# CHAPTER IV
# GEOMETRIC DESIGN OF TRAFFIC CALMING MEASURES

Chapter II outlined procedures for the selection of traffic calming measures. Chapter III specified which measures are acceptable in given applications. This chapter provides guidance on the geometric design of traffic calming measures thus selected.

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.

## 1. GENERAL GUIDANCE

Geometric design for traffic calming 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 as indicated in Sections 3 through 5 of this chapter. For alternative geometric designs, design speeds can be estimated using formulas and tables in Section 6 of this chapter. Midpoint speeds can also be estimated using the formula in Section 6.5.

Ordinarily, crossing speeds at slow points will be no more than *5 mph (8 kph) 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 (8 kph) above* the posted speed limit. The speed differential on a given stretch of roadway is thus limited to 10 mph (16 kph) 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." Geometrics of slow points are set such that a single unit truck 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-- all minor arterials or below in the functional hierarchy. Freeways and principal arterials, which carry the bulk of the heavy vehicle traffic, are ineligible for traffic calming under *Application Guidelines* in Chapter III.

Landscape plans will be developed in coordination with the Department's Field Services / Roadside Environment Section.

## 2. VOLUME CONTROL MEASURES

### 2.1 Full Closures

Full closures will be permitted on local streets in Delaware only on an exception basis, when other volume control measures have proven inadequate. Given the rarity of such cases, and the fact that turnarounds can be designed in so many ways, no typical design is has been developed for a full street closure.

### 2.2. Half Closures

The typical half closure has two geometric features designed to encourage compliance with the one-way restriction (see Figure IV-1). 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 Department will consider half closures at mid-block 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 5 feet (1.5 meters), wide enough to provide clearance for bicyclists but narrow enough to exclude automobiles.

Under the following circumstances, a contraflow bicycle lane may instead be located next to the motor vehicle lane: (1) for aesthetic or other reasons, a half closure is formed by a curb extension rather than an edge island, or (2) for emergency access purposes, a half closure has to have a wider opening in the unrestricted direction. In no case shall the opening be wider than 16 ft (4.9 m). When designed extra wide to accommodate turning emergency vehicles, it may be advisable to have a bicycle contraflow lane to discourage wrong-way movement of motor vehicles.

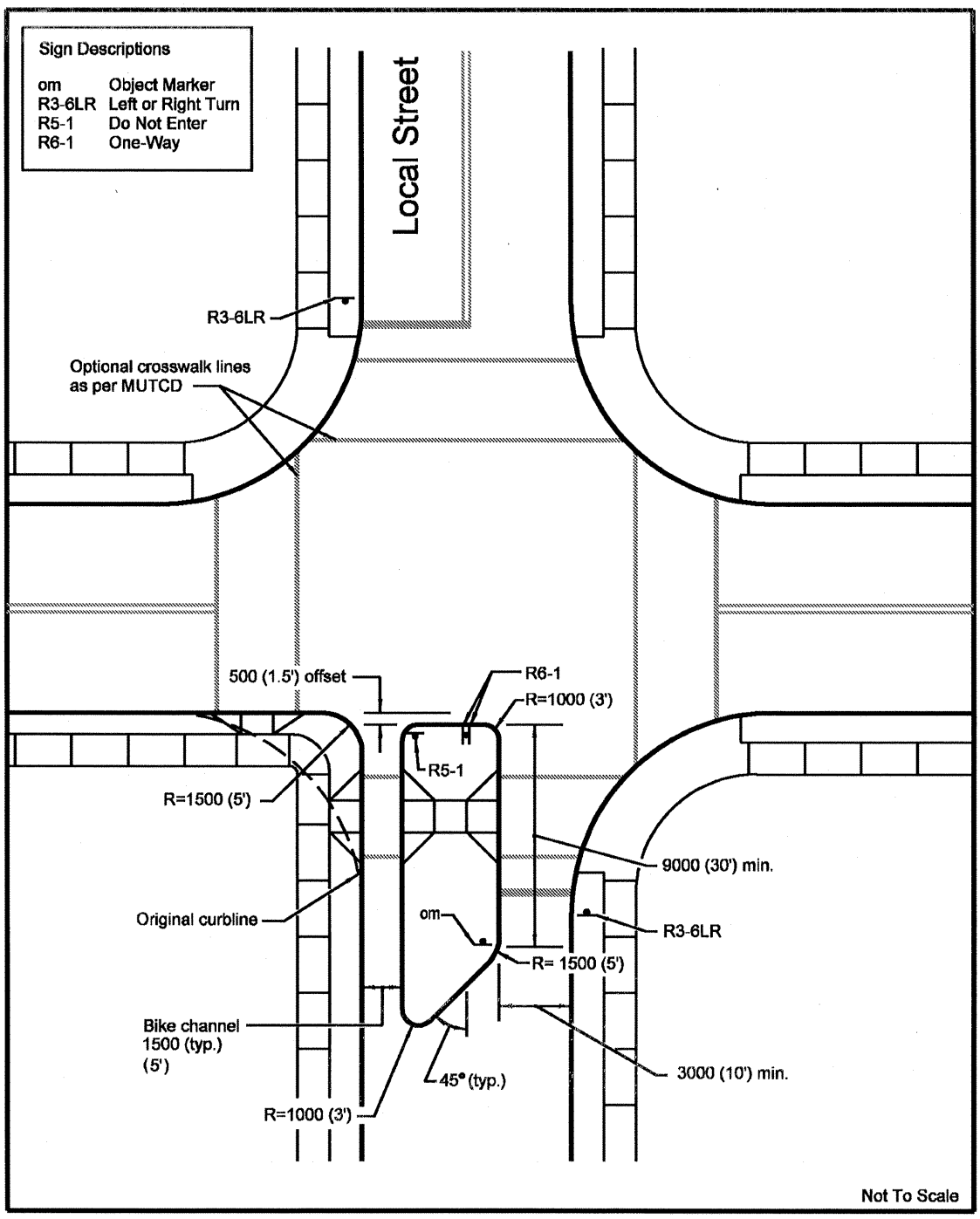



FIGURE IV-1. TYPICAL HALF CLOSURE

### 2.3. Other Volume Control Measures

Diagonal diverters, median barriers, and forced turn islands are also authorized for use in Delaware, subject to *Application Guidelines* in Chapter III. They present few design issues, as they are simple barriers blocking one or more movements at an intersection. The Delaware typical designs (Figures IV-2 through IV-4) have the following features:

(1) Diagonal diverters, median barriers, and forced turn islands will have clear widths sufficient for single-unit trucks to make turns at treated intersections without encroaching into opposing lanes.

(2) Diagonal diverters and median barriers will have openings 5 ft (1.5 m) 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 and median barriers 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 10 ft (3 m) shall be left free of landscaping and bollards.

(4) Diagonal diverters and median barriers will have barrier-type curbs to discourage unauthorized vehicles from traversing them. Curb heights as low as 6 inches (155 mm), less than Delaware's barrier curb, 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 plateau. See Section 5.2 for ADA requirements with respect to traffic islands.

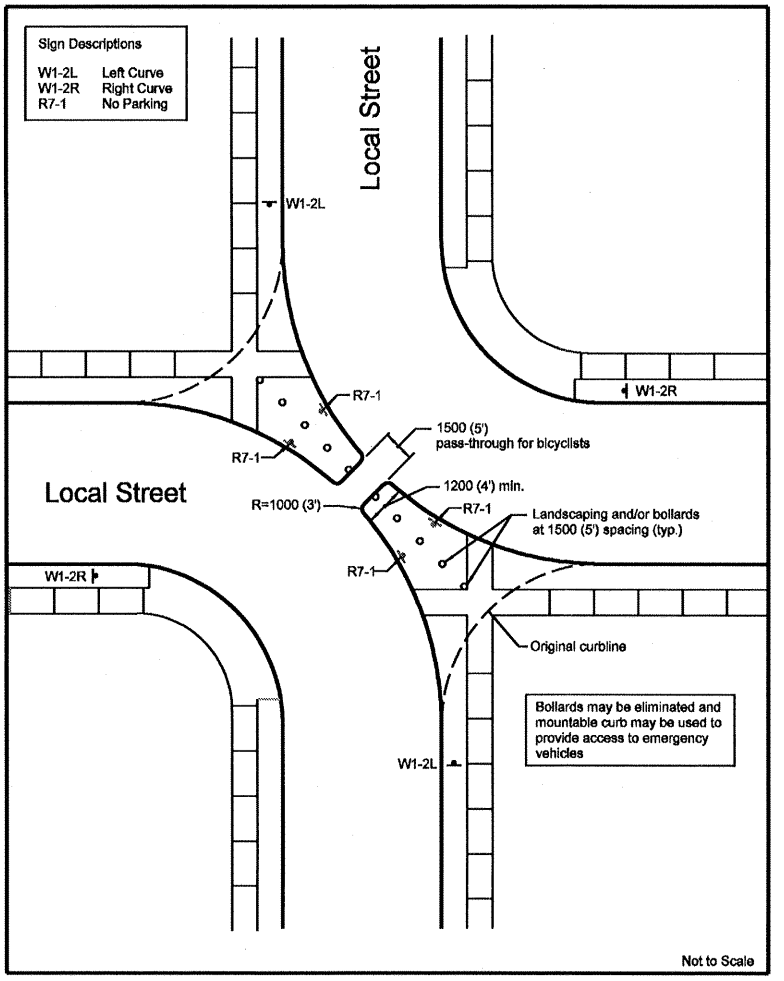



FIGURE IV-2. TYPICAL DIAGONAL DIVERTER

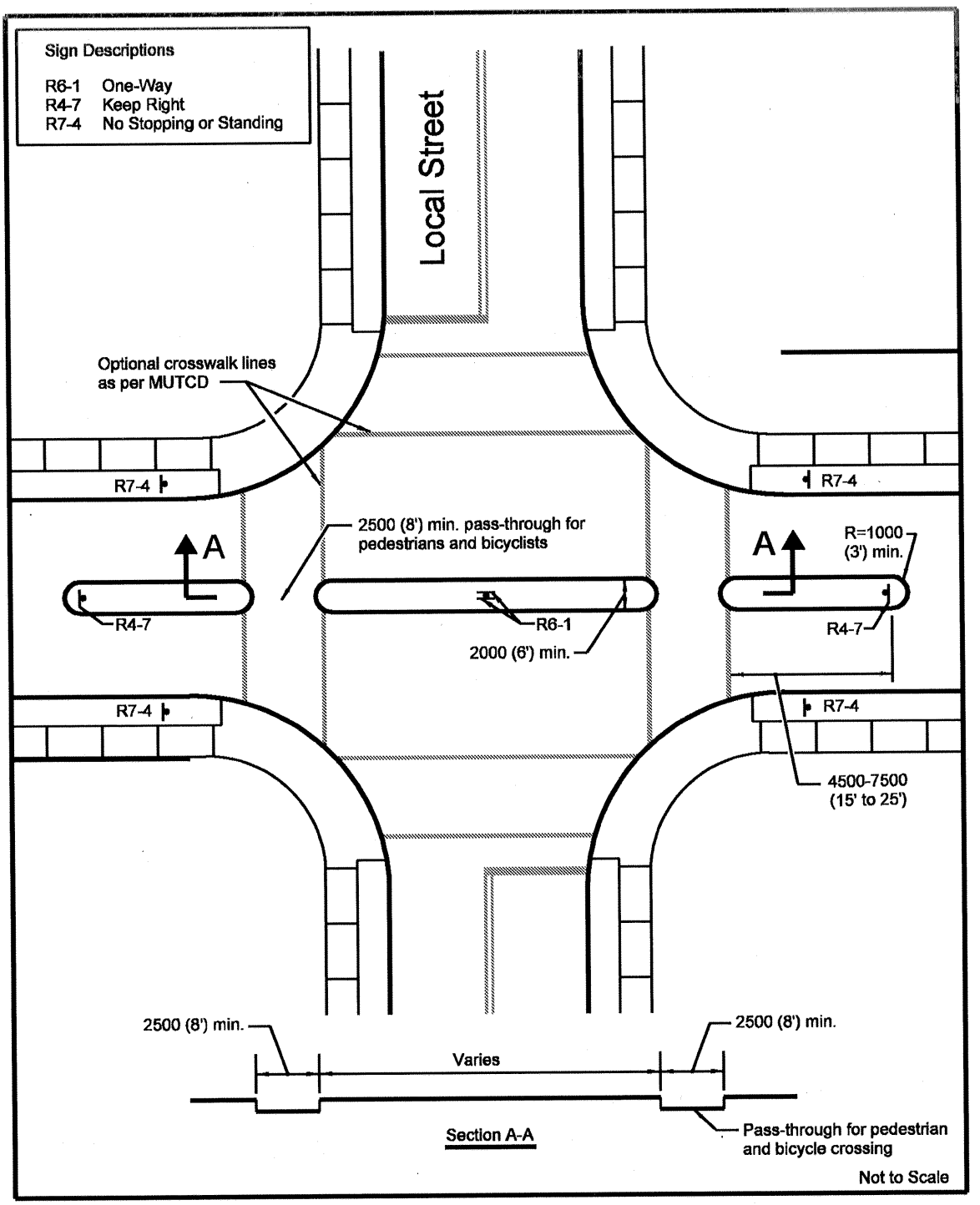



FIGURE IV-3. TYPICAL MEDIAN BARRIER

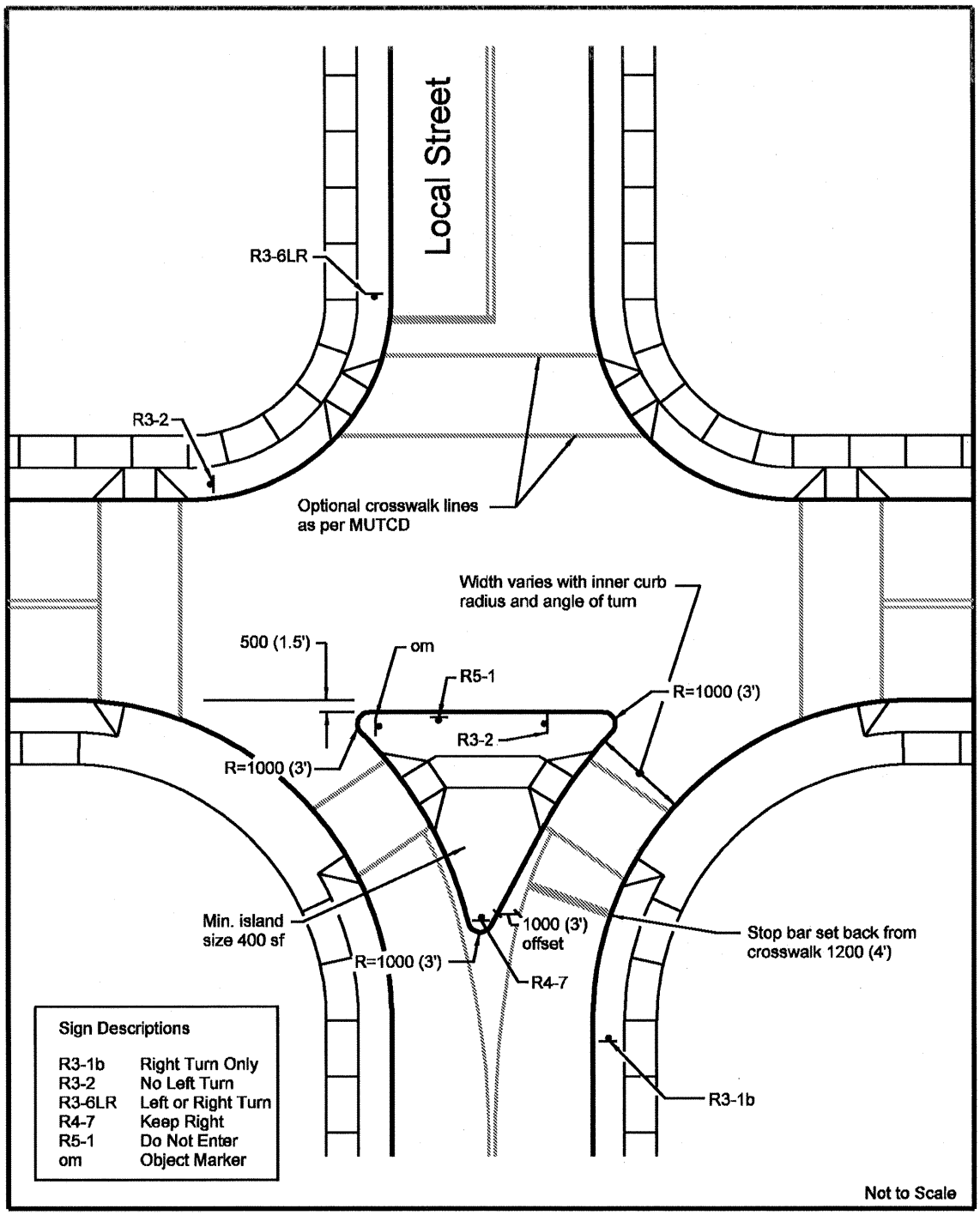



**FIGURE IV-4. TYPICAL FORCED TURN ISLAND**

## 3. SPEED CONTROL USING VERTICAL MEASURES

### 3.1. Speed Humps

The typical speed hump is 3 inches (75 mm) high and 14 ft (4.2 m) long in the direction of travel (see Figure IV-5). Its ramps are parabolic in shape. Its sides taper off at the gutter. It is made of asphalt, though brick is used outside the U.S., stamped asphalt is used occasionally in U.S., and rubber or thermoplastic is used for temporary (movable) humps.

The typical hump has a design speed of 25 mph (40 kph). This speed is safe and comfortable for automobiles. Larger vehicles have to cross the hump at lower speeds. The 14-ft (4.2-m) hump was chosen over the more common 12-ft (3.6-m) hump due to its slightly higher design speed and smoother ride for emergency vehicles.

On an exception basis, the Department will consider requests for humps with other profiles. To achieve particular crossing speeds, humps may range from 2 to 4 inches high (50 to 100 mm). Less than 2 inches (50 mm) produces little speed reduction, and more than 4 inches (100 mm) greatly increases the risk of grounding.

On an exception basis, humps may be shorter or longer than the typical design, though no shorter than 6 ft (1.8 m) in the direction of travel. If shorter, humps begin to function like speed bumps; vertical acceleration of the chassis and resulting discomfort are actually less at high than low speeds, encouraging motorists to speed.

Also, on an exception basis, ramps may be sinusoidal rather than parabolic in shape. The sinusoidal hump is bell-shaped rather than rounded at its ends. Because the initial rise is slower, sinusoidal humps produce a smoother ride for bicycles. Snow clearance may also be facilitated by the sinusoidal profile.

Finally, on an exception basis, the Department may allow humps that taper off before the gutter, forming a bicycle channel 4 ft (1.2 m) wide. This practice has the advantage of providing a flat surface for bicyclists but also encourages motorists to encroach into the bicycle channel, riding with one wheel up and the other down.

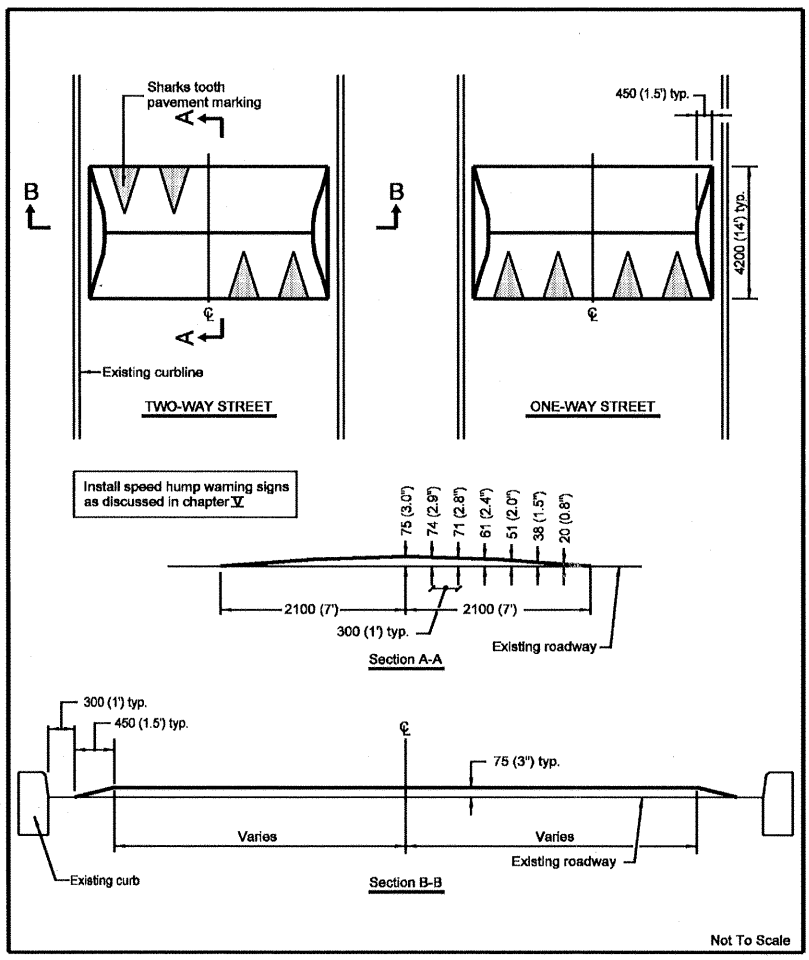



**FIGURE IV-5. TYPICAL SPEED BUMP**

### 3.2. Speed Tables

The typical speed table is 3 inches high (75 mm) and 22 ft (6.7 m) long in the direction of travel (see Figure IV-6). The plateau (flat top) is 10 ft (3 m), and each ramp is 6 ft (1.8 m). The plateau is made of asphalt, concrete, brick, concrete paver, stamped asphalt, or other patterned materials. The ramps are parabolic 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 (48 kph). This speed is safe and comfortable for automobiles. Larger vehicles have to cross the table at lower speeds.

On an exception basis, the Department will consider requests for tables with other profiles. Ramps may be either sinusoidal or straight (trapezoidal). For straight ramps, slopes should be no steeper than 1:10 nor less steep than 1:25. Slopes in this range render tables safe and effective. On transit and emergency response routes, the lower end of this range (1:25) is preferred.

The plateaus of speed tables may be as short as 8 ft (2.4 m) in the direction of travel. While the Department has established no upper limit on the length of speed tables or raised crosswalks, they tend to lose their effectiveness if more than 50 ft (15 m) long. Plateaus of 20 ft (6 m) or more are recommended to accommodate transit and emergency vehicles so they can cross with all wheels on the flat portion.

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

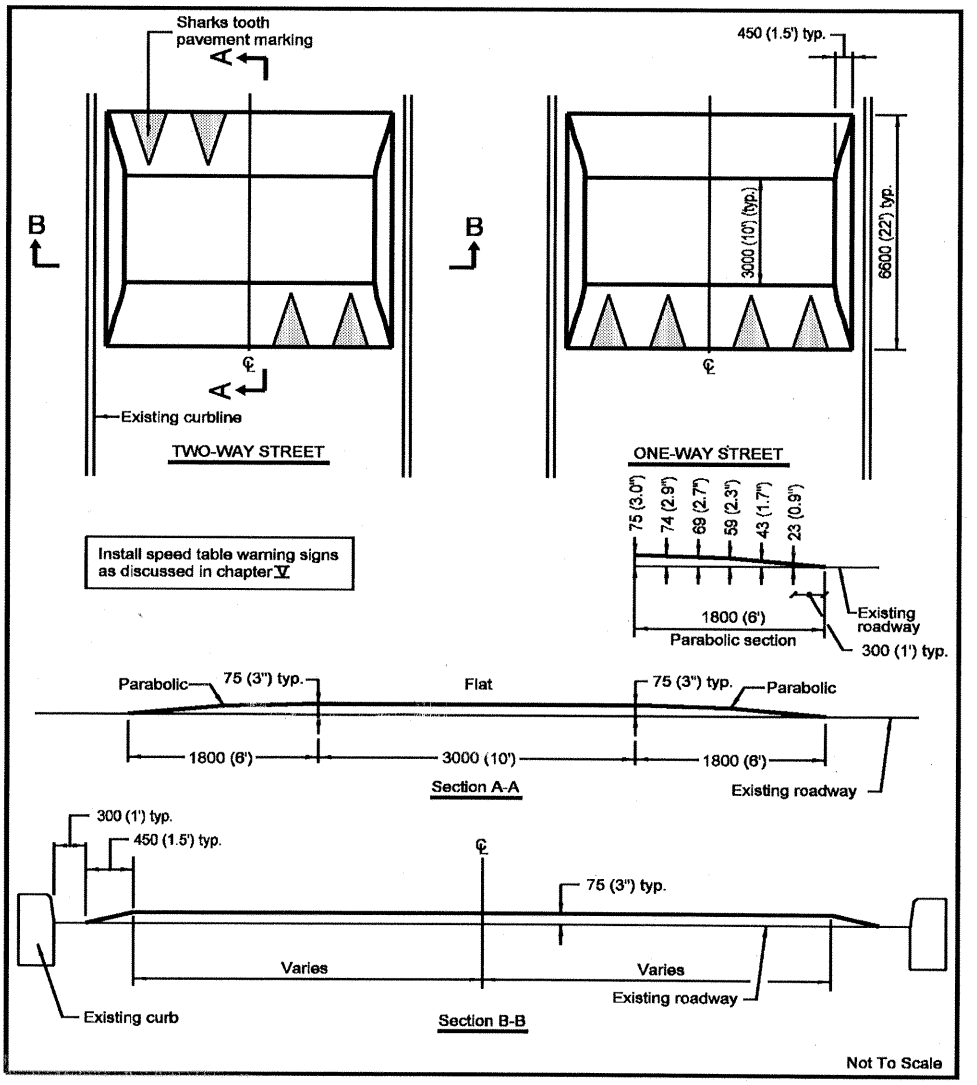



FIGURE IV-6. TYPICAL SPEED TABLE

### 3.3. Raised Crosswalks and Raised Intersections

A raised crosswalk is a speed table marked and signed for pedestrian crossing (see Figure IV-7). 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 as well to raised crosswalks.

A raised intersection is a speed table covering an entire intersection (see Figure IV-8). All other geometric requirements for speed tables apply as well to raised intersections.

If built to typical speed table specifications, a raised crosswalk or raised intersection will stop 3 inches (75 mm) short of standard curb height and sidewalk level. The sidewalk must connect to the crosswalk via curb ramps which 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 a hazardous area. Such a warning should be provided by means of a tactile surface. This may supplemented by bollards or other street furniture to protect waiting pedestrians and prevent corner cutting by motorists.

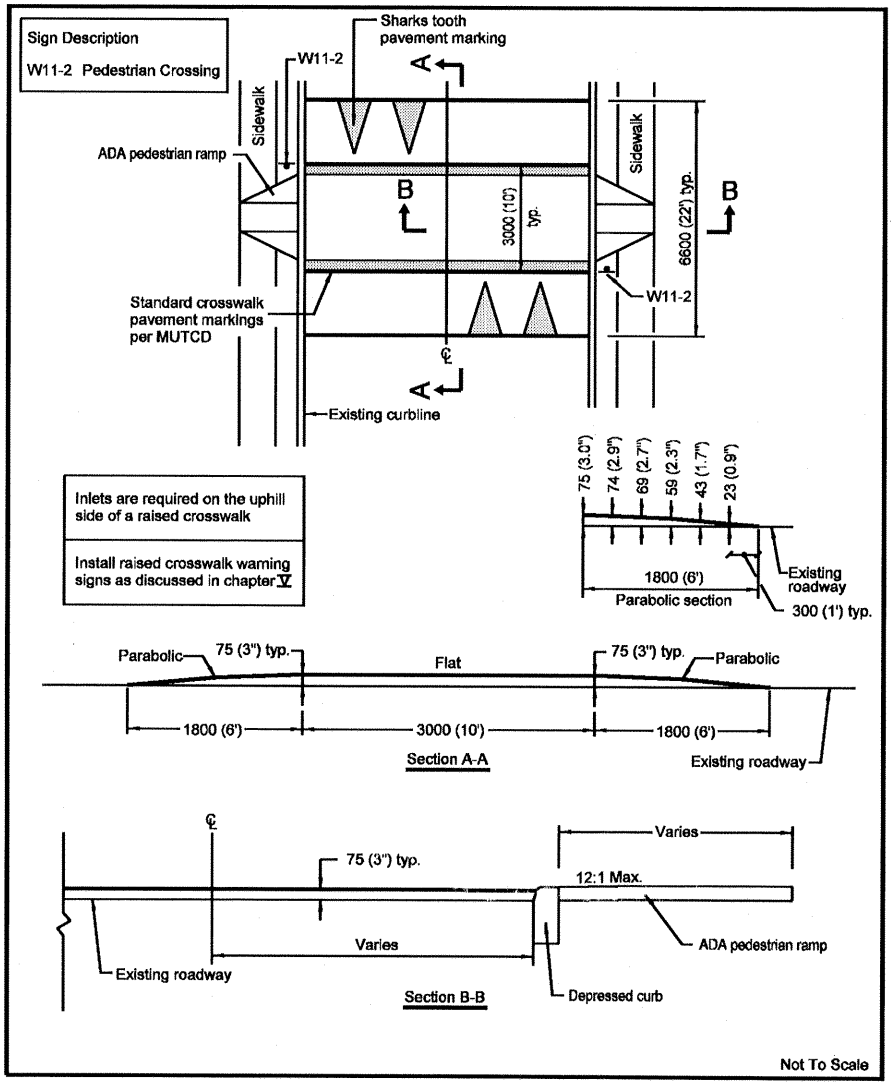



FIGURE IV-7. TYPICAL RAISED CROSSWALK

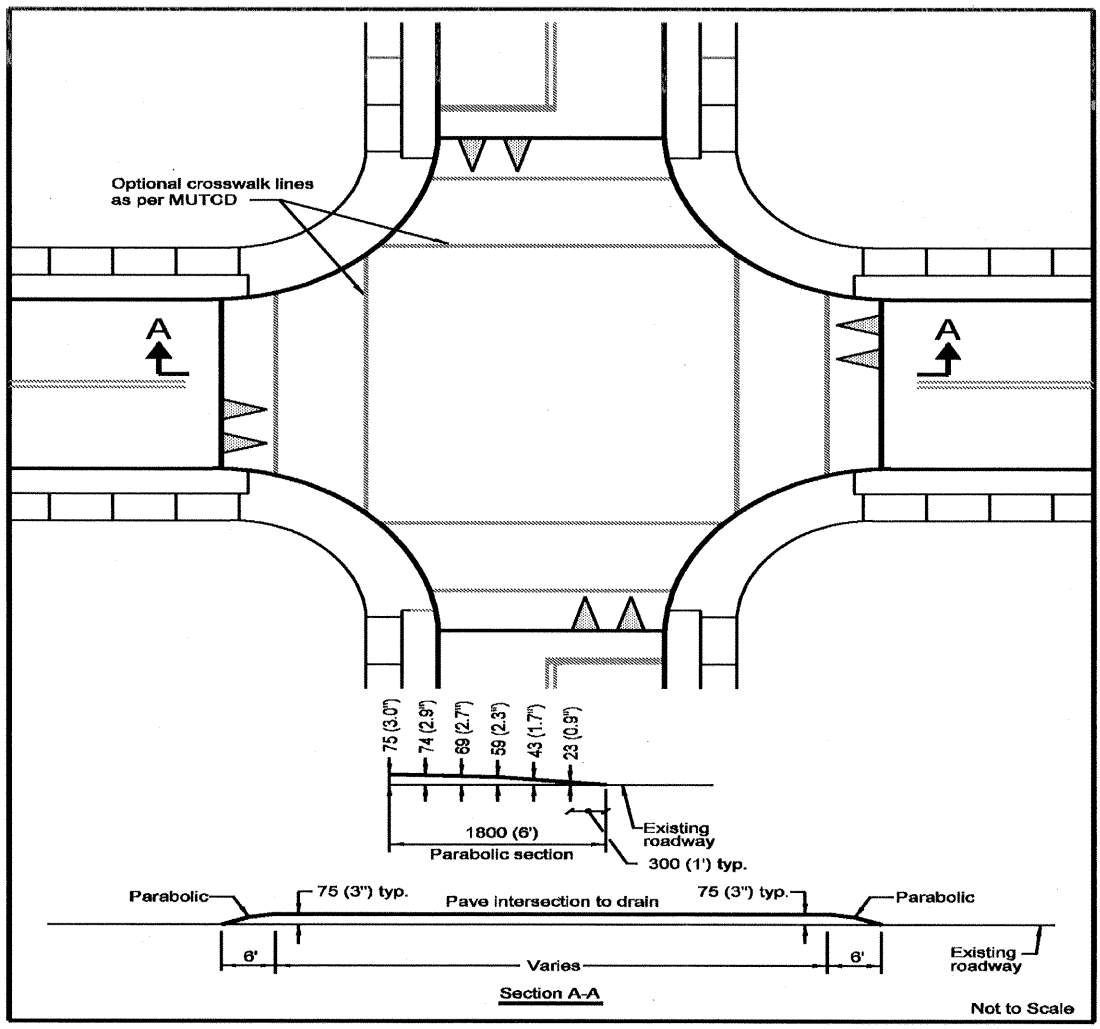



**FIGURE IV-8. TYPICAL RAISED INTERSECTION**

### 3.4. Accommodation of Bicyclists

Where cross sectional width is sufficient, the preferred treatment for bicyclists at vertical measures is a bypass lane, separated from the outside travel lane by a raised island to prevent gutter running. When bicycle lanes are bordered on both sides by vertical curbs, their channel widths shall be 5 ft (1.5 m), wide enough to provide clearance for bicyclists but narrow enough to exclude automobiles. Suitability of roadway treatment for bicyclists shall be evaluated for each traffic calming project.

Due to the tendency for gutter running in the absence of edge islands, 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.

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 1/4 in (6.5 mm) high to ensure a smooth ride for bicyclists.

### 3.5. Design Modifications for Hilly Terrain

Vertical speed control measures are ordinarily limited to grades of 8 percent or less. On an exception basis, the Department will consider the use of humps or tables on steeper grades, with appropriate modifications of vertical profiles. On grades of more than 8 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 IV-9). Otherwise, motorists will encounter actual gradients going uphill that are excessive, and going downhill that are ineffectual, increasing the risk of grounding or becoming airborne.

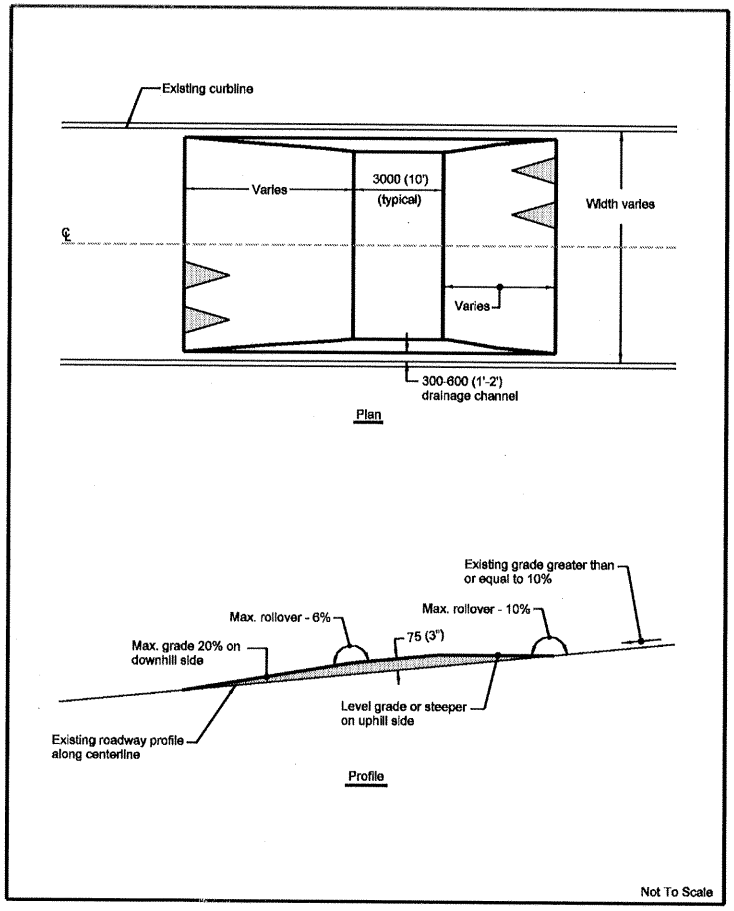



**FIGURE IV-9. VERTICAL PROFILE MODIFIED TO BE SAFE AND EFFECTIVE ON A GRADE**

## 4. SPEED CONTROL USING HORIZONTAL MEASURES

### 4.1. Mini-Traffic Circles

The typical traffic circle is shown in Figure IV-10. The travel path through the intersection has a horizontal curve radius of 95 ft (29 m), yielding a crossing speed of 20 mph (32 kph). See Section 6.2 for derivation. A low design speed was chosen to keep the circle as small as practical.

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, and trucks and buses generally cannot make left turns in prescribed manner, that is, by circulating counterclockwise around the center island.

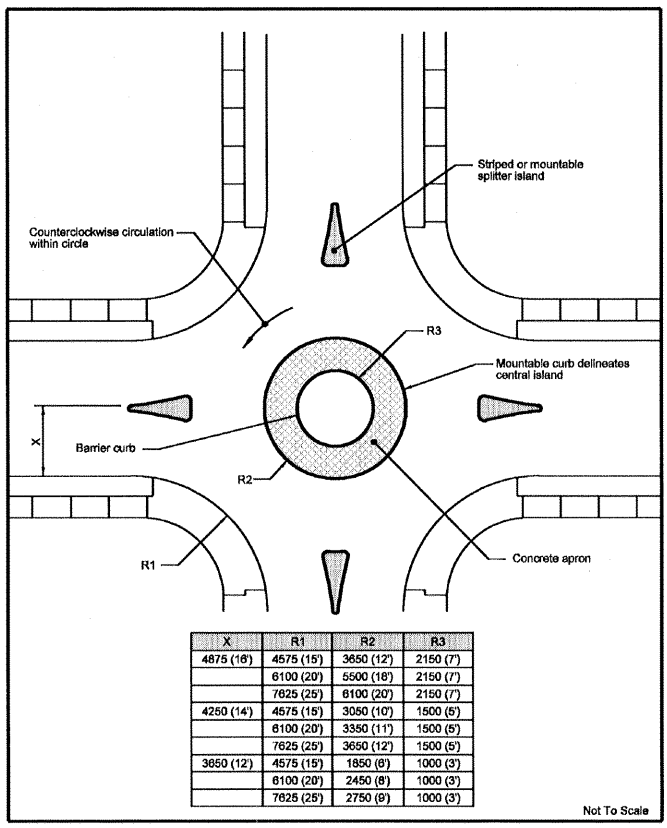
Most traffic circles, including the typical circle in Figure IV-10, have circular center islands and circular perimeters formed by the intersection corners. Where intersecting streets differ significantly in width, the center island may be elongated to better fit the intersection. An elongated circle 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. Automobiles and single unit trucks circulate counter-clockwise 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 IV-11. At 2 inches (50 mm) 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, 6 inches (150 mm) 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.

For aesthetics and attention-getting, the center island should be landscaped. Landscaping should be carefully planned for unrestricted visibility. To preserve sight lines, trees should have clear stem heights of at least 8 ft (2.4 m), and should be no more than 4 inches (100 mm) in diameter to ensure that they break away upon impact. Bushes or shrubs should grow to no more




| X | R1 | R2 | R3 |
|---|---|---|---|
| 4875 (16') | 4575 (15') | 3650 (12') | 2150 (7') |
| | 6100 (20') | 5500 (18') | 2150 (7') |
| | 7625 (25') | 6100 (20') | 2150 (7') |
| 4250 (14') | 4575 (15') | 3050 (10') | 1500 (5') |
| | 6100 (20') | 3350 (11') | 1500 (5') |
| | 7625 (25') | 3650 (12') | 1500 (5') |
| 3650 (12') | 4575 (15') | 1850 (6') | 1000 (3') |
| | 6100 (20') | 2450 (8') | 1000 (3') |
| | 7625 (25') | 2750 (9') | 1000 (3') |

**FIGURE IV-10. TYPICAL MINI-TRAFFIC CIRCLE**

than 2 ft (0.6 m) 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 1 to 2 percent offers these advantages without the risk of heavy vehicles turning over due to reverse superelevation.

On an exception basis only, the Department will consider mini-circles that fit within the curb lines of smaller intersections (Figure IV-12). Left turns are permitted in front of the center island. This alternative will be considered only where two conditions are met: (1) intersection widening is infeasible; and (2) entering volumes are less than 500 vehicles per day (50 vehicles during the peak hour), and still only in rare applications.

For specified street widths and corner radii, center island dimensions for the alternative design are given in Table IV-1. For other widths and corner radii, center island dimensions can be determined from the relationship between offset distances and opening widths.[2]

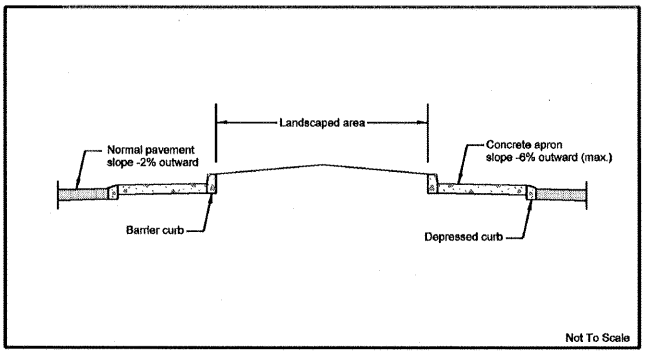



**FIGURE IV-11. ISLAND SECTION**

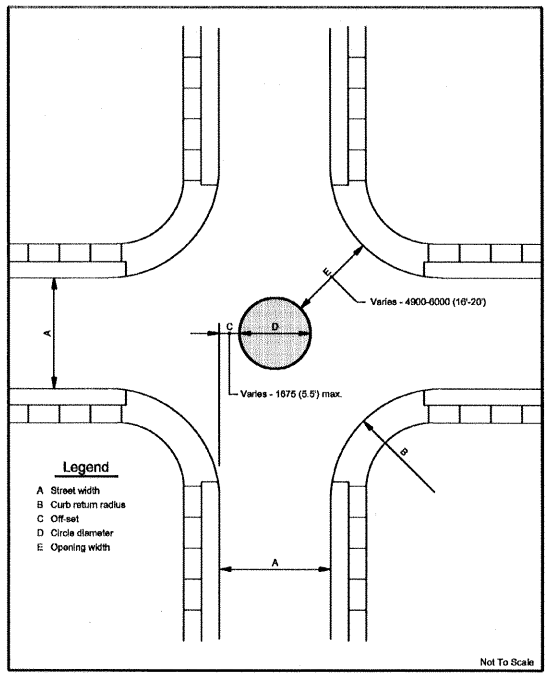



**FIGURE IV-12. ALTERNATIVE DESIGN FOR A MINI-CIRCLE**

**TABLE IV-1. ALTERNATIVE MINI-CIRCLE DIMENSIONS**

| "A" Street Width | "B" Curb Radius | "C" Offset Distance | "D" Circle Diameter | "E" Opening Width |
|---|---|---|---|---|
| 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 |

### 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. The typical roundabout is shown in Figure IV-13. In keeping with international practice, it has a design speed of 25 mph (40 kph).

The center island of the typical roundabout extends out 27 ft (8.2 m) from the center. The inner landscaped area has a radius of 21 ft (6.4 m). The outer mountable area (often referred to as a truck apron) has a width of 6 ft (1.8 m). The inscribed circle formed by the splitter islands has a radius of 48 ft (14.6 m). Automobiles and single unit trucks circulate around the center island, whereas buses and semitrailers have to mount the concrete truck apron to negotiate the roundabout. The travel path for automobiles and single unit trucks has a horizontal curve radius of 180 ft (55 m), which combined with 2 percent reverse superelevation, yields a circulating speed of 25 mph (40 kph). See Section 6.2 for derivation.

Roundabout entry and exit curves form the envelope of each splitter island. Pavement markings and a raised island fill the envelope. If pedestrians are anticipated, the raised island should extend at least 30 ft (9 m) from the intersection. The pedestrian crossing point should be set back 20 ft (6 m), or one car length, from the yield line so pedestrians can cross behind waiting cars. The pedestrian crossing point should be marked as a crosswalk. A cut-through flush with the pavement will allow pedestrians to cross at grade (see Section 5.2 for ADA requirements). If minimal pedestrian traffic is anticipated, shorter splitter islands will be permitted.

Other relevant geometric features of the typical roundabout include:

(1) Entry lanes flare on approaches to widths of 11 to 15 ft (3.4 to 4.6 m) at yield lines.

(2) Entry radii are tangential to the center island.

(3) Entry radii are smaller than the curved paths followed by vehicles traveling through the intersection.

(4) Circulating lane widths are between 1.0 and 1.2 times maximum entry lane widths.

(5) Exit radii are large, with straight paths preferred, to allow vehicles to accelerate as they exit. The exception is when an exit has a pedestrian crossing. In this case, a smaller exit radius is preferred to slow traffic.

On an exception basis, the Department will consider larger roundabouts with higher design speeds and greater capacity. Based on international practice, 30 mph (48 kph) is the highest circulating speed allowed in Delaware. Two lanes is the maximum number of circulating lanes, at least until considerable experience is gained with modern roundabouts. The Department will also consider smaller roundabouts with lower design speeds and less capacity. These may be appropriate on lesser streets in Delaware's functional hierarchy.

Also, on an exception basis, the Department will consider elongating roundabouts to better fit intersections whose entering roadways have different widths. An elongated roundabout consists of half circles with tangent sections between them. This design is applied on an exception basis since oval roundabouts have higher collision rates than do circular ones.

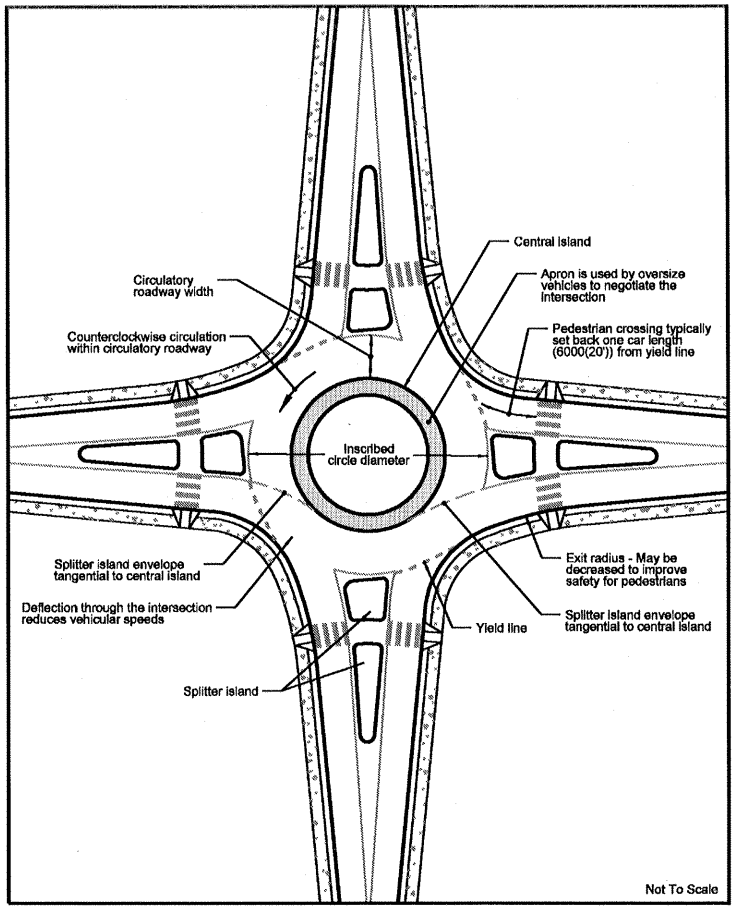



**FIGURE IV-13. TYPICAL ROUNDABOUT**

### 4.3. Chicanes

Chicanes can be created either by means of curb extensions or edge islands (see Figure IV-14). 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 may be semi-circular, triangular, or squared off. The typical chicane has trapezoidal islands based on the finding that this shape is more effective in reducing speeds than is a semi-circular shape.

Edge line tapers shall conform to the Manual on Uniform Traffic Control Devices (MUTCD) taper formula. The curb extensions or edge islands should have 45° 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.

Mountable curbs should be used on curb extensions and edge islands that form chicanes. For low-speed street conditions, mountable curbs may be placed at the edge of a through lane rather than offset by 1 ft (0.3 m) or more as with barrier curbs. The use of mountable rather than barrier curbs is prompted the complexity of movement through chicanes, and the fact that curb extensions and edge islands within chicanes are not expected to serve as pedestrian refuges.

The typical chicane separates opposing traffic by means of double solid yellow lines bordered by reflectors. 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 may be narrow and mountable without landscaping. This design has proven safe and effective outside the United States. Alternatively, if right-of-way permits, the median may be wider and landscaped with mountable curbs.

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

also an option best exercised with care since the act of negotiating a chicane is challenging enough without having to watch for automobiles pulling in and out of parking spaces. Also, the act of pulling in and out of parking spaces is challenging enough without having to cope with reduced visibility due to road curvature.

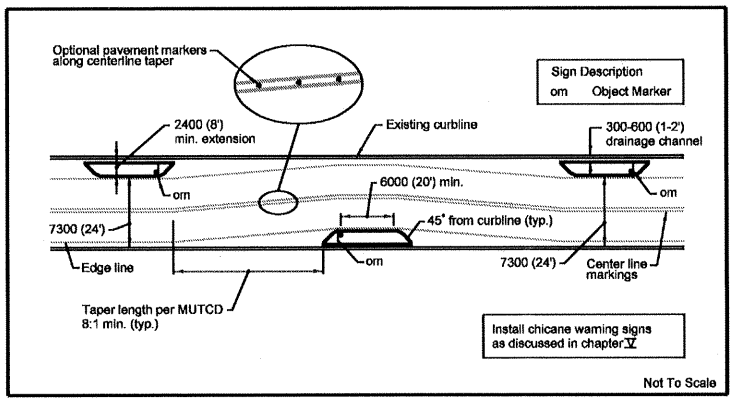



**FIGURE IV-14. TYPICAL CHICANE**

### 4.4 Lateral Shifts

The typical lateral shift is just one half of the typical chicane (see Figure IV-15). 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 (8 kph) 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 main roads (see Chaper III).

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 a such island, drivers cannot veer into the opposing lane, thus ensuring the safety and effectiveness of the lateral shift. On an exception basis, the Department will consider lateral shifts formed with parking bays. The comments regarding parking bays in chicanes apply here as well.

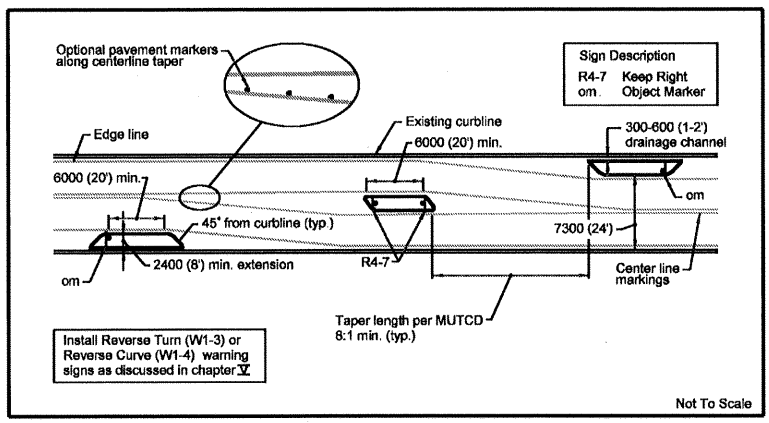



**FIGURE IV-15. TYPICAL LATERAL SHIFT**

### 4.5. Accommodation of Bicyclists

Bicyclists tend to get 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.

Typical designs assume that bicycle lanes will end 70 to 100 ft (21 to 30 m) upstream of slow points. This provides ample opportunity for bicyclists to merge into the traffic stream. At higher traffic volumes, the Department will consider bypass lanes at chicanes and lateral shifts, separated from main travel lanes by raised islands. The Department will also

consider taking bicycle lanes off the roadway on approaches to roundabouts, providing separate bicycle crossings at side streets. Based on accident studies outside the United States, bypasses lanes will ordinarily be required at roundabouts when entering volumes exceed 10,000 vpd.

## 5. NARROWINGS

### 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 IV-16). 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 radius small and allow large vehicles to swing wide into the opposing lane when making right turns. The Department will consider this practice on an exception basis when: volumes entering the intersection are less than 500 vehicles per day (50 vehicles during the peak hour) and heavy vehicle traffic is less than 2 percent of the daily total.

In cases where streets are narrow and traffic volumes high, as on some main shopping streets, the Department will consider setting choke points and crosswalks back from intersections a short distance to allow turns within lanes and short crossing distances at the same time.

### 5.2 Chokers

The typical two-lane choker is 20 ft (6 m) from curb to curb. It has a constricted length of 20 ft (6 m) in the direction of travel, the length of a passenger car (see Figure IV-17). The length is kept short so as not to block driveways nor to take away too much curbside parking.

A curb-to-curb width of the typical choker, while significantly less than Delaware's 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 Department will 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. Chokers can be hazardous to bicyclists, who get squeezed by passing motorists. For this reason, bypass lanes should be considered whenever both bicycle and motor vehicle traffic are heavy.

If centering a choker will result in undersized curb extensions on both sides of the street, the Department 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 8 ft (2.4 m) toward the centerline.

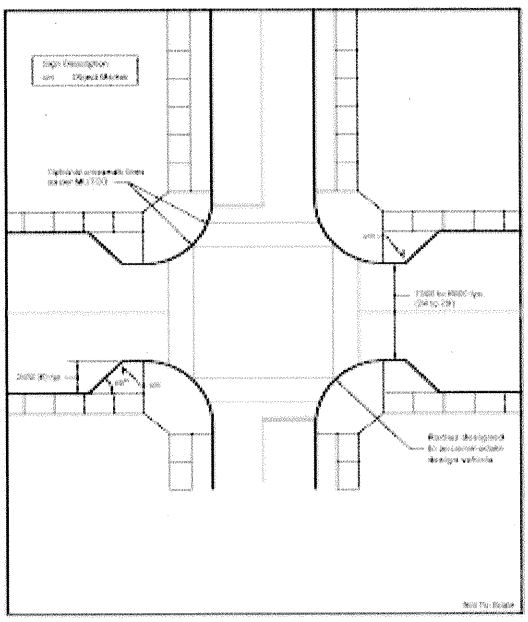


**FIGURE IV-16. TYPICAL NECKDOWN**

Edge line tapers shall conform to the

MUTCD taper formula. Curb extensions or islands should have 45° 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 8 ft (2.4 m) 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. Landscaping guidelines for traffic circles apply as well to chokers.

Within the choker, a change in pavement material should be considered. Textured surfaces such as brick and stamped asphalt reinforce the visual cues of narrowing and landscaping, thus 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, mountable curbs are preferred. Under low-speed street conditions, mountable curbs may be placed at the edge of a through lane rather than offset by 1 ft (0.3 m) or more as with barrier curbs.

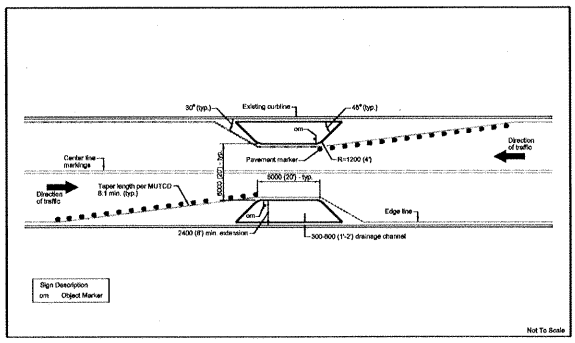



**FIGURE IV-17. TYPICAL CHOKER**

### 5.3. Center Island Narrowings

The typical center island narrowing is shown in Figure IV-18. The typical design incorporates these features:

(1) The center island is large enough to command attention, at least 6 ft wide and 20 ft long (1.8 by 6 m);
(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.

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 (see Figure IV-19). Ordinarily, a cut-through will be used in Delaware since a plateau with ramps requires a much wider center island (about 16 ft or 5 m wide at a minimum). When a cut- through is used, the longitudinal cut should be 12 ft (3.7 m) 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. Landscaping guidelines for traffic circles 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 1 ft (0.3 m) or more as with barrier curbs.

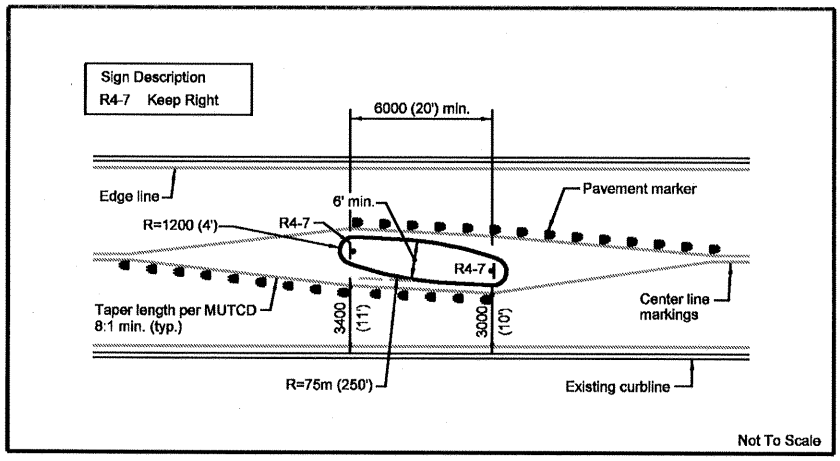



**FIGURE IV-18. TYPICAL CENTER ISLAND NARROWING**

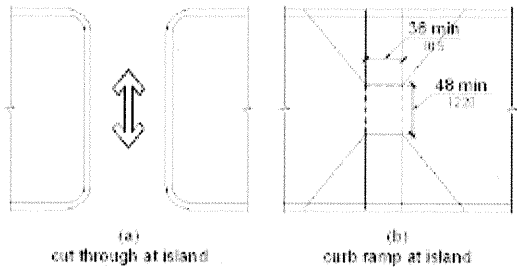



**FIGURE IV-19. ADA OPTIONS FOR PEDESTRIAN CROSSINGS AT ISLAND**

## 6. SPEED ESTIMATES

### 6.1 Speed vs. Vertical Curvature

#### 6.1.a Speed Humps

Delaware's typical speed hump has an 85th percentile crossing speed of just under 25 mph (40 kph). For other speed humps that are approximately circular in shape, crossing speeds can be estimated with a formula from Institute of Transportation Engineers' *Traffic Calming State-of-the-Practice* (SOP). The formula was derived using the common 12-ft (3.7-m) hump as a reference point. Whatever forces of centrifugal acceleration are tolerable going over this hump, at its 85th percentile speed, will be tolerable going over other vertical measures at their 85th percentile speeds.

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 ft and V is the velocity at which the curve is traversed in mph (as in Figure IV-20). Or, equivalently:

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

As humps becomes 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 depend more on the shape of the hump than on the height-to-length ratio. Two humps with the same height and length can have very different crossing speeds if one's profile is more rounded and the other's more triangular shaped. For every 10 percent increase in the ratio of cross sectional area to length, the 85th percentile crossing speed dropped by 5 percent. This relationship can be used to predict crossing speeds for alternative hump profiles relative to circular humps.

#### 6.1.b Speed Tables

Delaware's typical speed table has a design speed of 30 mph (48 kph). 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 6-ft (1.8 m) ramps at both ends with the same parabolic shape as the rises of a 12-ft (3.7-m) hump; it is as if the hump were pulled apart and a flat section inserted in-between. Yet, the typical speed table has an 85th percentile speed about 8 mph (13 kph) higher than that of a 12-ft (3.7 m) hump of the same 3 inch (77 mm) height.

The effective curvature of the typical speed table must be somewhere between the curvature of a 12-ft (3.7 m) hump and the curvature of a 22-ft (6.7 m) hump with the same overall rise, 3 inches (77 mm). If the same overall rise were distributed over 22 ft (6.7 m) in a circular hump, trigonometry tells us the hump would have radius of 250 ft (76 m). From equation (1), such a hump would have an 85$^{th}$ percentile speed of 38 mph (61 kph). The typical speed table has a crossing speed halfway between the design speeds of the two hump profiles to which it relates—21 mph (34 kph) for a 12-ft (3.7 m) hump and 38 mph (61 kph) for a 22-ft (6.7-m) 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 85$^{th}$ percentile crossing speeds for three U.S. applications are presented in Table IV-2.

**TABLE IV-2. CROSSING SPEEDS FOR SELECTED TRAPEZOIDAL TABLES**

| | Applications | Dimensions | Ramp Slopes | 85$^{th}$ Percentile Crossing Speeds |
|---|---|---|---|---|
| Boulder, CO | speed tables<br>raised crosswalks | 12' ramps<br>22' plateau<br>6" rise | 1:24 | 24 mph (39 kph) |
| Cambridge, MA | raised crosswalks | 6' ramps<br>10' plateau<br>6" rise | 1:12 | 21 (34 kph) |
| Gwinnett County, GA | speed tables | 6' ramps<br>10' plateau<br>3-5/8" rise | 1:20 | 25 (40 kph) |

The only other source of speed data for trapezoidal tables comes from Denmark (see Table IV-3). Danish guidelines apply to tables of one height only, 100 mm. Clearly, crossing speeds depend on multiple parameters: ramp slope and length, and plateau height and length. But the Danish results are the best available at this time.

**TABLE IV-3. DANISH SPEED ESTIMATES FOR FLAT-TOPPED MEASURES (100 mm height)**

| Ramp Length in ft (m) | Ramp Slope | Crossing Speed in mph (kph) |
|---|---|---|
| 2.3 (0.7) | 1:7 | 12 (19) |
| 2.6 (0.8) | 1:8 | 16 (26) |
| 3.3 (1) | 1:10 | 19 (31) |
| 4.3 (1.3) | 1:13 | 22 (35) |
| 5.6 (1.7) | 1:17 | 25 (40) |
| 6.6 (2.0) | 1:20 | 28 (45) |
| 8.2 (2.5) | 1:25 | 31(50) |

### 6.2. Speed vs. Horizontal Curvature

Delaware'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's Green Book). All are based on the formula from mechanics:

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

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

Table IV-4 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 2 percent reverse superelevation at a traffic circle, the required curve radius for a crossing speed of 20 mph (32 kph) would increase to 95 ft (29 m).

**TABLE IV-4. CURVE RADII FOR DIFFERENT CROSSING SPEEDS**

| Desired Speed mph (kph) | Assumed Side Friction Factor | Assumed Superelevation | Curve Radius ft (m) |
|---|---|---|---|
| 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., 1990, Figure III-17 and Table III-17.

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 IV-20). Path angles of 20° , 15°, and 10° permit crossing speeds of 20, 25, and over 30 mph (32, 40 and over 48 kph), respectively. Crossing speeds are about 5 mph (8 kph) lower for full chicanes (two lateral shifts in series) than single lateral shifts of the same dimensions.

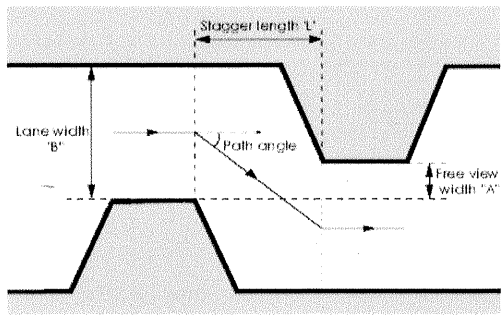



**FIGURE IV-20. GEOMETRIC PARAMETERS AFFECTING CROSSING SPEEDS**

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 negotiate their curves. Many 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 43-ft (13-m) radius, which has a crossing speed for passenger cars of 15 mph (24 kph), 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 offtracking and vehicle overhang. A single-unit truck sweeps an area 15 ft (4.6 m) wide on a horizontal curve of 45-ft (14-m) radius. 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.

**TABLE IV-5. DESIGN VEHICLE CHARACTERISTICS**

| | Width ft (m) | Minimum Inside Radius ft (m) | Minimum Design Turning Radius ft (m) | Minimum Sweep Radius ft (m) | Maximum Swept Path ft (m) |
|---|---|---|---|---|---|
| Passenger Car | 7 (2.1) | 14 (4.3) | 24 (7.3) | 25.5 (7.8) | 11.5 (3.5) |
| Single Unit Truck | 8.5 (2.6) | 27.8 (8.5) | 42 (12.8) | 44.1 (13.4) | 16.3 (5) |
| Single Unit Bus | 8.5 (2.6) | 24.4 (7.4) | 42 (12.8) | 46.5 (14.2) | 22.1 (6.7) |
| Semitrailer (WB-40) | 8.5 (2.6) | 18.9 (5.8) | 40 (12.1) | 41.5 (12.7) | 22.6 (6.9) |

Source: Adapted from American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, Washington, D.C., 1990, Tables II-1 and II-2.

### 6.3. Speed vs. 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 ft (90 to 150 m).

Instead of applying fixed guidelines, the Department will compute required spacing based on target speeds. Ordinarily, midpoint speeds will be allowed to climb no more than 5 mph (8 kph) 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), determine 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 ft (183 m) between slow points, midpoint speeds rise to 90 percent of their maximum value. The maximum value, however, is not the 85$^{th}$ percentile speed of the road before traffic calming but rather a speed between the pre-existing speed and the 85$^{th}$ percentile speed at the slow points. This means that for any reasonable spacing of slow points, the simple presence of traffic calming has a significant effect on travel speeds.

The relationship between midpoint speed and spacing of slow points is illustrated in Figure IV-21. In mathematical terms, the best-fit exponential curve is:

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

where

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

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

$85th_{street}$ = 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

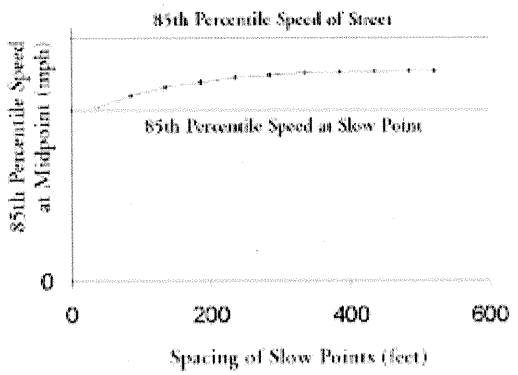



**FIGURE IV-21. SPEED VS. SPACING OF SLOW POINTS**

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 never has time to react.
2. The optimal relationship between offset distance and opening width is:

| 5.5 ft (1.67 m) max | 16 ft (4.9 m) min |
|---|---|
| 5 (1.52) | 17 (5.2) |
| 4.5 (1.37) | 18 (5.5) |
| 4 (1.22) | 19 (5.8) |
| 3.5 (1.07) or less | 20 (6.1) |

3. A 12-ft (3.7 m) hump with a height of 3-1/2 inches (90 mm) is equivalent to an arc of a circle with a radius of 62 ft (19 m). This can easily be determined from trigonometry. Such a hump has an 85-percentile crossing speed of 19 mph (31 kph). Given these values, the tolerable rate of centrifugal acceleration going over a speed hump must be on the order of 12.5 $ft/sec^2$ (3.8 $m/sec^2$). Admittedly, the physics of crossing a hump are being oversimplified. The force of impact with the hump will tend to reduce speeds; 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 effects. Here, only centrifugal forces are accounted for.
4. 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 IV-24.

## CHAPTER V
## SIGNING AND MARKING OF TRAFFIC CALMING MEASURES

If driven at excessive speeds, beyond that for which they are designed, traffic calming measures may pose a hazard to motorists. Government has a ministerial duty to warn motorists of hazardous conditions that it creates or becomes aware of. It is this duty to warn that necessitates the careful signing and marking of traffic calming measures.

To foster universal recognition, traffic calming measures in the State of Delaware shall be signed and marked according to the standard conventions outlined in this chapter. These conventions were developed with due consideration of the Federal Highway Administration's *Manual on Uniform Traffic Control Devices* (MUTCD).

The Department may deviate from its standard conventions where alternative schemes promise to be *more context-sensitive* and *equally effective*. In particular, on low-volume, low-speed streets, the Department will consider relaxation of signing and marking requirements. Alternative schemes may be proposed in writing by a municipality or neighborhood group.

### 1. GENERAL GUIDANCE FROM MUTCD

The MUTCD has been adopted by the State of Delaware 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 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.

## 2. GENERAL SIGNING AND MARKING CONVENTIONS

The following conventions shall be observed in the signing and marking of all traffic calming measures in Delaware.

### 2.1. Advance Warning Signs

Advance warning signs shall be provided for all traffic calming measures involving vertical or horizontal deflection including speed humps, speed tables, raised intersections, traffic circles, chicanes, and diagonal diverters.

Where such measures are used in a series spaced less than 500 feet apart, it is sufficient to provide a single advance warning sign before the first slow point in the series, with a rider indicating how far the series extends (as in Figure V-1). Where measures are used in isolation or at greater spacing, they shall be signed individually.

At intersecting cross streets in a series of slow points, additional warning signs shall be provided if the first slow point is more than 150 feet from the intersection. The warning sign may be placed in the direction of travel along the traffic calmed street, or may be displayed on the cross street (as in Figure V-2).

The location of advance warning signs shall generally conform to Table V-1 from MUTCD. For measures introducing vertical or horizontal deflection but maintaining travel lanes in both directions, placement guidelines for "Deceleration to Listed Advisory Speed" apply. For measures reducing a two-way cross section to a single shared lane, guidelines for "High Judgment Needed" apply.

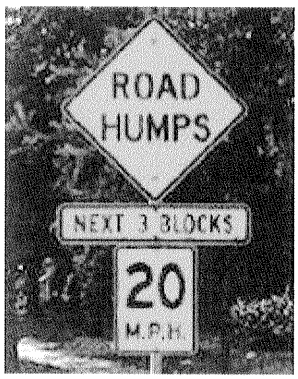



**FIGURE V-1. ADVANCE WARNING SIGN WITH RIDERS**

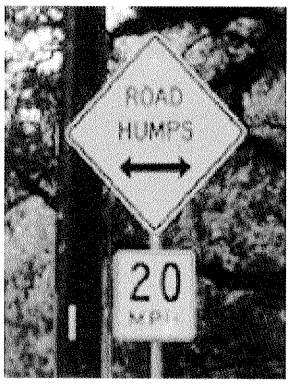



**FIGURE V-2. WARNING SIGN ON CROSS STREET**

**TABLE V-1. ADVANCE WARNING SIGN PLACEMENT**
**(number of feet upstream of condition)**

| Posted or 85th Percentile Speed | High Judgment Needed | Deceleration to Listed Advisory Speed | | |
|---|---|---|---|---|
| | | 10 mph | 20 mph | 30 mph |
| 25 | 250 | 100 | N/A | N/A |
| 30 | 325 | 150 | 100 | N/A |
| 35 | 400 | 200 | 175 | N/A |
| 40 | 475 | 275 | 250 | 175 |
| 45 | 550 | 350 | 300 | 250 |

Source: Federal Highway Administration (FHWA), *Manual on Uniform Traffic Control Devices*, Washington, D.C., 1988, p. 2C-2A.

FIGURE V-3. WARNING SIGN WITH ADVISORY SPEED PLATE

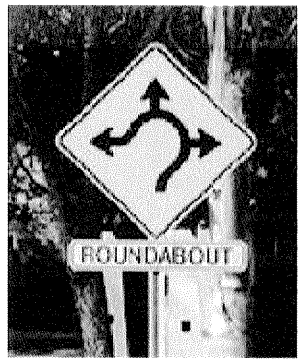



FIGURE V-4. WARNING SIGN WITH EDUCATIONAL PLAQUE

**2.2. Speed Advisories and Educational Plaques**

Traffic calming signs shall be supplemented with advisory speed plates wherever the comfortable crossing speed of measures (as determined from tables and formulas in Chapter IV) is less than the posted speed limit (as in Figure V-3). Educational plaques may be used initially in conjunction with signs for which no close analogy exists in the MUTCD (as in Figure V-4).

**3. STANDARD SIGNS**

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

**3.1. Standard MUTCD Signs**

For certain traffic calming measures, existing MUTCD signs are adequate.

- 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 Turn signs (W1-3) or Reverse Curve sign (W1-4) at lateral shifts, the appropriate sign depending on the design speed of the feature (W1-3 at 30 mph or less, W1-4 at higher speeds).

**3.2. New Standard Warning Signs**

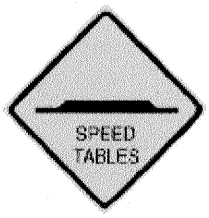
For other traffic calming measures, no existing MUTCD sign is suitable. New standard warning signs have been developed for use throughout Delaware. The design of the new signs reflects a preference, on the part of both MUTCD and the Citizen Advisory Committee, for symbols over word messages. The operative principle in the design of symbol signs is that the symbol itself faithfully represent the *geometrics* and *traffic flow pattern* of the measure.

The standard signs in Figure V-5 shall be used throughout Delaware in connection with the corresponding traffic calming measures. Mirror images of symbol signs should be used where the geometry of measures is the reverse of what is shown. All are diamond-shaped warning signs with the following standard dimensions and standard colors.

**Table V-2. SIGN DIMENSIONS AND COLORS**

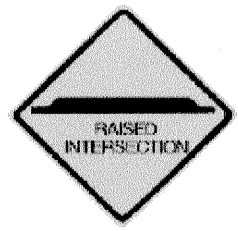
| Sign Dimensions | Color Code | | |
|---|---|---|---|
| | Background | Message | Border |
| 30" x 30" | Yellow | Black | Black |

**SPEED HUMP**

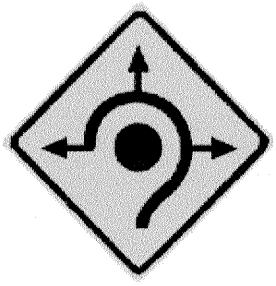



**SPEED TABLE**

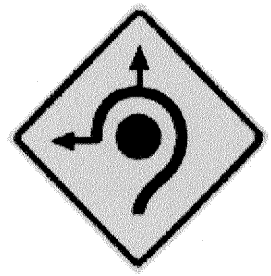
**RAISED CROSSWALK**




**RAISED INTERSECTION**

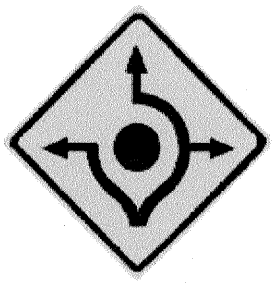


**4-WAY**

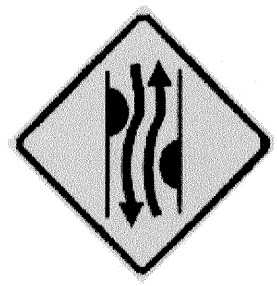


**3-WAY**

**TRAFFIC CIRCLE OR ROUNDABOUT**



**ALTERNATIVE TRAFFIC CIRCLE**
**(left turns in front)**



**TWO-LANE CHICANE**

**FIGURE V-5. NEW STANDARD SIGNS**

### 3.3. TRAFFIC CALMED AREA Sign

One additional standard sign has been developed for use throughout Delaware, the TRAFFIC CALMED AREA sign (see Figure V-6). It should be used on main access routes into neighborhoods, business districts, and entire communities that have been traffic calmed on a comprehensive, areawide basis.

Where four conditions are met, no additional warning signs are required in traffic calmed areas:

- TRAFFIC CALMED AREA signs are installed on all access routes, preferably on both sides of the street to emphasize the gateway effect
- an appropriate, uniform advisory speed are posted with each TRAFFIC CALMED AREA sign
- a slow point is proximate to each TRAFFIC CALMED AREA sign, and subsequent slow points are no more than 500 feet apart

It is recommended that formal gateway treatments be used on major access routes into traffic calmed areas; a formal gateway may consist of a roadway narrowing, textured and colored surface material, special landscaping, and/or other features that emphasize the fact that motorists are entering an area of special character.

## 4. SPECIFIC SIGNING AND MARKING CONVENTIONS

The following signing and marking conventions shall be followed with specific traffic calming measures in Delaware. For aesthetic reasons, signing and marking will be kept to a necessary minimum.

### 4.1 Signing and Marking of Vertical Measures

Advance warning signs will be deployed upstream of vertical measures, including speed humps, speed tables, raised crosswalks, and raised intersections. Pavement markings will be displayed on the up-ramps of the vertical measures themselves. Pavement legends will not be required in front of vertical measures. Nor will signs or object markers ordinarily be required at individual humps, tables, raised crosswalks, or raised intersections.

Signs or object markers may be useful on curbless sections to keep motorists from veering off the roadway to avoid vertical deflection (as in Figure V-7). They may also used to mark vertical measures on snow plow routes. However, for both of these purposes, other marking alternatives are available. Landscaping and decorative bollards, for example, will serve the same purpose with better aesthetics (as in Figure V-8).

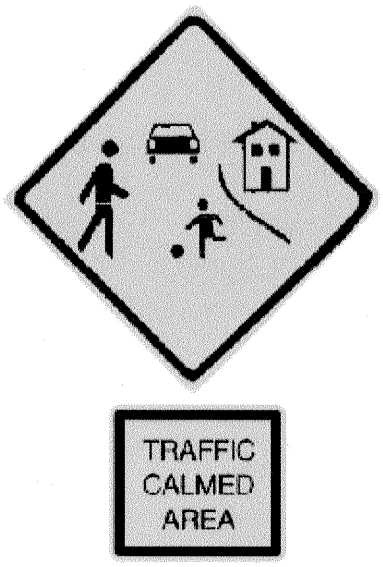
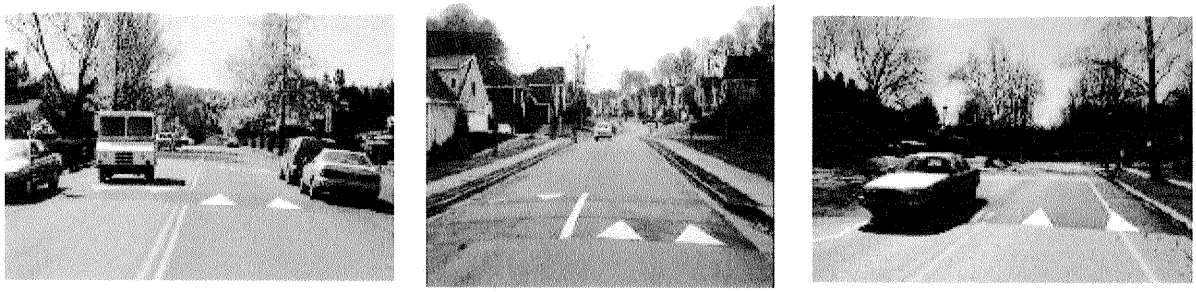



**FIGURE V-6. TRAFFIC CALMED AREA SIGN**

**FIGURE V-7. OBJECT MARKER NEXT TO SPEED HUMP ON A CURBKESS SECTION**

**FIGURE V-8. AESTHETIC OPTIONS TO OBJECT MAKERS**

Vertical measures in Delaware shall be marked with a simple shark's tooth pattern (as in Figures V-9 and V-10). This marking pattern has two advantages over most other common patterns: the large marked area is highly visible, and the asymmetric pattern directs drivers to the proper crossing point. There shall be at least two triangular shaped markings in each direction, and may be more than two in each direction on wider streets.



**Speed Hump** **Speed Table** **Raised Intersection**

**FIGURE V-9. SHARK'S TOOTH MARKING PATTERN ON DIFFERENT VERTICAL MEASURES**

The Department will consider exceptions to the shark's tooth pattern where vertical measures are marked in other ways more appropriate to the context. For example, the shark's tooth pattern may be omitted where the plateaus of raised crosswalks are marked in accordance with MUTCD guidelines for at-grade crosswalks, that is, with traverse white lines marking both edges of the crosswalk, with longitudinal white lines perpendicular to the crosswalk, or with both longitudinal and diagonal lines (see Section 3B-18, MUTCD). In a low-speed context such as traditional main street, the epartment will consider omission of separate markings in favor of colored and patterned surfaces of brick or concrete paver materials.

**4.2. Signing and Marking of Center Islands**

MUTCD requires the approach ends of traffic islands to have marked triangular neutral areas in front so as to guide vehicles in desired paths of travel along island edges. These areas may be identified by painting or by use of contrasting materials. Appropriate signs, such as the Keep Right (R4-7) sign, are placed on the approach ends facing traffic. Object markers are also placed on approach ends. These conventions shall apply to center island narrowings and midblock deflector islands on arterials and major collectors (as in Figure V-11).

On other streets, signing and marking requirements may be relaxed somewhat. MUTCD conventions apply to pedestrian refuge islands, traffic divisional islands, and traffic channelizing islands, all found on major streets and highways. On minor streets in other states, center islands are often designated with a single Keep Right sign and no object marker, and center lines shear off to the right to guide traffic past center islands rather than forming marked triangular neutral areas (as in Figure V-12). This signing and marking convention will be acceptable on such streets in Delaware. Sometimes, in other states, signs and object markers are omitted entirely in favor of reflective raised pavement markers on the approach ends and prominent landscaping within the islands. Few if any accidents occur since islands are still plainly delineated. This convention may be approved by the Department on an exception basis. Examples of signing and marking alternatives, that might be approved by the Department on an exception basis, are shown in Figure V-13.

**FIGURE V-10. STANDARD MARKING PATTERN FOR VERTICAL MEASURES**

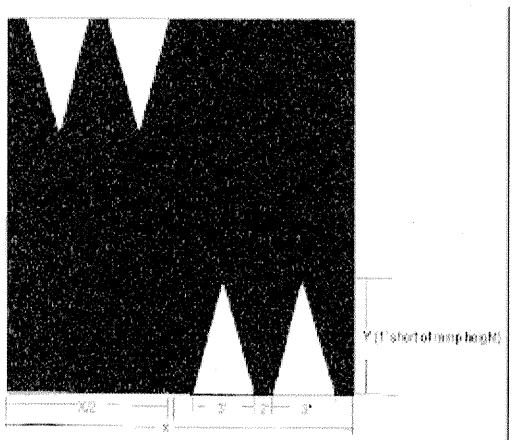


FIGURE V-11. SIGNING AND MARKING OF A CENTER ISLAND PER MUTCD

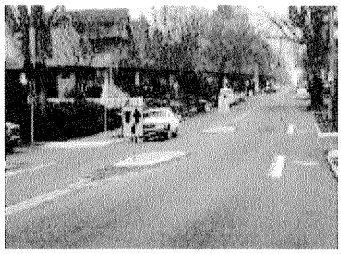


FIGURE V-12. SIGNING AND MARKING OF CENTER ISLANDS ON COLLECTOR ROADS

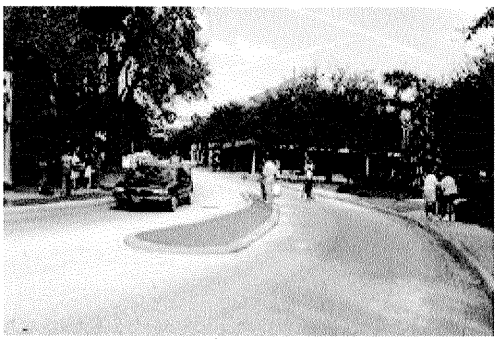
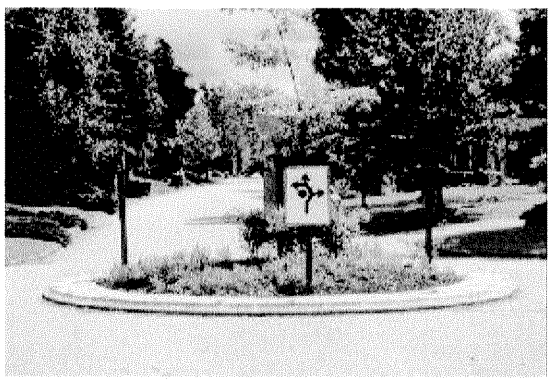


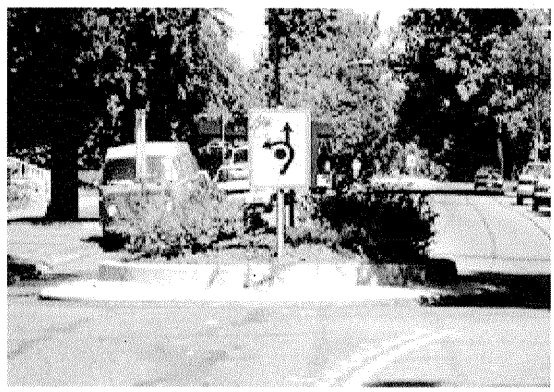
FIGURE V-13. SIGNING AND MARKING ALTERNATIVES ON AN EXCEPTION BASIS

### 4.3. Signing and Marking of Traffic Circles and Roundabouts

#### 4.3.a Mini-Traffic Circles

Circular intersections with smaller center islands will be signed and marked as mini-traffic circles. The sign, shown in Figure V-14, will be displayed on center islands facing traffic on all approaches. It will be supplemented by reflective raised pavement markers on the curbs of center islands. Center islands will be landscaped for greater visibility than can be achieved with signs and markings alone.





**4-Way Intersection** **3-Way Intersection**

**FIGURE V-14. SIGNING AND MARKING OF MINI-TRAFFIC CIRCLES**

Under certain circumstances (outlined in Chapter IV), the Department will consider an alternative traffic circle design which allows left turns in front of the center islands. Circles will be proceeded by the appropriate advance warning

sign (see Figure V-5) and center islands will be outfitted with a single Type 1 object marker facing each approach (as in Figure V-15).

**4.3.b Roundabouts**

MUTCD signing and marking conventions for traffic-control islands may apply, by analogy, to roundabouts and large traffic circles. The center islands of circular intersections are also in the path of approaching traffic and must be passed on the right. This analogy suggests the use of appropriate signs and object markers on the islands themselves, and marked triangular neutral areas on the approaches.

The distinction between roundabouts and mini-traffic circles, from a geometric standpoint, is outlined in Chapter IV. Generally, roundabouts have center islands of 40-foot diameter or more. Center islands are so large that the required movement of entering traffic may best be conceived as a right turn. The advance warning sign has already conveyed the essential geometry and traffic flow pattern of the roundabout. Roundabout islands in other states are signed with Large Arrow signs, Chevron signs, and/or ONE WAY signs (as in Figure V-16). In Delaware, the Large Arrow sign will be used consistently to indicate direction of flow. Splitter islands will be raised with curbs, will have marked neutral areas on their approach ends, and for longer splitter islands, will have Keep Right signs on their approach ends. Center islands will be landscaped for greater visibility than can be achieved with signs and markings alone. Splitter islands may be landscaped as well.

**FIGURE V-15. LEFT TURNS IN FRONT ON AN EXCEPTION BASIS**

**FIGURE V-16. SIGNING OF ROUNDABOUTS**

**4.4. Marking of Curb Extensions and Edge Islands**

For curb extensions or edge islands that deflect traffic—including chicanes, lateral shifts, and one-lane chokers—object markers shall be placed on the extensions or islands toward the side on which traffic is to pass. Ordinarily, Type 3 object markers will be used to mark these measures (as in Figure V-17). The Department may approve alternative marking conventions on an exception basis (as in Figure V-18).

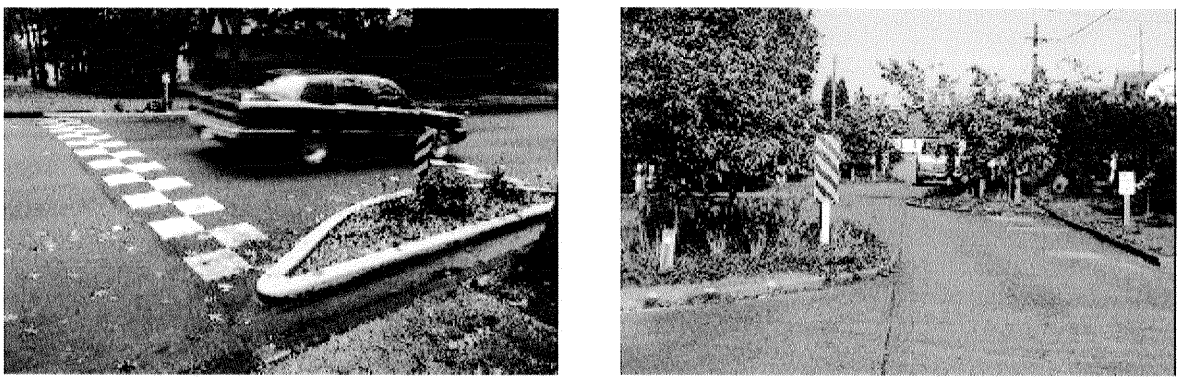


**FIGURE V-17. TYPE 3 OBJECT MARKERS ON CURB EXTENSIONS AND EDGE ISLANDS**

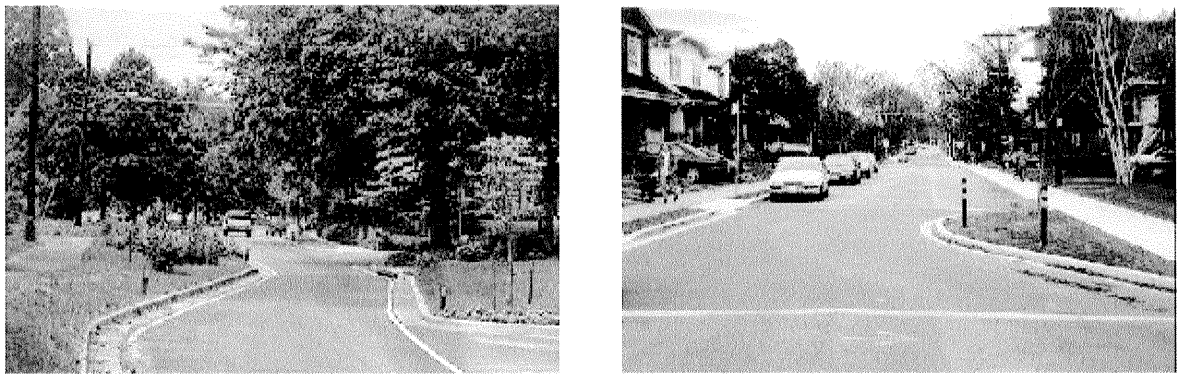


**FIGURE V-18. MARKING ALTERNATIVES ON AN EXCEPTION BASIS**

Generally, no special signing or marking is required on curb extensions or edge islands that fall outside the direct path of travel, as when curb extensions within a designated parking lane form protected parking bays (as in Figure V-19). There are exceptions to this general rule. On snow plow routes, object markers may be used to mark curbs that might otherwise be undetectable. Also, on curbless sections, object markers may be used to draw attention to the occasional island. However, for both of these purposes, other marking alternatives are available. Landscaping and monument signage, for example, can perform the same function more effectively than a simple object marker (as in Figure V-20).

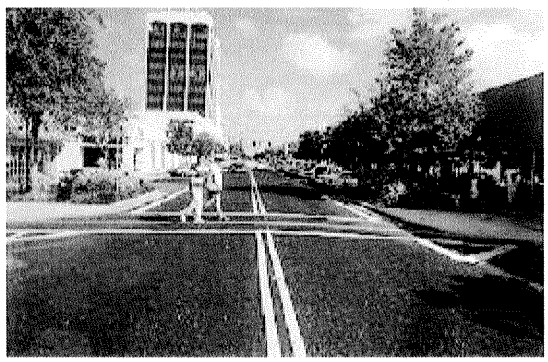


**FIGURE V-19. NO MARKINGS REQUIRED WITH PROTECTED PARKING BAYS**

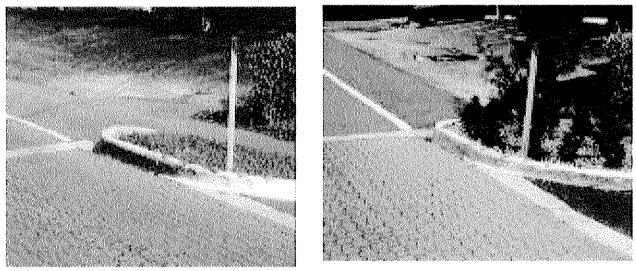


**FIGURE V-20. ADDITION OF LANDSCAPING ON A PROBLEM CHOKER PREVIOUSLY MARKED WITH REFLECTIVE POST ONLY**

**5. SPECIAL SIGNING FOR BICYCLE ROUTES**

Special signing shall be provided along traffic calmed streets that are designated as bicycle routes. Appropriate signing shall be used at closures and diverters to indicate that bicycle access is maintained; appropriate signing shall be used at horizontal measures to protect bicyclists from deflected motor vehicles. Examples of appropriate signing are shown in Figure V-22

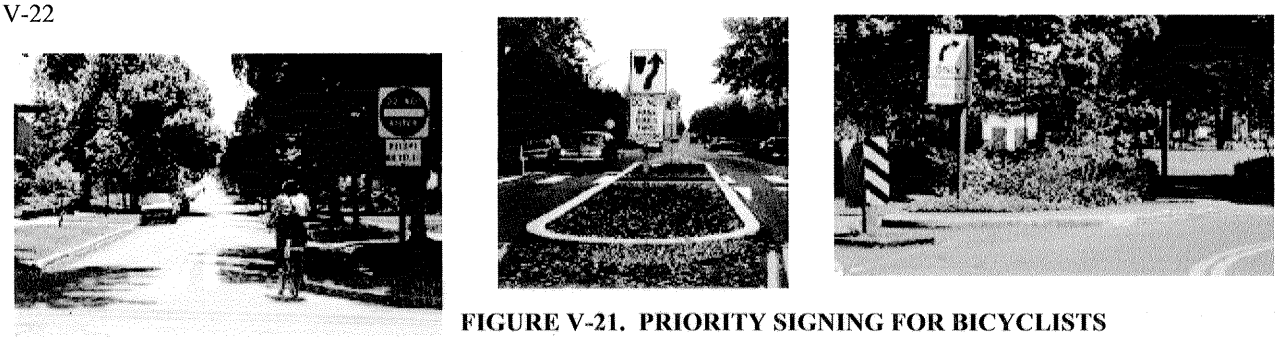


**FIGURE V-21. PRIORITY SIGNING FOR BICYCLISTS**