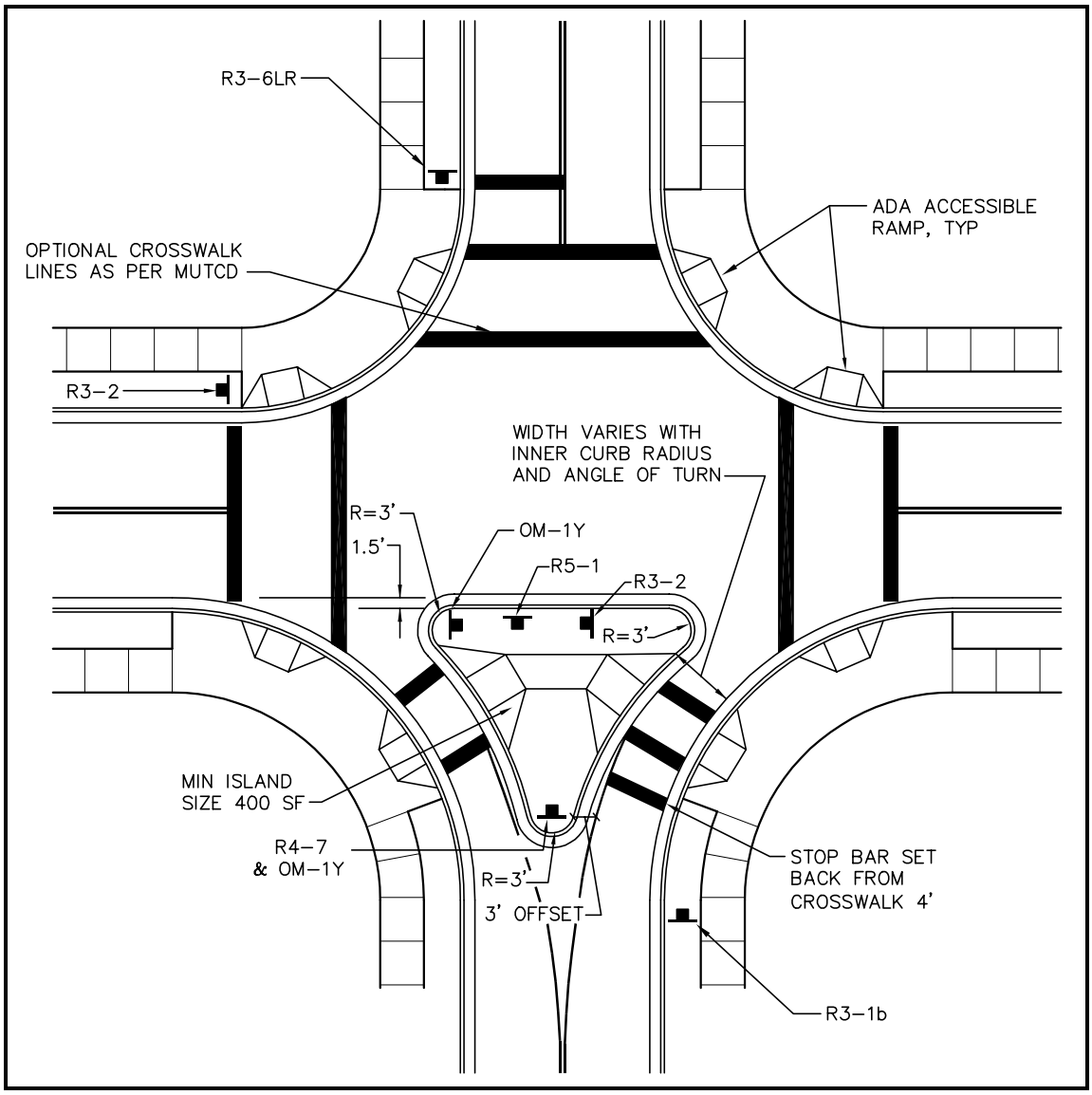


Figure 25: Typical Forced Turn Island

5.3 Vertical Speed Control Measures

5.3.1 Speed Humps

The typical speed hump is three inches high and 14 feet long in the direction of travel (see Figure 27). Its ramps are sinusoidal in shape. Its sides taper off at the gutter. It is constructed of asphalt though rubber or thermoplastic is used for temporary (movable) humps.

The typical hump has a design speed of 25 mph. This speed is safe and comfortable for automobiles. Larger vehicles have to cross the hump at lower speeds. The 14-foot hump was chosen over the more common 12-foot hump due to its slightly higher design speed and smoother ride for emergency vehicles.

Selection of the sinusoidal profile was influenced by the *Canadian Guide to Traffic Calming* (Transportation Association of Canada, 1998) which recommends all speed humps in Canada to be sinusoidal in shape rather than the parabolic shape more commonly used in the lower 48 states. The sinusoidal profile is bell-shaped rather than parabolic (see Figure 26) and typically provides a smoother transition for snow removal equipment and bicyclists.

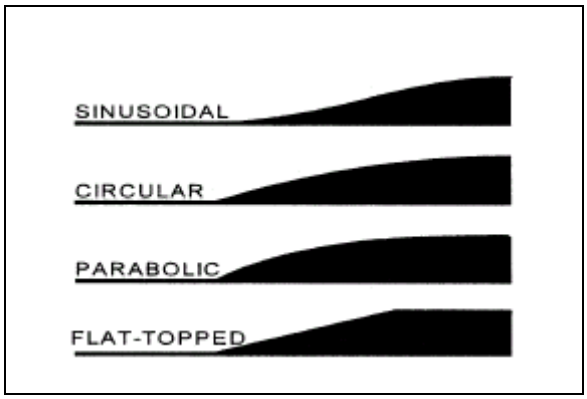
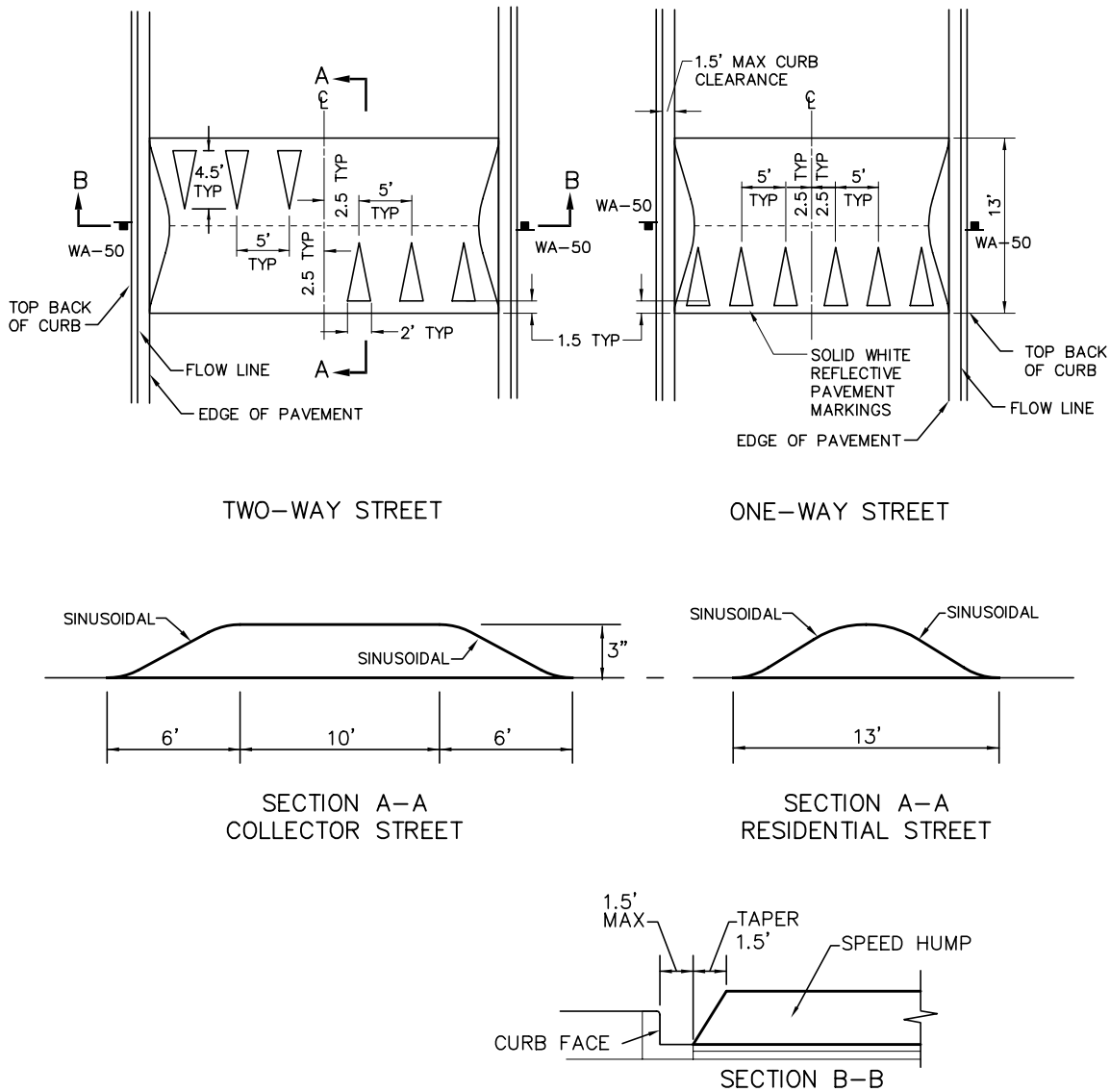


Figure 26: Various Hump Profiles

On an exception basis, the MOA will consider requests for humps with other profiles. To achieve particular crossing speeds, humps may range from two to four inches high. Less than two inches produces little speed reduction, and more than four inches greatly increases the risk of vehicle grounding.



Sinusoidal Speed Hump Development

Distance (ft)	0.000	0.41	0.82	1.23	1.64	2.05	2.46	2.87	3.28	3.69	4.10	4.51	4.92	5.33	5.74	6.15	6.55
Finished Height (in)	0	0.04	0.12	0.26	0.47	0.71	0.98	1.26	1.57	1.89	2.17	2.44	2.68	2.87	3.03	3.11	3.15

Figure 27: Typical Speed Hump

On an exception basis, humps may be shorter or longer than the typical design though no shorter than six feet in the direction of travel. Shorter humps tend to function like speed bumps.

Vertical acceleration of the chassis and resulting discomfort to the motorist are diminished at high speeds compared to low speeds thereby encouraging motorists to speed.[1]

Finally, on an exception basis, the MOA may allow humps that taper off before the gutter forming a bicycle channel three to four feet wide. This practice has the advantage of providing a flat surface for bicyclists but has the disadvantage of encouraging motorists to encroach into the bicycle channel riding with one wheel up and the other down.

5.3.2 Speed Tables

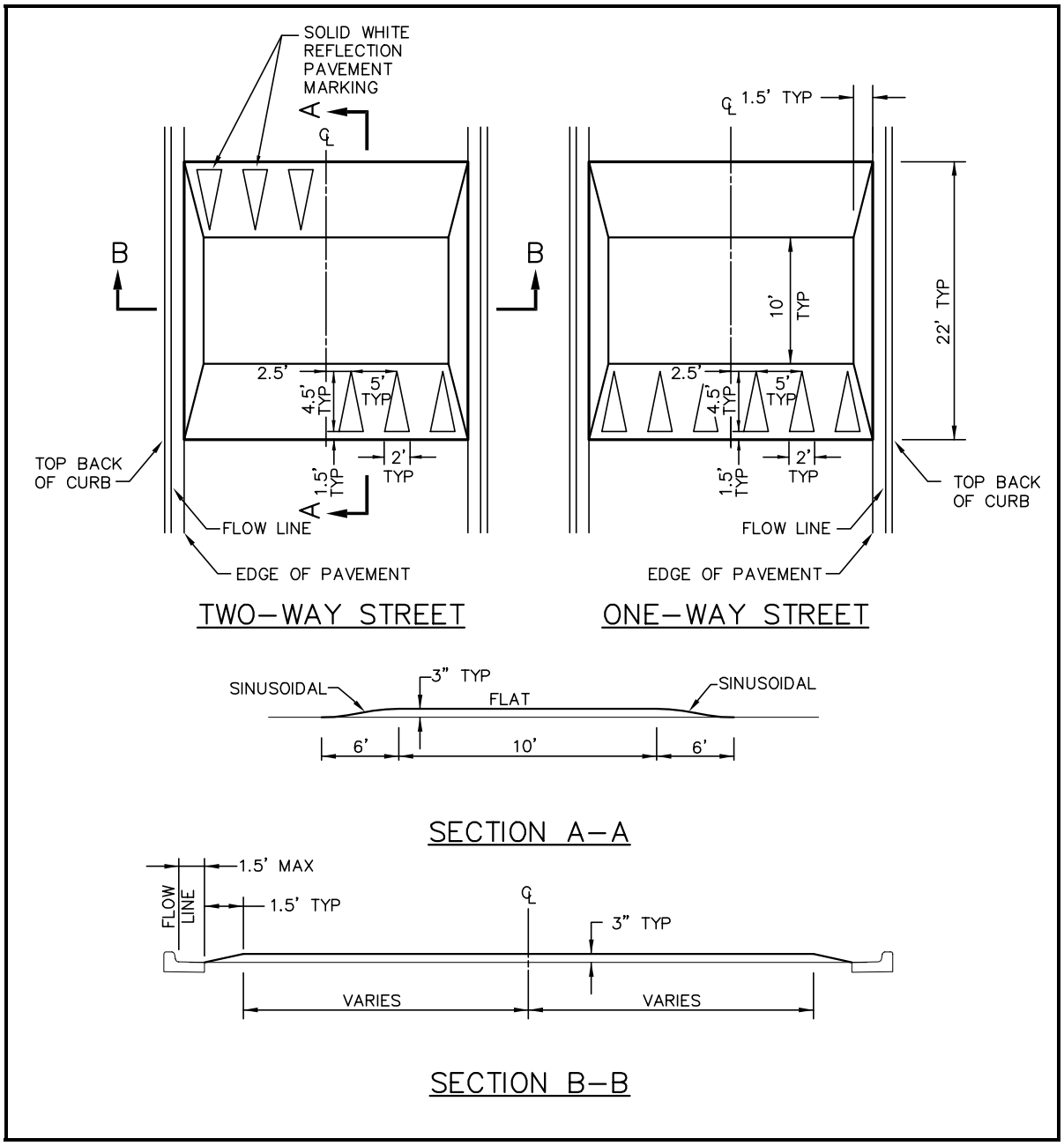
The typical speed table is three inches high and 22 feet long in the direction of travel (see Figure 28). The plateau (flat top) is ten feet long, and each ramp is six feet long. The plateau is made of asphalt, concrete, stamped asphalt or concrete, or other patterned materials as approved by the MOA Traffic Engineer. The ramps are sinusoidal in shape and ordinarily made of asphalt though concrete, brick, and concrete pavers are also used. The sides taper off at the gutter.

The typical speed table has a design speed of 30 mph. This speed is safe and comfortable for automobiles. Larger vehicles have to cross the table at lower speeds. Ramps shall be sinusoidal in profile. On an exception basis, the MOA will consider requests for tables with other profiles.

The plateaus of speed tables may be as short as eight feet in the direction of travel. While the MOA has not established an upper limit on the length of speed tables or raised crosswalks, they tend to lose their effectiveness if more than 50 feet long. On transit and emergency response routes, plateaus of 20 feet or more are recommended so that long wheelbase vehicles can cross with all wheels on the flat portion.

All other dimensional requirements for speed humps (as to height, profile development, etc.) apply as well to speed tables.

1 At higher speeds, the suspension system collapses on contact with a bump, with front wheels rising into the wheel wells while the chassis continues on a more level path than the vertical curvature would suggest. The mass of the vehicle body does not have time to react.



Sinusoidal Speed Hump Development

Distance (ft)	0.000	0.41	0.82	1.23	1.64	2.05	2.46	2.87	3.28	3.69	4.10	4.51	4.92	5.33	5.74	6.15	6.55
Finished Height (in)	0	0.04	0.12	0.26	0.47	0.71	0.98	1.26	1.57	1.89	2.17	2.44	2.68	2.87	3.03	3.11	3.15

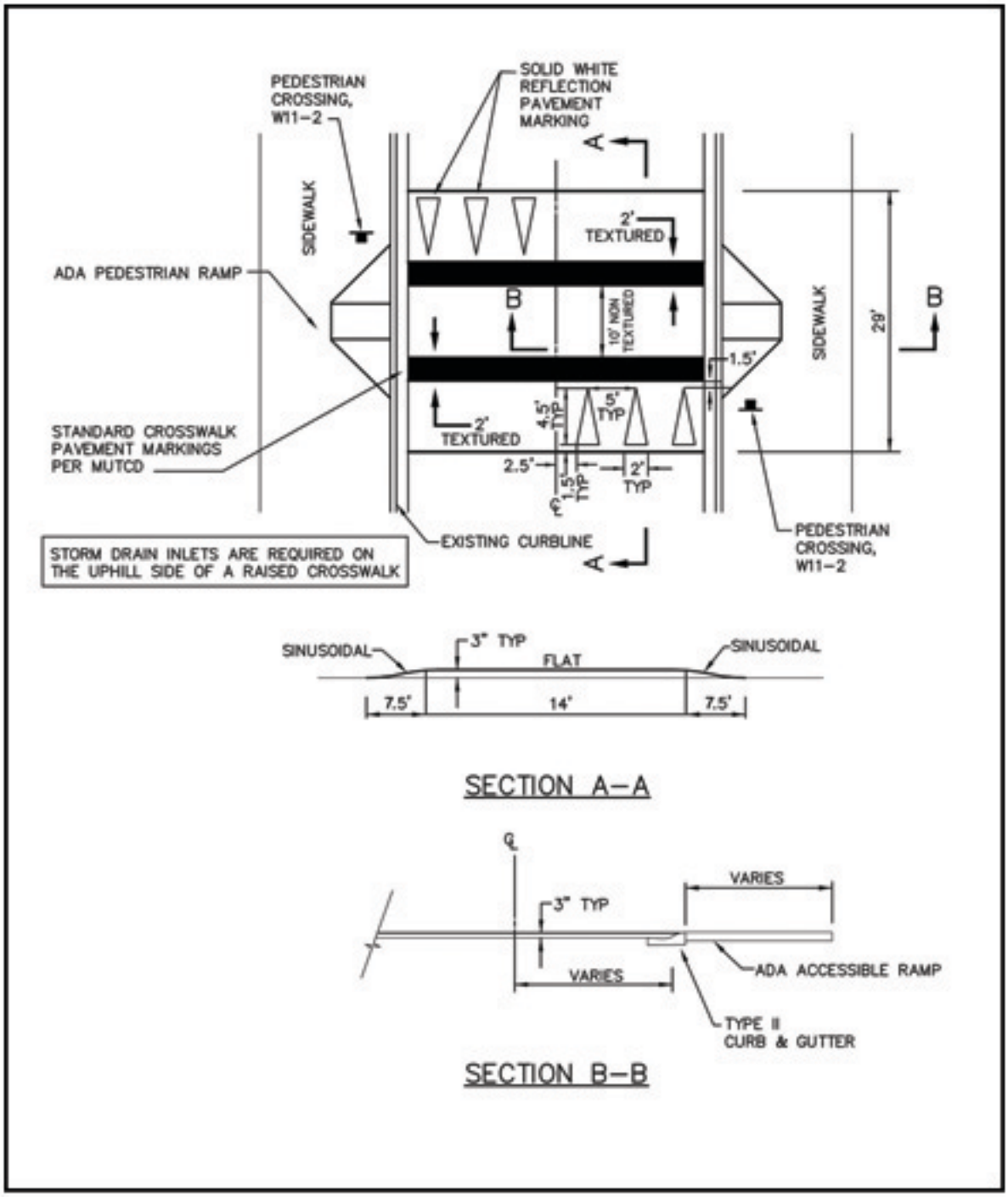
Figure 28: Typical Speed Table

5.3.3 Raised Crosswalks and Raised Intersections

A raised crosswalk is a speed table marked and signed for pedestrian crossing (see Figure 29). The only geometric differences between the two are: the raised crosswalk extends from *curb-to-curb* rather than tapering off at the gutter, and the raised crosswalk may be longer and higher than the typical speed table to bring it up to sidewalk level. All other geometric requirements for speed tables apply to raised crosswalks as well.

A raised intersection is a speed table covering an entire intersection (see Figure 30). All other geometric requirements for speed tables apply to raised intersections as well.

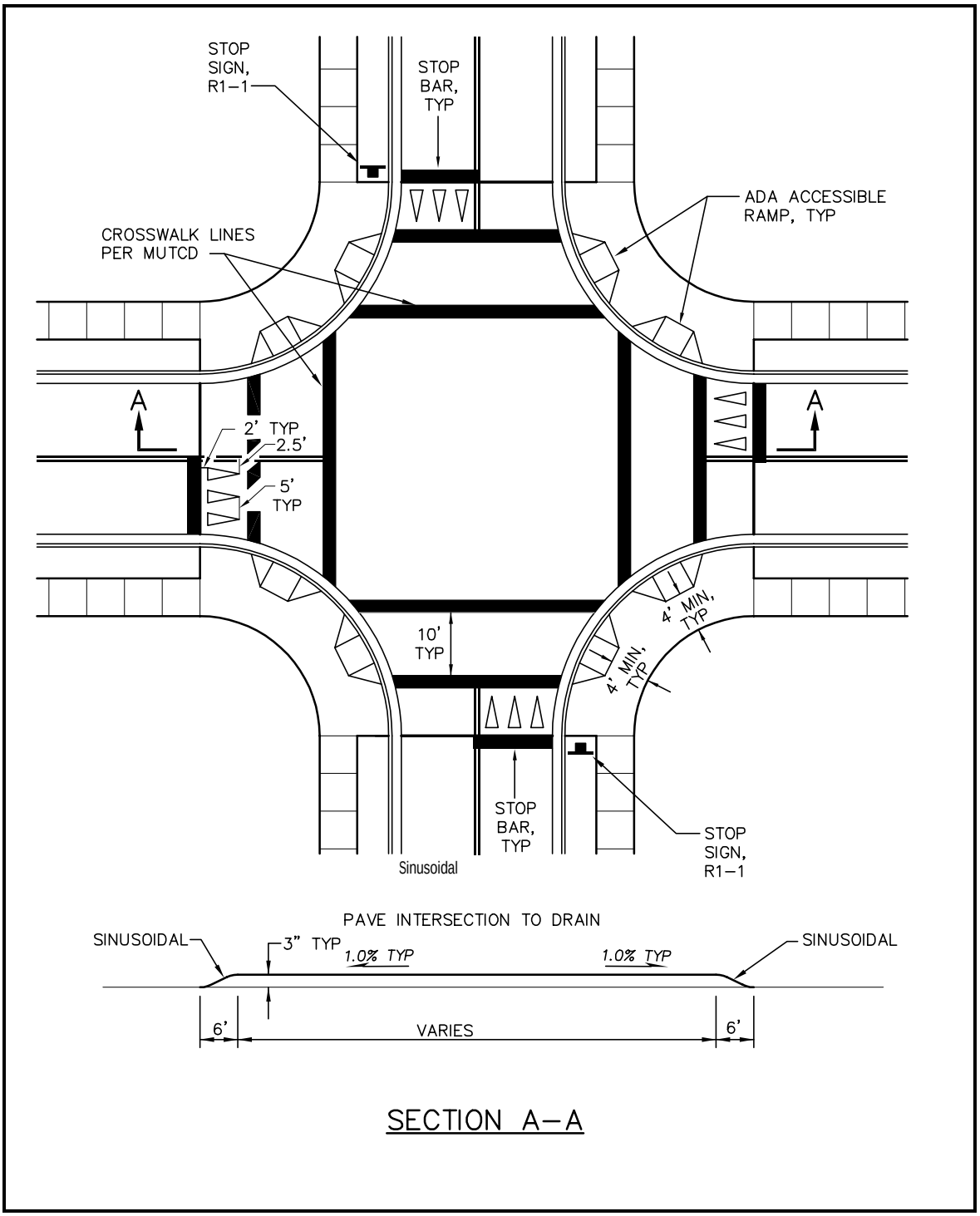
If built to typical speed table specifications, a raised crosswalk or raised intersection will stop three inches short of standard barrier curb height and sidewalk level. The sidewalk must connect to the crosswalk via curb ramps that meet ADA *Standards for Accessible Design*, 28 CFR Part 36, Appendix A. Alternatively, a raised crosswalk or raised intersection may extend to the sidewalk level. In either case, the visually impaired should be warned at the street edge that they are entering the traveled way. Such a warning should be provided by means of a tactile surface. Bollards or other street furniture to protect waiting pedestrians and prevent corner cutting by motorists may supplement this.



Distance (ft)	0.000	0.41	0.82	1.23	1.64	2.05	2.46	2.87	3.28	3.69	4.10	4.51	4.92	5.33	5.74	6.15	6.55
Finished Height (in)	0	0.04	0.12	0.26	0.47	0.71	0.98	1.26	1.57	1.89	2.17	2.44	2.68	2.87	3.03	3.11	3.15

Sinusoidal Speed Hump Development

Figure 29: Typical Raised Crosswalk



Sinusoidal Speed Hump Development

Distance (ft)	0.000	0.41	0.82	1.23	1.64	2.05	2.46	2.87	3.28	3.69	4.10	4.51	4.92	5.33	5.74	6.15	6.55
Finished Height (in)	0	0.04	0.12	0.26	0.47	0.71	0.98	1.26	1.57	1.89	2.17	2.44	2.68	2.87	3.03	3.11	3.15

Figure 30: Typical Raised Intersection

5.3.4 Accommodation of Bicyclists

Due to the tendency for gutter running by motorists attempting to maneuver around vertical measures, the measure must extend the full width of the roadway where practical. Where ROW width is insufficient to have a separated multi-use trail, the next best treatment for bicyclists is to direct them over vertical measures but have tapers on the edges that are gentle enough so they will not lose their balance. Where significant bicycle traffic is anticipated, side slopes on tapers shall be no steeper than 1:6 vertical:horizontal (v:h).

The vertical face (i.e. the upstand or lip) on the leading edge of humps, tables, raised crosswalks, and raised intersections shall be no more than one-quarter inch high to ensure a smooth ride for bicyclists.

5.3.5 Design Modifications for Hilly Terrain

Vertical speed control measures are ordinarily limited to grades of eight percent or less. On an exception basis, the MOA will consider the use of humps or tables on steeper grades with appropriate modifications of vertical profiles. On grades of more than eight percent, ramps must be steeper than normal on the uphill sides of humps or tables and less steep than normal on the downhill sides (see Figure 31). Otherwise, motorists will encounter actual gradients going uphill that are excessive and going downhill that are ineffectual increasing the risk of vehicle grounding or becoming airborne.

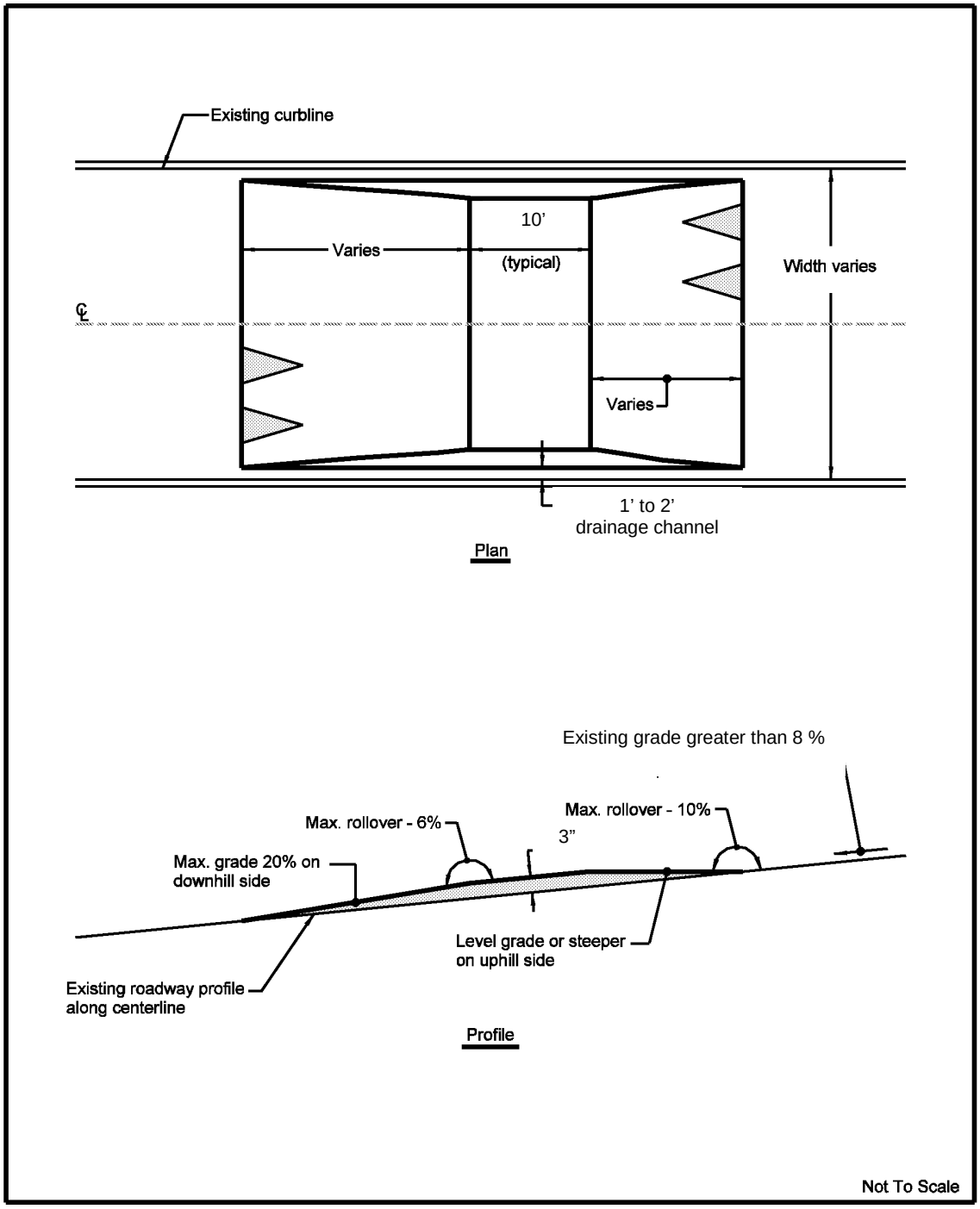


Figure 31: Vertical Profile Modified To Be Effective On An Incline Greater Than 8%

5.4 Horizontal Speed Control Measures

5.4.1 Traffic Circles

The typical traffic circle is shown in Figure 32. The travel path through the intersection has a horizontal curve radius of 95 feet yielding a crossing speed of 20 mph (see Section 5.6.2 for derivation.). A low design speed was chosen to keep the circle as small as practicable.

The design vehicle for the typical mini circle is a single unit truck. A single unit truck can pass through a treated intersection without having to mount the center island of the circle. Even though this circle is a relatively large for a neighborhood traffic circle, larger trucks and buses have to mount the center island when passing through a treated intersection. Trucks and buses generally cannot make left turns in the prescribed manner, that is, by circulating counterclockwise around the center island.

Most traffic circles, including the typical circle in Figure 32, have circular center islands and circular perimeters formed by the intersection corners. Where intersecting streets differ significantly in width, the center island may be elongated to better fit the intersection. An elongated circle consists of half circles with tangent sections between them.

Most traffic circles are deployed at four-way intersections, for this is where the greatest safety benefits accrue. For traffic circles at “T” intersections, curbs should be either extended at the entrance and exit to the intersection or indented within the intersection to ensure adequate deflection of vehicle paths along the top of the “T.”

The typical circle has a center island with two levels: a base that is mountable and a center that is not mountable. Automobiles and single unit trucks circulate counterclockwise around the base experiencing sufficient deflection to hold down their speeds. Large buses and trucks can use the base as an overrun area. If large vehicles are not part of the traffic mix, the center can be expanded and the overrun area reduced to a small mountable lip.

The center island has the cross section shown in Figure 33. At two inches high, the outer curb is not particularly visible from the driver’s angle of view nor is it protective of landscaping in

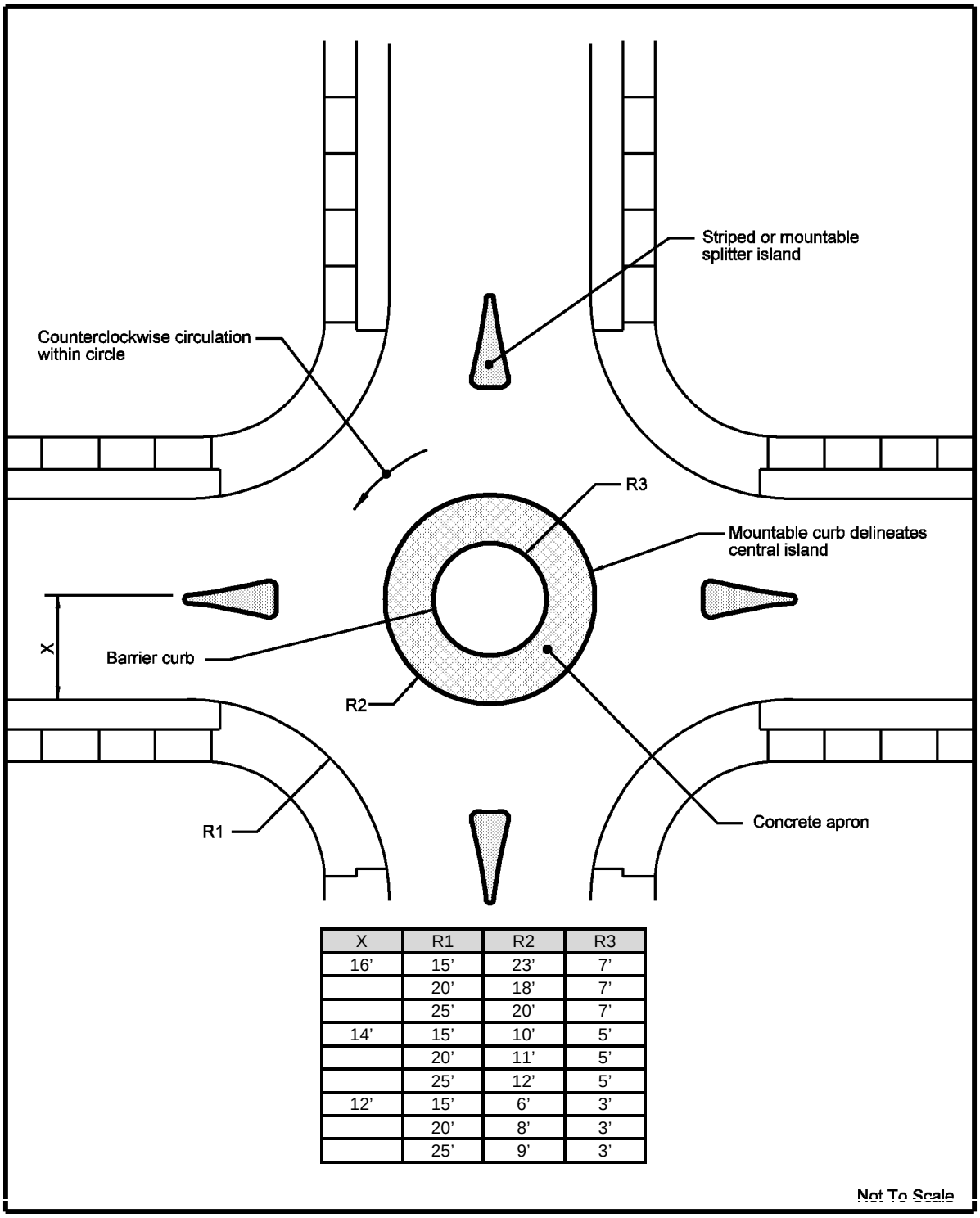
the center island. Hence, the base slopes upward toward the center and transitions into a barrier-type inner curb six inches high around the landscaped center. To function as an overrun area, the base must be load bearing and should slope upward at a rate of no more than 1:15 V:H.

For aesthetics and attention getting, the center island should always be landscaped. Landscaping should be carefully planned for unrestricted visibility. To preserve sight lines, trees should have clear stem heights of at least eight feet and should be no more than four inches in diameter to ensure that they break away upon impact. Bushes or shrubs should grow to no more than two feet in height. Groundcover plantings are particularly useful for landscaping of islands because they leave sight lines open and pose no danger to out-of-control drivers.

Finally, for visibility and drainage, the circulating lane will ordinarily slope away from the center island of the traffic circle. A slope of one to two percent offers these advantages without the risk of heavy vehicles turning over due to reverse superelevation.

On an exception basis, the Traffic Department will consider mini circles that fit within the curb lines of smaller intersections (Figure 34). Mini traffic circles will be considered where two conditions are met: (1) intersection widening is infeasible and (2) entering volumes are less than 500 vpd (50 vehicles during the peak hour). Mini traffic circles may have a reduced center island/apron or the center island/apron may be eliminated completely and replaced with striping. At mini traffic circles, buses and trucks are permitted to make left turns in front of the center island.

For specified street widths and corner radii, center island dimensions for the alternative design are given in Table 6. For other widths and corner radii, center island dimensions can be determined from the relationship between offset distances and opening widths.



X	R1	R2	R3
16’	15’	23’	7’
	20’	18’	7’
	25’	20’	7’
14’	15’	10’	5’
	20’	11’	5’
	25’	12’	5’
12’	15’	6’	3’
	20’	8’	3’
	25’	9’	3’

Figure 32: Traffic Circle

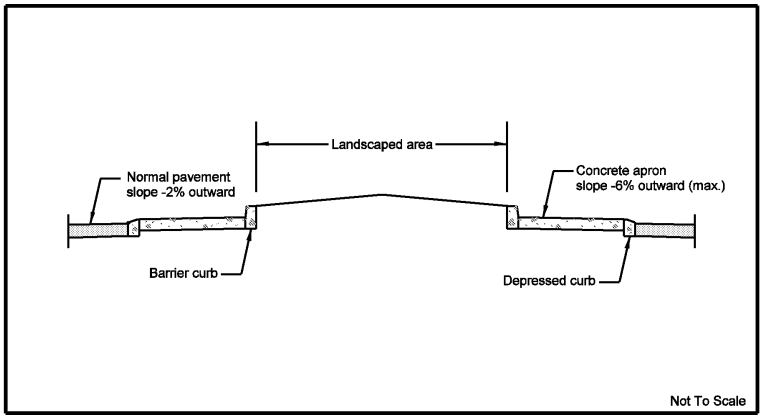


Figure 33: Island Section

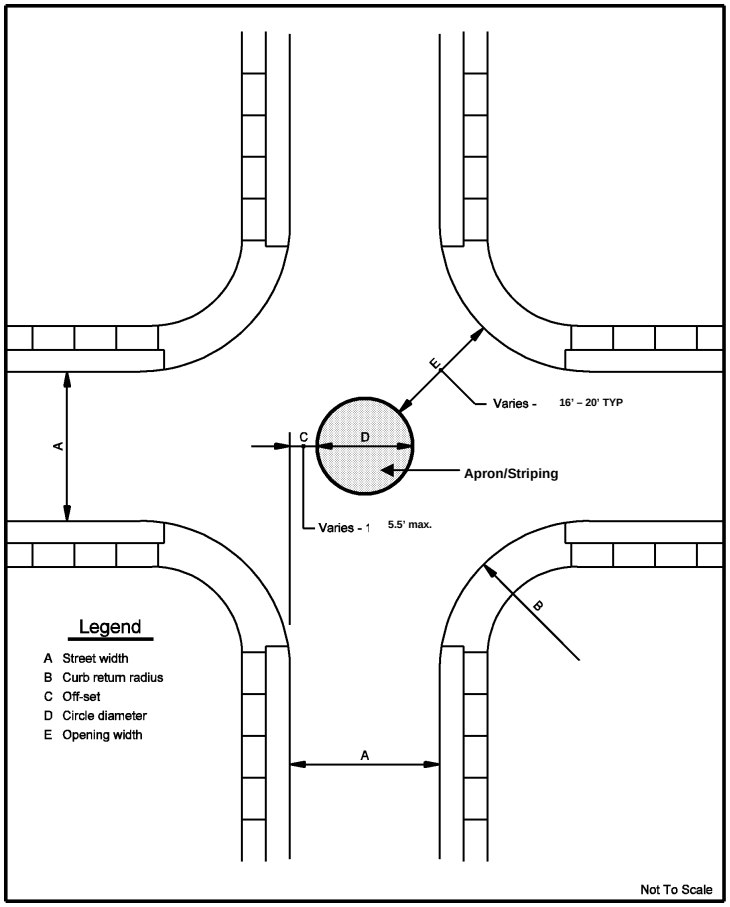


Figure 34: Alternative Design for a Mini Traffic Circle

Table 6: Center Island Dimensions

"A" Street Width (feet)	"B" Curb Radius (feet)	"C" Offset Distance (feet)	"D" Circle Diameter (feet)	"E" Opening Width (feet)
22	<14	Reconstruct curbs		
	15	5.5	11	16
	20	4.5	13	18
	25	4.0	15	19
24	<12	reconstruct curbs		
	15	5.0	14	17
	20	4.5	15	18
	25	3.5	17	20
30	10	5.5	19	16
	15	5.0	20	17
	20	4.0	22	19
	25	3.0	24	20
32	10	5.5	21	16
	15	4.5	23	18
	20	4.0	24	19
	25	2.5	27	20

The optimal relationship between offset distance and opening width is:

5.5 feet max	16 feet min
5	17
4.5	18
4	19
3.5 or less	20

5.4.2 Roundabouts

Roundabouts are distinguished from traffic circles by larger radii, correspondingly higher design speeds and capacities, and splitter islands on all approaches to slow traffic and discourage wrong-way movements. A typical roundabout is shown in Figure 35. The Federal Highway Administration (FHWA) has published a recommended practice guide for the design of roundabouts. Because there are many ways to design a roundabout, this manual will not provide a specific design. Rather, this manual will simply recommend that the principles in the FHWA

manual should be followed. Roundabouts, like traffic circles, will be evaluated on a case-by-case basis.

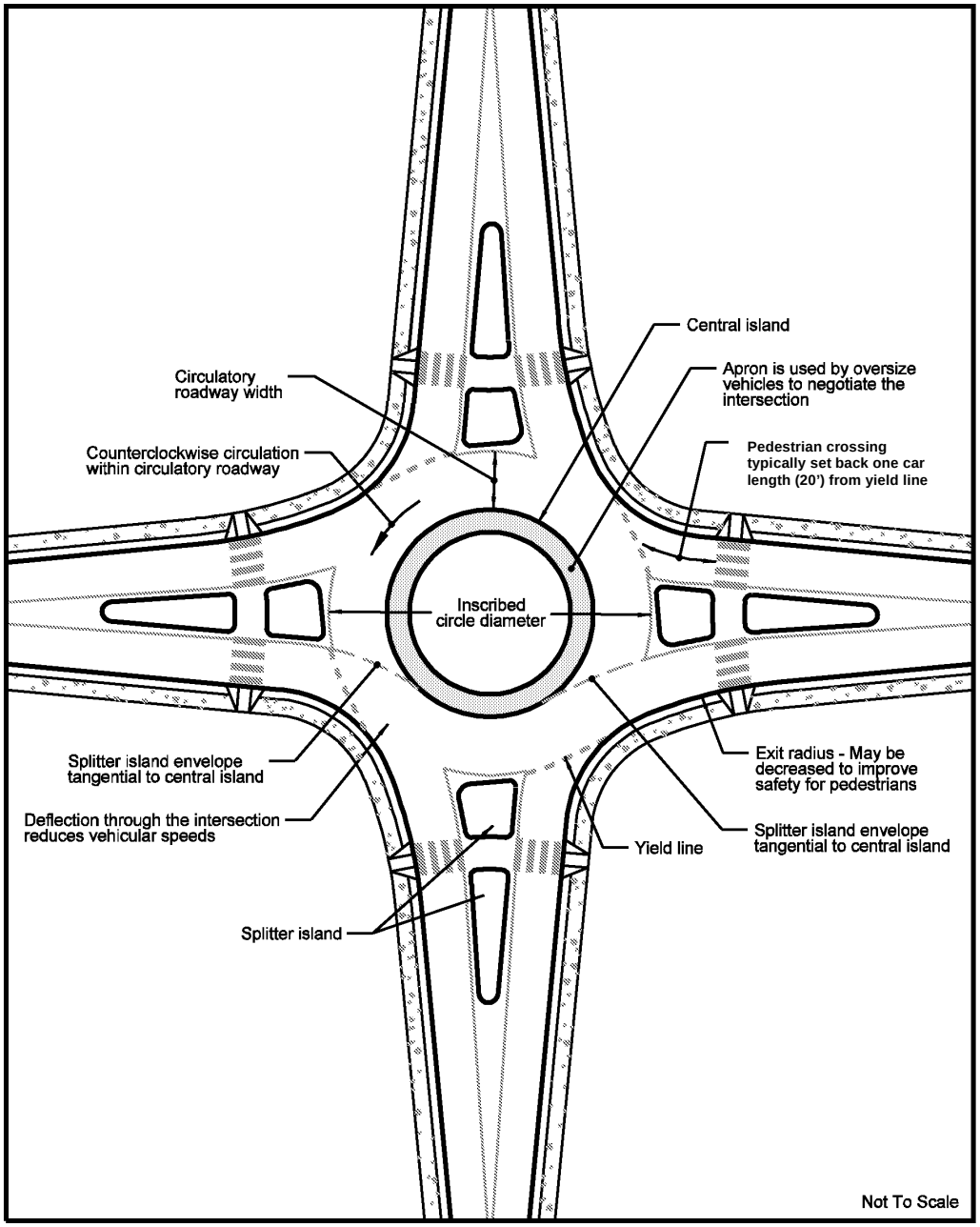


Figure 35: Typical Roundabout

5.4.3 Chicanes

Chicanes can be created either by means of curb extensions or edge islands (see Figure 36). The latter are less aesthetic but leave existing drainage channels open and tend to be less costly to construct. The curb extensions or edge islands should be semi-circular to facilitate snow removal equipment.

Edge line tapers shall conform to the *Manual of Uniform Traffic Code Devices* (MUTCD) taper formula. The curb extensions or edge islands should have 45-degree tapers to reinforce the edge lines.

Curb extensions or edge islands that form chicanes should have vertical elements to draw attention to them. Trees and other landscape materials meet this requirement. Landscaping guidelines for traffic circles apply as well to chicanes. An additional landscaping consideration on chicanes is to avoid the "picket fence" effect that can result from too closely spaced trees within the intersection sight triangles particularly on curb extensions. When a row of trees is installed, the trunks can create a "picket fence" obstruction effect that obstructs minimum intersection/driveway sight distance. Care should be taken not to plant too many trees at these locations.

Barrier curbs should be used on curb extensions and edge islands that form chicanes. Bollards should be placed at all changes in horizontal alignment to clearly delineate the curb line for snow removal operations. The bollards shall be placed with a minimum of two feet and a maximum of three feet from the face of the curb to the face of the bollard.

The typical chicane separates opposing traffic by means of double, solid yellow lines. Even this may not be enough to discourage some motorists from cutting across the centerline to minimize deflection. To further discourage this behavior, a raised median may be installed. The median shall be a minimum of four feet wide and mountable with or without landscaping.

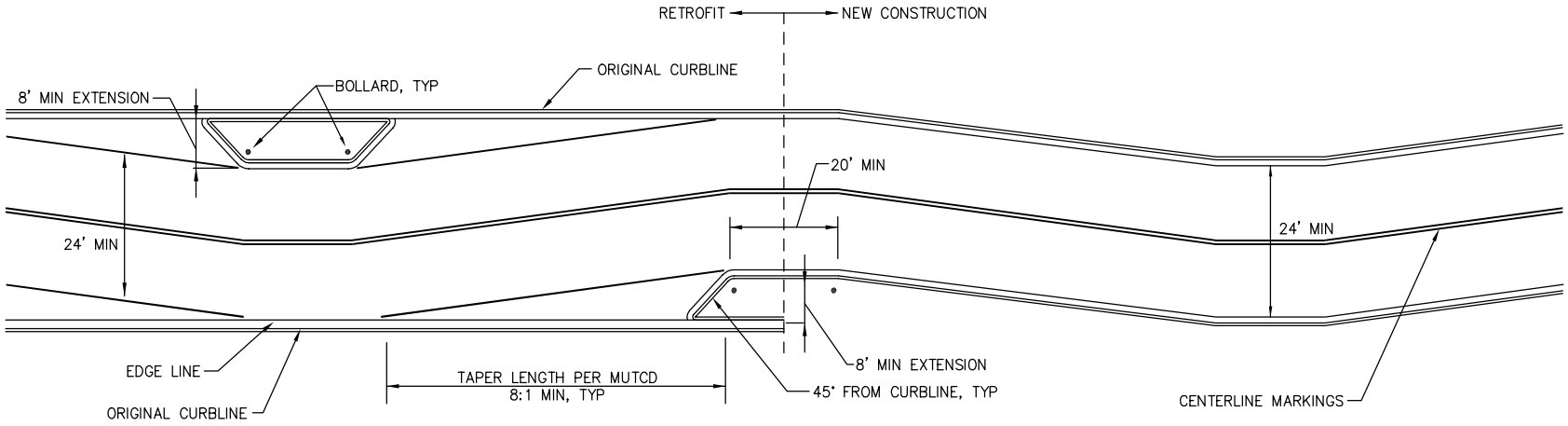


Figure 36: Typical Chicane

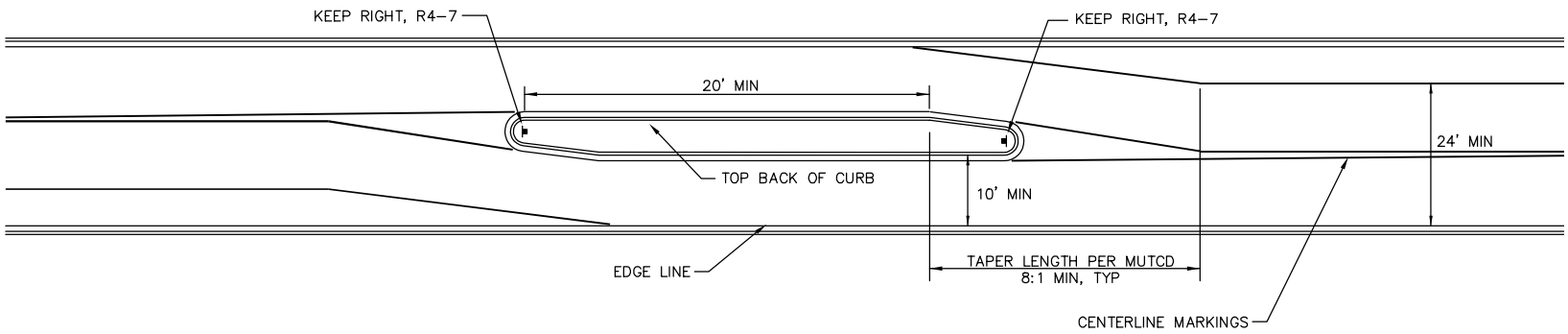


Figure 37: Typical Lateral Shift

On an exception basis, the MOA will consider chicanes formed with parallel parking bays alternating from one side of the street to the other. This is a relatively inexpensive design option and is common in redesigned streets.

5.4.4 Lateral Shifts

The typical lateral shift is just one half of the typical chicane (see Figure 37). It has the same dimensions and details as the typical chicane but because the roadway alignment shifts only once, has a crossing speed 5 mph higher than a chicane of the same dimensions. A higher crossing speed is desirable because lateral shifts are one of the few traffic calming measures suitable for collector roads.

The typical lateral shift separates opposing traffic by means of a landscaped center island. Absent such an island, some drivers will cross the centerline so as to minimize deflection. With an island, drivers cannot veer into the opposing lane thus ensuring the effectiveness of the lateral shift. On an exception basis, the MOA will consider lateral shifts formed with parking bays. The comments regarding parking bays in chicanes apply as well to lateral shifts.

5.4.5 Accommodation of Bicyclists

Bicyclists tend to be squeezed or cut off at horizontal speed control measures. On streets with little bicycle traffic and/or low volume motor vehicle traffic, such conflicts are sufficiently infrequent to require no special accommodation of bicyclists. Where volumes of both bicycle and motor vehicle traffic are high, special accommodation should be made such as constructing a separated multi-use trail.

5.5 Narrowings

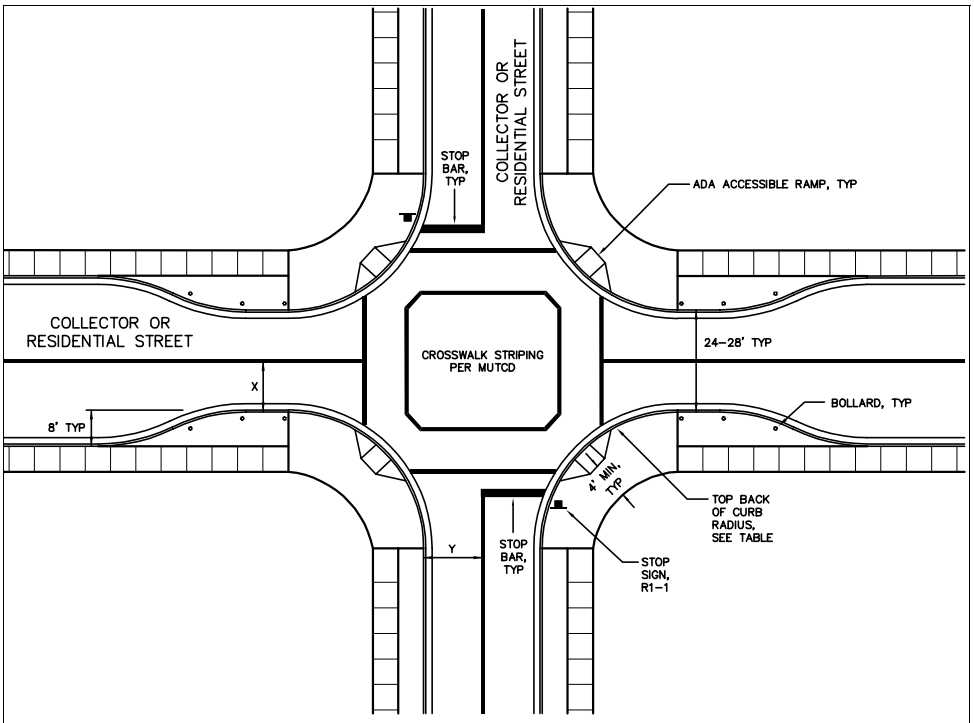
5.5.1 Neckdowns

The typical neckdown is used in connection with on-street parking and, unlike a conventional intersection with a large curb return radius, offers a short crossing distance and high visibility

for pedestrians (see Figure 38). In the typical design, the curb return radii and street widths are such that single unit trucks can stay to the right of the centerlines when making right turns.

When streets are wide to begin with and have parking lanes on main and cross streets, intersections can be narrowed down without necessitating encroachment by trucks into opposing lanes. When streets are narrow and/or without curbside parking, intersections cannot be narrowed down without encroachment. Many jurisdictions keep corner radii small and allow large vehicles to swing wide into the opposing lane when making right turns. On an exception basis, the MOA will consider this practice when volumes entering the intersection are less than 500 vpd (50 vehicles during the peak hour), heavy vehicle traffic is less than two percent of the daily total, and the roadway is not a transit route[1]. Otherwise, curb radius should be large enough to allow a single unit truck (or bus) to maneuver the corner without encroaching into the opposite lane.

1 R. Ewing, *Traffic Calming State-of-the-Practice*, Institute of Transportation Engineers, Washington, D.C., 1999



TBC to Centerline		TBC Radius
X	Y	
12"	12"	40'
12"	14'	32'
12"	16'	26'
14'	12"	37'
14'	14'	35'
14'	16'	24'

Figure 38: Typical Neckdown

In cases where streets are narrow and traffic volumes are high, as on some main shopping streets, the MOA may consider setting choke points and crosswalks back from intersections a short distance to keep large vehicle turns within lanes and to create shorter pedestrian crossing distances at the same time.

Bollard and landscape guidelines for chicanes apply as well to neckdowns.

5.5.2 Chokers

The typical two-lane choker is 25 feet from curb face to curb face. It has a minimum constricted length of 20 feet in the direction of travel; the length of a passenger car (see Figure 39). The constricted length is kept short to avoid blocking driveways and displacing curbside parking.

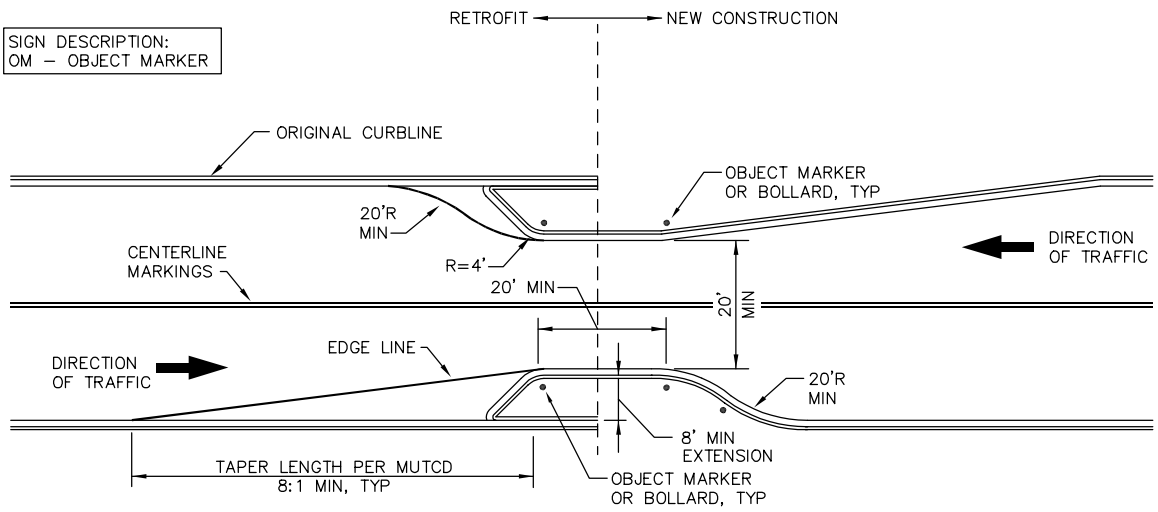


Figure 39: Typical Choker

A curb-to-curb width of the typical choker, while significantly less than the MOA standard roadway design width, will have a modest effect on speeds because vehicles can still easily pass each other. Therefore, on an exception basis where traffic is light and the proportion of large vehicles is low, the MOA may consider narrower cross sections.

Chokers can be created either by means of curb extensions or edge islands. The latter are less aesthetic but leave existing drainage channels open. They also make it possible to provide bicycle bypass lanes on streets without curbside parking.

If centering a choker will result in undersized curb extensions on both sides of the street, the MOA will consider shifting the choker to one side of the street. An undersized extension is one that fails to fully shadow a parking lane. That is, one extending less than eight feet toward the centerline.

Edge line tapers shall conform to the MUTCD taper formula. Curb extensions or islands should have 45-degree tapers to reinforce the edge lines. On streets without edge lines (basically, streets at the bottom of the functional hierarchy), no edge lines are required at chokers.

When used in connection with curbside parking, chokers may extend to the edge of the travel lane to form protected parking bays. Absent an edge line or marked parking spaces, chokers should extend no farther than eight feet toward the centerline.

Curb extensions or edge islands that form chokers should have vertical elements to draw attention to them, preferably landscaping. Any vertical element shall be of breakaway or yielding design. Bollard and landscaping guidelines for chicanes apply as well to chokers.

Within the choker, a change in pavement material should be considered. Textured surfaces, such as stamped asphalt or concrete, reinforce the visual cues of narrowing and landscaping thereby warning motorists of the constriction and emphasizing its special character. Otherwise, two-lane narrowings may be so subtle as to be missed.

For chokers that serve as pedestrian peninsulas, barrier curbs shall be used to provide an added measure of pedestrian protection. Otherwise, barrier or mountable curbs shall be used based on a case-by-case evaluation.

5.5.3 Center Island Narrowings

The typical center island narrowing is shown in Figure 40. The typical design incorporates these features:

(1) the center island is large enough to command attention (at least 6 feet wide and 20 feet long),

(2) the approach nose is offset to the left from the perspective of approaching traffic, and

(3) the center island curb forms a diverging taper to deflect traffic toward the right.

Center islands should be at least one car length but not much longer. Center islands are most effective in reducing speeds when they are short interruptions to an otherwise open street section rather than long median islands that channelize traffic and separate opposing flows. The latter have been found to actually increase running speeds while the former (perhaps because they appear as obstacles to approaching traffic) slow traffic to a degree. Short islands have the added

advantage of keeping driveway access open in both directions, which is desirable at lower functional classification levels where traffic calming is most often practiced.

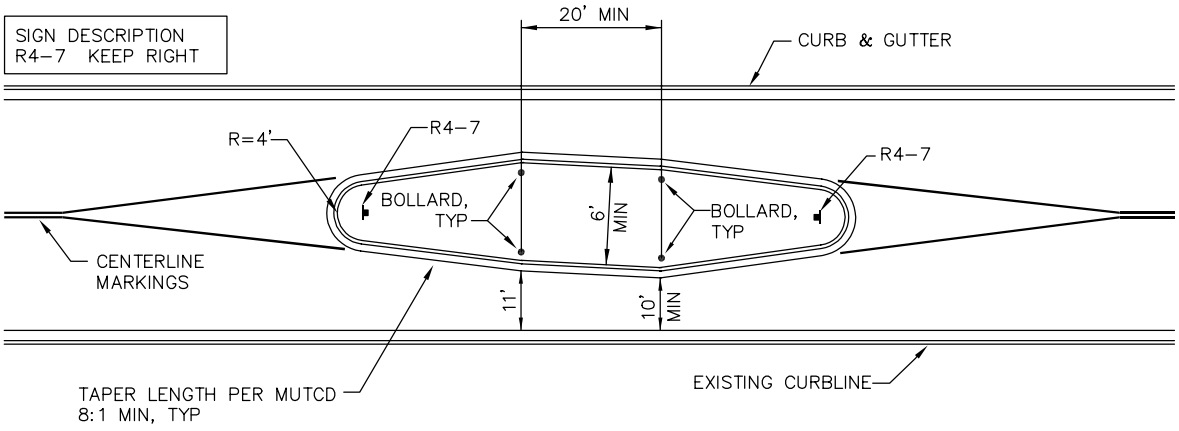


Figure 40: Typical Center Island Narrowing

When center islands are placed at pedestrian crossings, ADA requires that they have pass-throughs that are traversable by the disabled. This requirement may be met with cut-throughs flush with the roadway to provide a level crossing or it may be met with gentle ramps up to a plateau wide enough for a wheelchair. ADA requirements are contained in Sections 4.3 and 4.7 of the ADA *Standards for Accessible Design*. Ordinarily, a cut-through will be used in the MOA since a plateau with ramps requires a much wider center island (about 16 feet wide at a minimum). When a cut-through is used, the longitudinal cut should be 12 feet or the crosswalk width, whichever is greater.

Center islands should have vertical elements to draw attention to them, preferably landscaping. Any vertical element shall be of breakaway or yielding design. Bollard and landscaping guidelines for chicanes apply as well to center island narrowings.

For center islands that serve as pedestrian refuges, barrier curbs shall be used to provide an added measure of pedestrian protection. Otherwise, mountable type curbs are preferred. Under low-speed street conditions, mountable curbs may be placed at the edge of a through lane rather than offset by one foot or more as with barrier curbs.

5.6 Speed Estimates

5.6.1 Speed Versus Vertical Curvature

5.6.1.1 Speed Humps

MOA's typical speed hump has an 85th percentile crossing speed of just under 25 mph. For other speed humps that are approximately circular in shape, crossing speeds can be estimated with a formula from ITE's *Traffic Calming State-of-the-Practice*. The formula was derived using the common 12-foot hump as a reference point. Whatever forces of centrifugal acceleration are tolerable going over this hump at its 85th percentile speed, will be equally tolerable going over other vertical measures at their 85th percentile speeds[1].

The following formula applies to any measure of approximately circular shape:

$$R = V^2/5.81$$

where R is the radius of a vertical curve in feet and V is the velocity at which the curve is traversed in mph (as in Figure 37). Or, equivalently:

$$V = 2.41\ (R)^{1/2} \qquad (1)$$

As humps become less circular in shape, equation (1) becomes less accurate in predicting the centrifugal forces humps impart. A method of adjusting for deviations from a purely circular shape is suggested by T.F. Fwa and C.Y. Liaw, *Rational Approach for Geometric Design of Speed-Control Road Humps* (Transportation Research Record 1356, 1992, pp. 66-72).

Using precise hump measurements and corresponding speed data, Fwa and Liaw found that crossing speeds depended more on the shape of the hump than on the height-to-length ratio. Two

1 A 12-foot hump with a height of 3-1/2 inches is equivalent to an arc of a circle with a radius of 62 feet. This can easily be determined from trigonometry. Such a hump has an 85-percentile crossing speed of 19 mph. Given these values, the tolerable rate of centrifugal acceleration going over a speed hump must be on the order of 12.5 feet/second^2. Admittedly, the physics of crossing a hump are being oversimplified. The force of impact with the hump will tend to reduce speed; the smaller vertical displacement as the front wheels rise into the wheel wells will tend to increase them. It would require a much more sophisticated analysis than this one to capture these high-speed efforts. Here only centrifugal forces are accounted for.

humps with the same height and length can have very different crossing speeds if one's profile is more rounded and the other is more triangular shaped. For every ten percent increase in the ratio of cross sectional area to length, the 85th percentile crossing speed dropped by five percent. This relationship can be used to predict crossing speeds for alternative hump profiles relative to circular humps.

5.6.1.2 Speed Tables

MOA's typical speed table has a design speed of 30 mph. For other speed tables with circular (or near-circular) ramps, speeds can be estimated using methodology introduced in ITE's *Traffic Calming State-of-the-Practice*. To illustrate, the typical speed table has six-foot ramps at both ends with the same parabolic shape as the rises of a 12-foot hump; it is as if the hump were pulled apart and a flat section inserted between the ramps. Yet, the typical speed table has an 85th percentile speed, about 8 mph higher than that of a 12-foot hump of the same three inch height.

The effective curvature of the typical speed table must be somewhere between the curvature of a 12-foot hump and the curvature of a 22-foot hump with the same overall rise of three inches. If the same overall rise were distributed over 22 feet in a circular hump, trigonometry tells us the hump would have a radius of 250 feet. From equation (1), such a hump would have an 85th percentile speed of 38 mph. The typical speed table has a crossing speed halfway between the design speeds of the two hump profiles to which it relates—21 mph for a 12-foot hump and 38 mph for a 22-foot hump. This relationship (speeds halfway between extremes) can be used to estimate crossing speeds for parabolic speed tables with other dimensions.

For trapezoidal speed tables, no method of speed estimation is available. Field testing must substitute for theory. Ramp dimensions, slopes, and 85th percentile crossing speeds for three U.S. applications are presented in Table 7.

Table 7: Crossing Speeds For Selected Trapezoidal Tables

	Applications	Dimensions	Ramp Slopes	85th Percentile Crossing Speeds
Boulder, CO	speed tables raised crosswalks	12-foot ramps 22-foot plateau 6-inch rise	1:24	24 mph
Cambridge, MA	raised crosswalks	6-foot ramps 10-foot plateau 6-inch rise	1:12	21
Gwinnett County, GA	speed tables	6-foot ramps 10-foot plateau 3-5/8-inch rise	1:20	25

The only other source of speed data for trapezoidal tables comes from Denmark (see Table 8). Danish guidelines apply to tables of one height only, four inches. Clearly, crossing speeds depend on multiple parameters: ramp slope and length and plateau height and length. However, the Danish results are the best available at this time.

Table 8: Danish Speed Estimates For Flat-Topped Measures (Four-Inch Height)

Ramp Length in Feet	Ramp Slope	Crossing Speed in mph
2.3	1:7	12
2.6	1:8	16
3.3	1:10	19
4.3	1:13	22
5.6	1:17	25
6.6	1:20	28
8.2	1:25	31

5.6.2 Speed Versus Horizontal Curvature

MOA's typical traffic circle, chicane, and lateral shift have design speeds of 20, 25, and 30 mph, respectively. For other measures with horizontal curves, crossing speeds can be estimated as described in this section.

Most horizontal speed control measures including chicanes, lateral shifts, and even traffic circles consist of reverse curves. They require a turn in one direction and then back in the original direction; sometimes more than once. The physics of movement is complex in reverse curves.

No standard highway design text or manual provides insight into comfortable speeds on such curves. Fortunately, reverse curves can often be analyzed as a series of simple curves and where they cannot, there has been enough field testing to make speed estimates possible.

It is standard practice to analyze measures with long horizontal curves, such as roundabouts and bends, as a series of simple curves. Where preceded or followed by short curves, the long curves tend to dominate crossing speeds and the short curves can often be ignored.

For simple horizontal curves, crossing speeds can be estimated with graphs and tables from the American Association of State Highway and Transportation Officials' *A Policy on Geometric Design of Highways and Streets* (AASHTO, 1994). All are based on the formula:

$$R = V^2/15(e+f) \qquad (2)$$

where R is the horizontal curve radius in feet, V the speed of travel around a curve in mph, e is the superelevation rate, and f is the side friction factor.

Table 9 relates turning speeds to horizontal curve radii using AASHTO's side friction factors. Negligible superelevation is assumed, which is common on low-speed streets. At locations with superelevation or reverse superelevation, equation (2) can be used to refine estimates of horizontal curve radii. For example, assuming two percent reverse superelevation at a traffic circle, the required curve radius for a crossing speed of 20 mph would increase to 95 feet.

Table 9: Curve Radii For Different Crossing Speeds

Desired Speed in mph	Assumed Side Friction Factor	Assumed Superelevation	Curve Radius in feet
15 (24)	0.35	0.00	43 (13)
20 (32)	0.30	0.00	89 (27)
25 (40)	0.25	0.00	167 (51)
30 (48)	0.22	0.00	273 (83)

Source: Side friction factors are based on American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, Washington, D.C., 1994, Figure III-8 and Table III-6.

For measures with short reverse curves, such as chicanes and lateral shifts, crossing speeds are primarily a function of "stagger length" and "free view width" and, consequently, "path angle" through the lateral shift (see Figure 41). Path angles of 20, 15, and 10 degrees permit crossing speeds of 20, 25, and over 30 mph, respectively. Crossing speeds are about 5 mph lower for full chicanes (two lateral shifts in series) than single lateral shifts of the same dimensions.

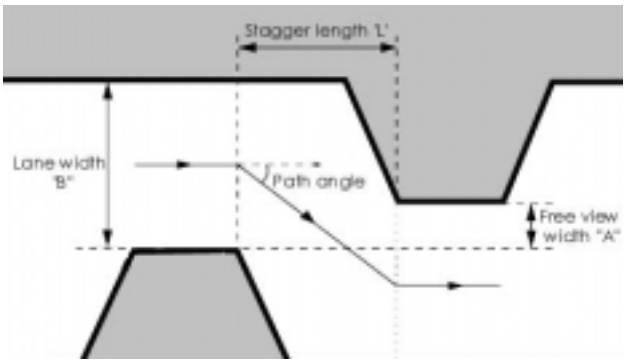


Figure 41: **Geometric Parameters Affecting Crossing Speeds**

An additional constraint on horizontal curvature is the presence of long wheelbase vehicles. All streets will have at least an occasional moving van, garbage truck, or emergency vehicle negotiating their curves. Many streets serve school buses. These vehicles can be assumed to take sharp curves at such low speeds that the only issues are the turning radius of the vehicle and its path width. A horizontal curve of a 43-foot radius, which has a crossing speed for passenger cars of 15 mph, can be negotiated by all but the largest trucks. The bigger problem on such tight curves is the sweep of a truck or bus due to off tracking and vehicle overhang. A single unit truck sweeps an area 15 feet wide on a horizontal curve of a 45-foot radius[1]. Such vehicles must either be accommodated through lane widening or allowed to sweep into the opposing lane when no traffic is approaching. On low volume, residential streets, the probability of two vehicles meeting at a slow point and one vehicle being oversized may be low enough that the latter presents no problem. On other streets, lanes must be wide enough to accommodate the swept paths of design vehicles (see Table 10).

1 For information on track width and overhang for other design vehicles, see American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, Washington, D.C., 1990, Figure X.

Table 10: Design Vehicle Characteristics

Design Vehicle	Width (feet)	Minimum Inside Radius (feet)	Minimum Design Turning Radius (feet)	Minimum Sweep Radius (feet)	Maximum Swept Path (feet)
Passenger Car	7	14	24	25.5	11.5
Single Unit Truck	8.5	27.8	42	44.1	16.3
Single Unit Bus	8.5	24.4	42	46.5	22.1
Semitrailer (WB-40)	8.5	18.9	40	41.5	22.6

Source: Adapted from American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, Washington, D.C., 1994, Tables II-1 and II-2.

5.6.3 Speed Versus Spacing of Slow Points

Drivers accelerate between slow points. To counter this tendency and limit midpoint speeds, many U.S. jurisdictions have established guidelines for the spacing of slow points. Prescribed spacing is typically in the range of 300 to 500 feet.

Instead of applying fixed guidelines, the MOA will compute required spacing based on target speeds. Ordinarily, midpoint speeds will be allowed to climb no more than 5 mph above the posted speed limit. This maximum speed, along with the crossing speed at slow points and the comfortable travel speed on the street itself (between slow points), determines the required spacing of slow points.

Required spacing will be estimated with a formula from ITE's *Traffic Calming State-of-the-Practice*. As spacing increases to 600 feet between slow points, midpoint speeds rise to 90 percent of their maximum value. The maximum value, however, is not the 85th percentile speed of the road before traffic calming, but rather a speed between the pre-existing speed and the 85th percentile speed at the slow points. This means that for any reasonable spacing of slow points, the simple presence of traffic calming usually has a significant effect on travel speeds.

The relationship between midpoint speed and spacing of slow points is illustrated in Figure 42. In mathematical terms, the best-fit exponential curve is:

$$85^{th}_{midpoint} = 85^{th}_{slow\ point} + (85^{th}_{street} - 85^{th}_{slow\ point}) * a * (1 - e^{-b\ *\ spacing}) \qquad (3)$$

where:

$85^{th}_{midpoint}$ = 85th percentile speed at midpoint after calming

$85^{th}_{slow\ point}$ = 85th percentile speed at the slow point

85^{th}_{street} = 85th percentile speed of street before treatment

a = 0.56 = estimated parameter representing the proportion of way back to pre-treatment levels that speed climbs as spacing becomes large

b = 0.0040 = estimated parameter representing the rate at which speed climbs with spacing

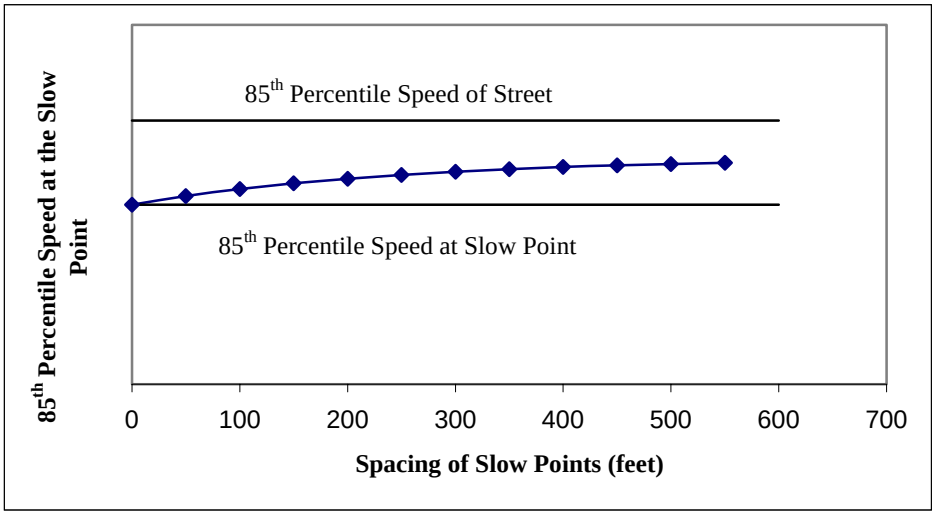


Figure 42: Speed Versus Spacing Of Slow Points

5.7 Signage and Striping

To foster universal recognition, traffic calming measures in the MOA shall be signed and marked according to the standard conventions outlined in the FHWA's MUTCD, the MOA Traffic Manual, and as directed by the MOA Traffic Engineer.

The MOA may deviate from its standard conventions where alternative schemes promise to be more context sensitive and equally effective. Signage original to the MOA may be required at traffic calming measures not previously constructed in the MOA. Alternative signage and striping schemes may be proposed in writing by a developer, designer, or contractor.

5.7.1 General Guidance from *Manual of Uniform Traffic Control Devices*

The MUTCD has been adopted by the MOA and sets the standard for signing and marking of physical roadway features. The following general conventions apply to traffic calming measures.

- Warning signs need not be used where hazards are self-evident.
- Signs must be legible which requires high visibility, lettering or symbols of adequate size, and short legends for quick comprehension.
- Sign lettering must be in upper-case letters of the type approved by FHWA.
- Signs must be reflectorized or illuminated to show the same shape and color by day and night.
- Signs are ordinarily placed on the right-hand side of the road where the driver is looking for them.
- Signs are ordinarily mounted separately except where one sign supplements another as advisory speed plates supplement warning signs.
- Before any street is opened to traffic, all hazardous conditions must be signed and marked.
- Signs should be used conservatively.

- Symbol signs are preferred to word signs when an appropriate symbol exists.
- New symbols when not readily recognizable should be accompanied by educational plaques.
- Analogous signs shall be used for new situations similar to those for which standard signs already exist.

5.7.2 Standard Signs

The following signs shall be used consistently throughout the MOA in connection with the corresponding traffic calming measures.

5.7.2.1 Standard *Manual of Uniform Traffic Control Devices* Signs

For most traffic calming measures, current MUTCD signs are typically adequate. The most common signage includes the following:

- DEAD END signs (W14-1) far enough in advance of full closures and half closures to allow traffic to turn off at the nearest intersecting street.
- DO NOT ENTER signs (R5-1) at half closures or other traffic calming measures that preclude movement in a particular direction for a short distance.
- Turn signs (W1-1R or W1-1L) in advance of diagonal diverters or other traffic calming measure whose geometrics require turns to be made at less than 30 mph and less than the posted speed limit approaching the turn.
- Large ARROW signs (W1-6) on diagonal diverters and other measures that require sharp changes in the direction of travel.
- KEEP RIGHT signs (R4-7) on center islands of any length.
- REVERSE CURVE (W1-4) at lateral shifts.

- PEDESTRIAN CROSSING signs (W11A-2) in advance of diagonal diverters where crosswalks are located at or near the diverter.

- OBJECT MARKER signs (OM-14) at median noses.

6.0 PLANNING, ENGINEERING, AND CONSTRUCTION COSTS

6.1 Planning, Engineering, and Construction Costs

This chapter presents planning level cost estimates for performing the planning, engineering, and construction of proposed traffic calming improvements. The cost estimates shown in Table 11 are based on the experiences of the traffic calming improvement projects that were performed in the Fairview and Mountain View neighborhoods in 1998 through 2000. Extrapolation of those costs to future improvements should be escalated to account for inflation and other factors that were unknown during the writing of this report.

Table 11: Typical Estimated Construction Cost of Various Traffic Calming Measures In Anchorage

Traffic Calming Device	Estimated Construction Cost	Comments
Neckdown	$30,000	Per Intersection Approach
Diverter	$120,000	Four-Way Intersection
Closure	$50,000	
Chicane	$130,000	Per 300-foot City Block
Speed Hump (temp)	$3,000	Plus Annual Installation and Removal
Speed Hump (perm)	$5,000	
Traffic Circle	$30,000	

Table 11 includes only costs for traffic calming measures that have heretofore been constructed in Anchorage. All of the costs in Table 11 are based on the assumption that the project is a retrofit improvement and not part of the original construction. Improvements constructed as part of the original construction will typically cost significantly less. It should be noted that none of the costs shown in Table 11 include planning, engineering, project administration, construction inspection, annual maintenance, or ROW acquisition costs. Engineering costs can conservatively be estimated at about ten percent of the construction cost.

Factors that strongly influence the construction cost include:

- presence of existing utilities that must be relocated,
- amount of storm drainage improvements required to accommodate the realigned roadway/curb lines,
- size of the project (a larger project will typically have lower unit costs than a smaller project due to economies of scale),
- degree of traffic maintenance that is required during construction (typically, this is a low cost item since most traffic calming is performed on residential streets), and
- amount of landscaping that is included in the design.

As discussed previously in this manual, it is recommended that traffic calming improvements be planned based on an area-wide or neighborhood evaluation of transportation issues. The resulting transportation study should provide a recommended framework plan for implementing traffic calming improvements in that neighborhood. Using this process enables the neighborhood traffic calming improvements to be implemented in an organized way and provides a basis for prioritizing the improvements so that the improvements that will provide the most benefit to the community can be constructed first. A transportation study, as described herein, typically costs about $50,000 to perform.

7.0 SUMMARY

This TCPM serves as a resource for the design, planning, and construction communities as well as the public in general to provide guidelines by which traffic calming principles and projects will be implemented in the MOA. This manual is a working document that will evolve and adapt to the Anchorage and nationwide perspectives and lessons learned regarding traffic calming practices. Several major points have surfaced through the course of assembling this manual.

- **Traffic calming is not a "magic bullet."** Traffic calming devices are effective in some circumstances at appropriately reducing traffic volumes and speeds. The device should be selected based on established criteria and engineering judgment from the variety of devices included in the "toolbox" of traffic calming measures contained herein. Traffic calming is not the solution for all of Anchorage's traffic safety concerns. Traffic calming improvements should only be considered where sound judgment and experience dictates that the modifications may be appropriate.

- **Area-wide versus intersection-by-intersection.** Generally, traffic calming improvement projects should be implemented following a neighborhood traffic analysis that considers the area roadway system that will be impacted by the proposed improvements. Spot improvements should be more rare in occurrence and implementation will be heavily dependent on the judgment of the MOA Traffic Engineer. In some cases, and at the discretion of the MOA Traffic Engineer, traffic calming measures may be installed temporarily on a trial basis to determine the impacts to the community. If proven successful, the improvements could later be permanently installed.

- **Consider MOA and agency issues in the planning of traffic calming.** Past experience in Anchorage and nationwide has shown that traffic calming measures will require sacrifices to accomplish the greater good. Traffic calming devices typically require additional street maintenance effort, slower response times for emergency services, and modifications to transit, refuse collection, and commuter routes. These concerns should be balanced with roadway safety and neighborhood livability concerns as part of the neighborhood traffic analysis.

- **Talk to the public early and often.** The success of traffic calming improvements, particularly retrofit devices, is heavily dependent on an appropriate level of public and resource agency involvement in both disseminating the information and involving residents and agency representatives in selecting which device(s) will provide the greatest level of support and benefit to the neighborhood. The public involvement effort should begin during the planning stages of the project and continue through completion of the proposed installation.

- **Traffic calming measures typically reduce speeds and volumes while increasing traffic safety.** The reduction in speeds and traffic volumes varies with type of device, but extensive studies have been performed which show that significant decreases in speeds and/or volumes are achievable through traffic calming. For many of the traffic calming devices (particularly speed humps), improved safety is documented through significant reductions in crash rates, crash frequency, crash severity, and pedestrian involvement.

- **Use traffic calming techniques in the design of new streets and subdivisions.** Waiting until after streets have been constructed and then retrofitting them with traffic calming treatments is not the most cost-effective approach. Implementing traffic calming into the design and construction of new neighborhoods and developments is the best approach.

- **Measure the effects.** Post-construction evaluation will be a priority to the MOA in determining which types of devices will remain part of Anchorage's "toolbox" of approved traffic calming devices or if any additional items should be added that are not currently included. The MOA Traffic Department will continue to monitor before and after speed, volume, and accident data. This TCPM will be revised as appropriate to respond to changes in traffic calming practices that result from on-going and future monitoring.