The Traffic Calming Manual
Chittenden County Regional Planning Commission, Vermont

prepared by:
T. J. Boyle and Associates
Landscape Architects and Planners, Burlington, VT.
and
Resource Systems Group, Inc.
Transportation and Environmental Consultants, Norwich, VT.

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Traffic Calming Manual
City residential neighborhoods must coexist with traffic, and at the same time, are very vulnerable to its impacts. In his book, Livable Streets, Donald Appleyard had found that traffic volumes and speeds on neighborhood streets were very closely related to many other measures of the "livability" of neighborhoods, particularly for families with children, the city's most vulnerable residents. These measures included:

- friendliness of the street, measured by the numbers of friends and acquaintances on the street, the ease of visiting neighbors, and the amount of "neighboring" that happens on front porches and sidewalks.

- the boundarys and awareness levels of a residents home territory, or "turf", extending beyond their own residence, and

- noise levels, air pollution, and amount of sleep disturbance.

Traffic calming provides a way to enhance these positive attributes of urban residential areas, and keep them vibrant, satisfying places to live. Participation of residents in the design and implementation of a traffic calming scheme in their neighborhood can instill pride in one's neighborhood, and provide them a sense of empowerment that their concerns have been heard and acted upon. In fact, the most prevalent problems in nationwide surveys of urban residents was found to be noise and high traffic volumes, compared to crime, litter, and other typical urban neighborhood problems.

If it is desired to discourage further suburbanization in the Burlington area, then an important activity towards this goal is to preserve and enhance the urban residential areas. These neighborhoods have the best access to, and are likely to make the most use of, public transit and alternative transportation.

While traffic is an unavoidable part of city life today, it is possible, with the traffic calming techniques described in this manual, to modify driver behavior through residential areas. These techniques will cause drivers to either drive more slowly through neighborhoods, or to choose arterial routes instead, and either result would address most residents' concerns about traffic.

This study is part of a four part Traffic Engineering and Transportation Planning Services effort including:

- Traffic Calming Strategy for Burlington's Old North End
- City Wide Study for Development of Truck Routes
- Revision of the Downtown Parking Study
- Regional Congestion Management Strategy
PREFACE

The Planning Services were conducted as a joint effort by Resource Systems Group of Norwich, Vermont, FitzPatrick-Llewellyn, Inc. of Williston, Vermont, and T. J. Boyle and Associates of Burlington, Vermont.

This report and the "Traffic Calming Pilot Study of a Neighborhood in Burlington's Old North End", are a collaborative effort of T. J. Boyle and Associates performing planning, community input, and report writing and Resource Systems Group conducting traffic studies, analyzing data and reviewing the report. The work was performed in close association with the Department of Public Works’ staff, Scott Johnstone, Director of Public Works, and Norm Baldwin, Traffic Division Head.

We would like to thank the following people for their support and review of the report in process:

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We would especially like to thank the community members of Ward Street, Strong Street, Drew Street, Blodgett Street and Pitkin Street for their participation, input, and patience in this planning effort.

Credits:

T. J. Boyle and Associates
Jane Sorensen, Project Manager
Sandra Short, Typist and Editor
William Mechnick, Graphics
Terrence J. Boyle, Principal

Resource Systems Group
Lucy Gibson, Project Manager
Norm Marshall, Principal

Traffic Calming Manual

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Definition of Traffic Calming

Traffic Calming is a physical redesigning of streets to encourage drivers to obey speed limits, parking ordinances, and to utilize arterial roads for through passage. The traditional traffic control devices utilized in the United States, including stop signs, speed limits, and slow: children playing signs, rely on frequent enforcement to be effective. There are often not enough police forces or funding to maintain enforcement on all road lengths and intersections, which results in unchecked speeders and stop sign roll-through. Traffic Calming offers a variety of physical alterations of the roadway or "devices" along with traditional signage to make it difficult to pass through the roads faster than the designated speed limit. Ideally, traffic calming is designed on a neighborhood basis creating a system of devices to slow vehicles on residential streets and direct traffic onto desired routes.

This manual focuses on neighborhood traffic calming with a brief discussion on safety of pedestrians when crossing arterials. It includes a discussion on the Traffic Calming Planning Process, Warrants for Traffic Calming, and descriptions of the Traffic Calming Devices.

Objectives

The primary objective of traffic calming is to improve the safety of pedestrians and drivers and their passengers. The secondary objectives are to create an improved streetscape with less noise, pollution, and disruption, and to provide more green space.

In designing a Traffic Calming Plan, care is needed to ensure reasonable access for residents, emergency vehicles, delivery trucks and public transportation. The design must be attentive to existing drainage patterns and utilities. Some relocations of catch basins and drain inlets are likely. Accurately locating existing drainage and utility structures on the base plan will aid in designing a cost effective plan. The plan should also be designed to minimize maintenance. Some landscape maintenance can be performed by volunteer neighborhood residents. The Burlington Department of Public Works has stated they are considering down-sizing their snow plows for easier maneuvering on residential streets.
Experience Elsewhere

There are many examples of successfully "traffic calmed" streets, particularly in Europe, Japan, and Australia. The Woonerf, or "living street", is an extreme utilization of traffic calming that has been used extensively in European countries and is spreading rapidly in Japan and Australia. The Woonerf has two main qualities: 1) the street is designed to make it visually clear that the whole street is usable by pedestrians, and 2) the traffic control devices are designed as positive amenities for residents to enhance the visual quality of the street or to provide space for various street activities. The result is something of a courtyard shared by cars and people. However, most of these communities are less dependent upon the private automobile than the United States.

Ideally, a U.S. city would be concurrently developing plans for alternative modes of transportation to reduce automobile use while developing traffic calming for their residential streets. Burlington, and the surrounding communities, are currently developing plans for an alternative transportation system, focussing primarily on bicycle routes to provide connections of residential areas to schools, work areas, shopping centers, and bus route terminals.

Seattle, Washington is perhaps the most active city in the United States in implementing traffic calming devices. The Seattle Traffic Engineering Department has developed a Point Criteria system based on traffic accidents, speeds, and volumes to determine priority areas for calming. Before any plan is implemented, 60% of the residents and businesses in the neighborhood must have signed a petition stating their support. The traffic circle is the most common device utilized in Seattle with proven success in reducing traffic accidents and reducing speeds.
Planning Process Introduction

Traffic Calming is more than simply providing a technical solution to a specific traffic problem. It is a design process involving zoning and land use, transportation, utility infrastructures, emergency and service accessibility, and community perceptions, needs, and preferences. Participation and consultation by relevant authorities and neighborhood residents and businesses is critical for the success of the plan. The following process is modeled after Seattle, Washington’s Point Criteria system, with added notes from Michael Wallworks “Traffic Calming”, and from the Old North End Pilot Study experience.

The steps in the planning process are as follows:

Step One: Traffic Problem Identification

A. Complaint of Traffic Problem

A resident or group of residents, business owner, city councilor or other city authority reports to the Department of Public Works of a residential road or neighborhood traffic problem.

B. Preliminary Investigation

The Department of Public Works reviews readily available data such as traffic accident and traffic violation reports from the Police Department, any existing traffic study results of the area, a neighborhood walk-through, and meetings with neighborhood residents to make a preliminary assessment of the problem.

C. Preliminary Problem Assessment

In the preliminary investigation, the Department of Public Works may find that the problem is better treated by other programs. For example, there may be many children playing in the street due to a lack of a nearby park, or truck traffic may be generated by inappropriate zoning in a residential area. Alternatively, the problem may be an isolated intersection with poor roadway geometrics or shortened sight distances. These problems can be attended to without going through a traffic calming study. If the traffic problem is indeed widespread in the neighborhood, the Department of Public Works would make a decision to proceed with supplying petition forms to the neighborhood.
D. Neighborhood Petition

The Department of Public Works would supply petition forms to a neighborhood representative, perhaps through the Neighborhood Planning Assembly. The petition form is for neighbors to request a Traffic Safety Analysis and a Traffic Calming Plan if the analysis shows it is warranted. Signatures must be gathered from at least 60% of the households (owners or renters), businesses, landlords, and landowners within the affected area. Once the needed volume of petitions is delivered, they would proceed to Step Two.

**TRAFFIC CIRCLE PETITION**

Exhibit 2

We, the undersigned residents or business owners, do respectfully petition the Seattle Engineering Department for a traffic circle at the intersection of ____________ for the reasons that:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

***PLEASE NOTE ANY ADDITIONS, CORRECTIONS OR VACANCIES TO THE ATTACHED MAP***

CONTACT PERSON ________________________________

PHONE ________________________________

SIGNATURE ________________________________ NAME PRINTED ________________________________ ADDRESS ________________________________ APT. NO. __________

EXHIBIT 4

TITILE: NTCPROM, III

Date

As you requested over the telephone, I am sending you a package for applying to the 1989 Neighborhood Traffic Control Program (NTCP) for the installation of a traffic circle in the intersection of ____________. We have enclosed an informational brochure, a sample petition form, and a map with a petition area marked on it.

Please fill out the top portion of the petition form and circulate it through the petition area. Signatures are needed from at least 60% of the households and any businesses in the petition area for the project to compete for funds. Each unit in an apartment building will be counted as a household, i.e., a 4-unit apartment building will be counted as 4 households. Only one signature per household or business is needed.

Good luck with the petition circulation. If you or your neighbors have any questions or comments, please call me at 684-5087. I will be happy to discuss them with you.

Sincerely,

[Signature]

[Contact Information]

Enclosures

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Standard forms from the Seattle Engineering Department
PLANNING PROCESS

Step Two: Project Initiation

A. Traffic Safety Analysis:

The Department of Public Works or a consultant would conduct a traffic study and evaluate data on the following:

1. Point Criteria Data
   a. Traffic accident history - location and number
   b. Speed studies
   c. Volume counts

2. Supplementary Data
   a. License plate survey for cut through volumes
   b. Parking capacity and use
   c. Pedestrian and bicycle use
   d. Bus Routes
   e. Existing traffic controls
   f. Arterial use and spare capacity
   g. Major traffic generators

The Point Criteria data would be used to rank the neighborhood based upon the system developed in Seattle revised to be neighborhood-wide. Please find the Seattle Engineering Department’s Point Criteria System in the next chapter, titled “Warrants for Traffic Calming”. We recommend evaluating each road length and its intersection separately for their respective accumulated points. If no location within the neighborhood accumulates at least three points, the neighborhood representative is contacted, and the project is put on hold. If any location accumulates three points, the neighborhood points are totaled and averaged by number of blocks, and ranked against all other petitioning neighborhoods for prioritization. The supplementary data would help to define the problems.

B. Community Input

As a neighborhood is identified as high on the prioritization list, a community meeting would be scheduled and advertised. At the meeting the Department of Public Works, or consultant, would present the Traffic Safety Analysis Data, clearly identifying any traffic problems, and soliciting the neighborhood residents' views and input. A door-to-door
survey of the neighborhood could be utilized to allow those unable to attend the meetings to provide their observations and perceptions. Neighborhood residents can provide insights into unreported traffic accidents, unsafe sight distances or parking locations, locations with high numbers of pedestrians, pedestrian destinations, noise problems and conflict areas. We find a one-page survey, (with a 6" string stapled in the corner for hanging on the door knob for pick-up) is effective for receiving a high percentage of responses.

C. Defining Traffic Calming Objectives

Based upon the Traffic Safety Study, Community Meeting, and Survey, a list of objectives tied to specific locations can be developed. They would likely include speed reductions, volume controls, perhaps truck rerouting, parking control, noise reduction, pedestrian safety, and others.
Step Three: Developing Alternative Plans

A. Develop Alternative Plans

A series of two to three alternative Traffic Calming Plans would be developed responding to the agreed upon objectives. Each plan would be evaluated for its advantages and disadvantages in meeting the objectives and relative costs.

B. Relevant Authority Review

The Alternative Plans would be reviewed by the relevant city authorities including the Fire Department, Police Department, City Councilors, Utility Companies and any branches of the Department of Public Works who might be effected by the plans. Written review comments from each department would be advisable.

C. Community Review

A second Community Meeting would be held to review the Alternative Plans, to receive their ideas, concerns and feedback. Again, a door-to-door survey could be utilized to guarantee further participation.
Step Four: Traffic Calming Plan Development

A. Plan Development

From the review process, a plan would be selected and developed to more accurately respond to existing drainage patterns and structures, utility locations, emergency vehicles turning radii, and concerns of the reviewing parties.

B. Relevant Authority Review

The Traffic Calming Plan would be reviewed by the same authorities as in Step Three.

C. Community Review

The plan would be revised to reflect the authorities' concerns, and presented to the neighborhood through a meeting and door-to-door leaflet. The door-to-door leaflet should include explanation of the devices and comments by authorities and the members of the neighborhood who attend the meetings.
PLANNING PROCESS

Step Five: Temporary Traffic Calming Plan Implementation

A. Temporary Devices Installed

Temporary Devices Plan reflecting the permanent Traffic Calming Plan would be developed and the devices and warning signs would be installed and maintained in position for at least two months. Notice of the installation should be warned by leaflet to each household and business in the neighborhood at least one week prior to implementation.

B. Traffic Study with the Temporary Devices in Place.

After the temporary structures have been in place three weeks at a minimum, a traffic study replicating that of the Traffic Safety Analysis would be performed to test the effectiveness of the plan. The study should investigate impact on surrounding neighborhoods and arterials.

C. Relevant Authority Review

The respective authorities would again be asked to document their review comments in writing. The Fire Department and Department of Public Works should be encouraged to test drive the appropriate emergency vehicles, snow removal and street cleaning vehicles, through the temporary devices.

D. Community Meeting

A meeting would be scheduled to report the results of the traffic study and to receive input on problems and successes of the temporary traffic calming devices. Small revisions would be noted and the devices adjusted. Any substantial revisions which could be justified may require extending the temporary devices duration, and repeating the traffic study.

E. Community Survey and Petition

A door-to-door survey would be conducted, seeking feedback on the locations and types of devices implemented. Neighborhood representatives would be responsible for distributing and collecting petitions supplied by the DPW. If more than 40% of all the residents, businesses, landowners, and landlords oppose the installation of the permanent Traffic Calming Plan, the Department of Public Works would discontinue the planning effort. After a waiting period of six months, or any time thereafter, any resident could appeal to the neighborhood, gather signatures from 60% of the residents, businesses, landlords or landowners and reopen the process.
Step Six: Permanent Traffic Calming Implementation

A. Construction Plan and Implementation

Should the petition result in 60% or greater support, final engineering plans would be developed, again reviewed by the relevant authorities and neighborhood, and the Traffic Calming Plan implemented.

B. Traffic Study

Another traffic study replicating the Traffic Safety Analysis and Temporary Devices Traffic Study should be performed to verify that the final plan is effective, and to develop a resource data base on the effectiveness of Traffic Calming Techniques utilized in the plan.
Warrants for Traffic Calming

Presently there are not accepted standard warrants for most of the individual traffic calming devices. The Seattle Point Criteria System, however, offers a standard for whether “Traffic Calming” in general is warranted. The Seattle Engineering Department evaluates, rates, and implements traffic calming on individual locations. We recommend operating on a neighborhood-basis. As explained in the Planning Process: Traffic Safety Analysis Section, each road length and its intersections would be evaluated separately for their respective accumulated points. If any neighborhood road length or intersection accumulates three points, the whole neighborhood is warranted for Traffic Calming. This is assuming the neighborhood traffic operates as a system, and that treating one location within the system will have impacts on the rest of the neighborhood.

The Seattle Engineering Department Point Criteria System is as follows:

<table>
<thead>
<tr>
<th>Points</th>
<th>Accident History</th>
<th>Traffic Volumes (Weekday Average)</th>
<th>Traffic Speeds (85th % Speed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>0.5–0.875 Accidents annually</td>
<td>500-1100 vehicles per day</td>
<td>26-29 miles per hour</td>
</tr>
<tr>
<td>1</td>
<td>0.876-1.250 Accidents annually</td>
<td>1101-1700 vehicles per day</td>
<td>29.1-32 miles per hour</td>
</tr>
<tr>
<td>2</td>
<td>1.251-1.625 Accidents annually</td>
<td>1701-2300 vehicles per day</td>
<td>32.1-35 miles per hour</td>
</tr>
<tr>
<td>3</td>
<td>1.626-2.000 Accidents annually</td>
<td>2301-2700 vehicles per day</td>
<td>35.1-38 miles per hour</td>
</tr>
<tr>
<td>4</td>
<td>2.001-2.375 Accidents annually</td>
<td></td>
<td>38.1-41 miles per hour</td>
</tr>
<tr>
<td>5</td>
<td>2.376-2.750 Accidents annually</td>
<td></td>
<td>41.1-44 miles per hour</td>
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</tbody>
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If “non-correctable” intersection accidents exceed an average of 2 per year over the last three years, average traffic volumes and speeds are used.

If accidents on a mid-block section of street exceed 2 per year over the last three years, average traffic volumes and speeds are used.
General Principles on Choosing Devices and Designing the Plan

Once a neighborhood has been evaluated to warrant traffic calming, the decision on which devices to utilize are primarily an engineering judgment resulting from traffic studies of physical and traffic factors along with community preferences. The more traditional traffic control devices, such as stop signs, traffic signals, and pedestrian signalization, have standard warrants in the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD). Most of the devices have some level of standard dimensioning. Many of the Traffic Calming devices require standard warning signs and object markers placed in typical locations in advance of the device. Devices requiring warning signs are traffic circles, speed humps or bumps, roadway weavings, chokers, mid-block pedestrian crossings, diagonal diverters, and street closings. Descriptions of the warning signs standards, and dimensions of the devices and references to the appropriate MUTCD sections are identified in the discussion of each device in the following Traffic Calming Devices Description.

The following are some principles to consider when designing a Neighborhood Traffic Calming Plan as developed through years of experience by Edwin Von Borstel, the Neighborhood Systems Engineer in Seattle, Washington:

- **Do not try to divert all of cut-through traffic volume.** Some residents of adjacent neighborhoods and others may simply prefer residential streets over arterials. Slowing devices can effectively control the cut-through speeds.

- **Do not chase the problem around the neighborhood.** If a non-arterial route is closed, a user preferring residential streets will be diverted, potentially disrupting a neighborhood or street that did not have a problem before. Treat the neighborhood as a system, and focus primarily on treating speeding and accident problems. This will be less disruptive and more cost effective.

- **Involve everyone in or near the neighborhood from the beginning.** People will be more willing to accept changes if they are made aware of the problems early in the process. The process of choosing devices must involve the community that will be effected by the solution.
Types of Devices

Traffic Calming devices can be sorted and arranged in various ways. The following arrangement is based primarily by function and secondarily by location. The categories are:

Slowing Devices

Slowing devices function primarily to reduce speeds by physical alterations of the roadway. To be effective, they should be installed every 300' - 500' along the roadway. They are effective in reducing accidents and traffic speeds within their vicinity, but generally have little effect on traffic volumes. Reasonable access is maintained to homes by residents and emergency vehicles. Slowing devices tend to be only moderately controversial as access is maintained, only slowed.

Slowing Devices by Location are:

- **Intersections**
  - Neck Down
  - Reduced Radii
  - Raised Intersections
  - Traffic Circle
- **Mid-Block**
  - Roadway Weavings
  - Chokers
  - Speed Hump
  - Speed Bump
  - Mid-Block Pedestrian Crossing
  - Textured Paving
- **Road Lengths**
  - Medians and Islands
  - Narrow Streets

Operational Controls

Operational Controls are traditional traffic controlling devices which function to control speeds and direct traffic primarily by signage. They are effective in stopping cut-through traffic and controlling speeds when there is sufficient enforcement. These devices are generally not controversial unless traffic is diverted to other residential streets. Access for emergency vehicles can be maintained, since they are permitted to travel the “wrong way” when necessary.

Operational Controls by Location are:

- **Intersections**
  - Signalized Intersections with Pedestrian Crosswalks
  - Stop Signs
  - Turning Restrictions and No Through Traffic
- **Road Lengths**
  - Speed Limits
  - One Way Streets
TRAFFIC CALMING DEVICES

Types of Devices

Physical Diverters

Physical Diverters function to physically prohibit certain movements at intersections. They can be implemented as a system to cut off all through routes, and to create a neighborhood pedestrian pathway requiring no street crossings. These are the most controversial devices, as all cut-through volumes will be diverted, access by emergency vehicles is greatly hindered, and convenient vehicular access to homes is reduced.

Physical Diverters by Location are:

<table>
<thead>
<tr>
<th>Intersections</th>
<th>Road Lengths</th>
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<tbody>
<tr>
<td>Diagonal Diverters</td>
<td>Dutch Woonerf</td>
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<td>Street Closing</td>
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TRAFFIC CALMING DEVICES

Slowing Devices: Intersections

Advantages
Visual sense of narrow street slows traffic.
Shortens pedestrian crossing distance.
Provides a gateway.

Neck Down
A "neck-down" or "bump-out" reduces speeds by reducing lane widths. They are typically extensions of the curb, often coordinated with on-street parking and crosswalks. General dimensions are 6 feet wide by 20 feet long with a 15' radius. As parking is not permitted within 50' of an intersection, the neck down could take this whole length. An eight foot width may be possible when travel lanes exceed 10 feet. Be aware of drainage patterns and structures.

Disadvantages
May require moving catch basins and drains.
May be expensive to retrofit existing streets.
May reduce existing parking though illegal spaces.

Graphics from Carpenter, Jot; Editor, Handbook of Landscape Architectural Construction, The Landscape Architecture Foundation.
TRAFFIC CALMING DEVICES

Slowing Devices: Intersections

Reduced Radii
A 10' radii at intersections of minor roads is adequate for passenger vehicles where there is little occasion for truck turning. The reduced radii forces slower turning and pedestrian crossing distance. (The 1990 AASHTO Greenbook, page 713, recommends radii at 15'-25' for minor streets).

Advantages
- Reduces turning speeds.
- Reduces pedestrian crossing distances.

Disadvantages
- May impede emergency vehicular access.
- May be expensive to retrofit existing streets.

Raised Intersections
Raised intersections are a variation of a speed hump, raising the whole intersection four inches. Approach inclines are the same as Speed Humps. A raised intersection can be combined with rough textured or special paving to highlight an intersection as a pedestrian zone. This treatment is most appropriate where there are pedestrian/vehicle conflicts.

Advantages
- Slows vehicles in critical area.
- Highlights intersections.
- Pedestrian safety.

Disadvantages
- May increase speed of an occasional thrill seeker.
- Increased difficulty of making a turn.
- Need to work with utility and drainage.
- Costly to install.
Traffic Calming Devices

Slowing Devices: Intersections

Traffic Circles
Traffic Circles are islands, usually landscaped, which are placed in the center of a non-arterial intersection in residential neighborhoods. They should be sized to the geometrics of the existing intersection to allow a single unit truck to pass by without going over it. The circle is constructed with a mountable two foot wide concrete curb so that larger vehicles can get by without going into the landscaped area. Risers can be added to existing utility covers to bring up to grade. Warning signs are placed in advance of the devices, see section "Warning Signs" for suggested locations, adjust to local conditions. Object markers are placed in the center of the circle, one facing each entering roadway. Seattle, Washington has used traffic circles extensively with much success.

Advantages
Collision reduction.
Speed reduction.
Neighborhood acceptance.
Increased greenspace.
Eliminates need for signalization.

Disadvantages
Costly to install.
Initial driver confusion.
Need to work with existing utilities.

Design Criteria: from Seattle Traffic Engineering

1. The distance between a traffic circle and the street curb projection (off-set distance) shall be a maximum of 5 1/2 feet. See Intersection Diagram next page.
2. The width between a traffic circle and a curb return (opening width) shall be a minimum of 16 feet and a maximum of 20 feet. See Intersection Diagram.
3. As the off-set distance decreases from the maximum 5 1/2 feet, the opening width shall increase from the minimum 16 feet. See Intersection Diagram and Dimension Chart.
4. The outside 2 feet of the traffic circle will be constructed with a mountable monolithic cement concrete curb and pavement surface doweled to the existing pavement.
5. Traffic circles will be landscaped when agreement with neighborhood is made for them to maintain.
6. Traffic circles less than 15 feet in diameter will have one tree centered along with other plantings.
7. Traffic circles at least 15 feet in diameter will have three trees equally spaced and set back 4 feet from the curb face along with other plantings.
TRAFFIC CALMING DEVICES

Slowing Devices: Intersections

INTERSECTION DIAGRAM

Legend:
A Street Width
B Curb Return Radius
C Off-Set Distance
D Circle Diameter
E Opening Width

OPTIMUM CRITERIA

<table>
<thead>
<tr>
<th>Off-Set Distance</th>
<th>Opening Width</th>
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<tr>
<td>5.5 max</td>
<td>16 min</td>
</tr>
<tr>
<td>5.0'</td>
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</tr>
<tr>
<td>4.5'</td>
<td>18'</td>
</tr>
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DIMENSION CHART

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<tr>
<th>A STREET WIDTH</th>
<th>B CURB RETURN RADIUS</th>
<th>C OFF-SET DISTANCE</th>
<th>D CIRCLE DIAMETER</th>
<th>E OPENING WIDTH</th>
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<td>12'</td>
<td>5.5'</td>
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<td>14'</td>
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</tr>
<tr>
<td>25'</td>
<td>12'</td>
<td>5.5'</td>
<td>14'</td>
<td>19'</td>
</tr>
</tbody>
</table>

| 24' >          | 12'                   | 5.5'               | 12'               | 16'             |
| 18'            | 10'                   | 5.0'               | 14'               | 16'             |
| 22'            | 8'                    | 4.5'               | 16'               | 16'             |

| 25' >          | 12'                   | 5.5'               | 12'               | 16'             |
| 20'            | 10'                   | 5.0'               | 12'               | 16'             |
| 24'            | 8'                    | 4.5'               | 14'               | 16'             |

| 30' >          | 12'                   | 5.5'               | 10'               | 18'             |
| 20'            | 10'                   | 5.0'               | 10'               | 18'             |
| 24'            | 8'                    | 4.5'               | 12'               | 18'             |

| 32' >          | 12'                   | 5.5'               | 10'               | 18'             |
| 20'            | 10'                   | 5.0'               | 10'               | 18'             |

| 36' >          | 12'                   | 5.5'               | 8'                | 20'             |
| 20'            | 10'                   | 5.0'               | 8'                | 20'             |

| 40' >          | 12'                   | 5.5'               | 6'                | 22'             |
| 20'            | 10'                   | 5.0'               | 6'                | 22'             |

* Existing Substandard Width Streets
Traffic Calming Manual
Page 19
TRAFFIC CALMING DEVICES

Slowing Devices: Mid-Block

Roadway Weavings
Roadway Weaving is an alteration of the roadway to physically force slower speeds on residential streets. The travel lane widths remain constant while being angled to the right or left. The taper length of the alteration is calculated as:
\[
\text{Length of Taper} = \frac{\text{width of transition} \times \text{design speed}^2}{60}
\]
for speeds less than 40 mph. On roads with parking on one side, roadway weaving is accomplished by moving parking from one side of the road to the other at mid-block. Weaving should not occur through intersections. Avoid driveways within the weaving tapers and insure positive drainage. Warning signs are needed in advance of the devices, see Warning sign section and adjust to local conditions.

Disadvantages
Loss of parking spaces.
May confuse drivers initially.

Chokers
Traffic lanes for two-way streets, may be narrowed to one lane making it impossible for two cars to pass one another. This is a similar effect of a one lane bridge on a two way street. The narrowness of the choker and the warning signs alert the driver of the obvious danger, forcing slow travel or choosing to avoid this as a through route. Generally the choker is 20 feet long plus 45 degree angles back to the curb at both ends. The remaining travel lane should be a minimum of 10 feet wide. Warning signs should be placed 150' in advance of the device; adjust for local conditions, see Warning signs section. Chokers can be used at intersections to create gateways.

Disadvantages
Can be hazardous if not designed and maintained properly.
Initial driver confusion.
Confrontation between on-coming uncivil drivers could create problems.
TRAFFIC CALMING DEVICES

Slowing Devices: Mid-Block

Speed Hump

A Speed Hump is a gentle rise in the roadway that is easily negotiated at slow speeds, but uncomfortable to driver and passengers above design speeds. The Institute of Transportation Engineers recommends that speed humps have a maximum height of 3 inches to 4 inches with a travel length of about 12 feet. Most drivers will slow to 15 mph at the hump and 20 mph to 25 mph between properly spaced humps in a system. They should be used only on local two-lane residential streets with less than 3,000 vehicles per day, with a speed limit of 30 mph. Requires warning signage in approach, see section of Warning Signs and adjust for local conditions. Humps may be coordinated with special paving for pedestrian crossings.

Disadvantages

May increase speed of an occasional thrill seeker.
May divert traffic to other streets.
May impede snow plowing.
May be of concern for emergency vehicles.
May be considered a recurrent nuisance for residents.

Advantages

Reduces speeds.
Reduces volumes.
Some reduction in accidents.
Discourages truck traffic.
Relatively inexpensive to install.

TRAFFIC CALMING DEVICES

Slowing Devices: Mid-Block

Speed Bump
A speed bump is an abrupt rise in the roadway more commonly used in parking lots and private roadways. They are generally not recommended for public roadways. They are generally from 3 inches to 6 inches in height with a length of 1 foot to 3 feet. A speed bump causes significant discomfort at 20 mph and generally results in vehicles slowing to 5 mph. They can cause damage and loss of control of vehicles, particularly those with near-rigid suspensions such as bicycles and motorcycles.

Advantages
Significantly reduces speeds.
Significantly reduces volumes.
Relatively inexpensive to install.

Disadvantages
Can be dangerous, can cause damage to cars, possible liability.
May increase speed of an occasional thrill seeker.
May divert traffic to other streets.
May increase road noise.
May impede snow plowing.
May be of concern for emergency vehicles.

The difference between a speed bump and a speed hump from ITE Journal May 1993, p. 12.
Mid-Block Pedestrian Crossing

Mid-Block Crossings may be warranted on local roads in residential areas where there are pedestrian traffic generators such as markets, schools or parks along the street. There are three types of mid-block crossings: 1) pedestrian refuges can be a raised median allowing pedestrians to cross only one direction of traffic at a time, 2) pedestrian crossings can be created by a mid-block neck down or choker reducing the crossing distance, 3) signalized crossings may be desirable if current warrants set in the MUTCD Section 4C are met. These warrants are too lengthy for inclusion here. See also MUTCD 4B-29, Pedestrian Detectors, 4D 1 through 7, and to 3B-18 for general guidelines for signalization.

Advantages
Pedestrian safe crossing.
Reduces speeds.
May create space for landscaping.

Disadvantages
Can create false sense of safety, if not signalized.
If not many pedestrians, drivers tend to ignore, creating a dangerous crossing.

Textured Paving

Rough surfaces can be accomplished by scarifying existing pavement, applying a rough gravel skim coat, adding rumble strips, or a change of paving to cobbles, bricks, or pavers. Rough roadway surfaces can be implemented with other traffic calming devices, particularly when used to alert drivers to the presence of pedestrians. A pavement change can occur mid-block with other pedestrian crossing devices, over entire intersections creating a plaza effect, just on crosswalks at intersections, or over the length of a roadbed as seen in many historic districts.

Advantages
Reduces speeds.
Can be beautiful.

Disadvantages
Can be slippery, icy, or heave if installed poorly or poor choice of materials.
Can be costly.
Can be noisy.
TRAFFIC CALMING DEVICES

Slowling Devices: Road Length

**Medians and Islands**

Medians and islands can be used to channelize traffic, provide refuge for pedestrians, reduce the crossing distance, and improve the streetscape. Medians should be at a minimum 6 feet wide. Extend median noses to the extension of the intersecting curb line. Medians and islands are most suited to roads with minimal curb cuts, excess roadway width or underused parking lane. They are often not suited for residential streets with driveways. Medians and islands should have warning signs in advance and object markers on the device. Object markers are an 18" yellow reflector diamond panel with 9 yellow 3" reflectors. The marker is mounted 4' above the road surface, at both ends of the median.

**Disadvantages**

Reduces accessibility to driveways.
May be costly to install.
May impede snow plowing.
Need to be aware of drainage and utilities.

**Narrow Streets**

Narrow traffic lanes of 9 1/2, feet at a minimum, encourage slower driving speeds, and reduce pedestrian crossing distances. Pedestrian accident risks increase as the road becomes wider since the time of exposure is increased. Roadways can also be "visually narrowed" by planting trees two to four feet from the curb edge and encouraging a minimal building set-back. The AASHTO Greenbook p. 436, states "street lanes for moving traffic preferably should be at least 10 ft. wide...where available or attainable width of right-of-way imposes severe limitations, 9 ft. lanes can be used in residential areas...".

**Advantages**

Reduces speeds.
Increases pedestrian safety by reducing crossing distance.

**Disadvantages**

Expensive to retrofit existing streets.
May impede emergency vehicular access.
Advantages
Increases pedestrian safety by alerting drivers and directing pedestrians.

Disadvantages
None apparent.

Signalized Intersections with Pedestrian Crosswalks
Crosswalks should be provided for each leg of a signalized intersection. A pedestrian signal with push buttons should be installed at a standard position at the end of each crosswalk leg. The crosswalks should be as near as possible to the intersection zones parallel to the intersecting roadway and a minimum of 2 feet from the projected curb line to the crosswalk line. Textured or raised crosswalks provide an audible and visual contrast, clarifying pedestrian zones. All crosswalks should be illuminated. Eight percent ramps should be installed at all crosswalks, one for each crosswalk leg end. Avoid locating ramps at the apex of the radius, pointing to the center of the intersection. Warrants for signalized crossings listed in MUTCD Section 4C are too lengthy for inclusion here. See also MUTCD Section 3B-18 Crosswalks and Crosswalk lines and 4D Pedestrian Signals.

MUTCD 3B-18 Crosswalks and Crosswalk Lines
Crosswalk markings at signalized intersections and across intersectional approaches on which traffic stops, serve primarily to guide pedestrians in the proper paths. Crosswalk markings across roadways on which traffic is not controlled by traffic signals or STOP signs, must also serve to warn the motorist of a pedestrian crossing point. At non-intersectional locations, these markings legally establish the crosswalk.

Crosswalk lines shall be solid white lines, marking both edges of the crosswalk. They shall be not less than 6 inches in width and should not be spaced less than 6 feet apart. Under special circumstances where a stop line is not provided or where vehicular speeds exceed 35 MPH or where crosswalks are unexpected, it may be desirable to increase the width of the crosswalk line up to 24” in width. Crosswalk lines on both sides of the crosswalks should extend across the full width of pavement to discourage diagonal walking between crosswalks.
MUTCD 3B-18 Crosswalks and Crosswalk Lines - CONTINUED

Crosswalks should be marked at all intersections where there is substantial conflict between vehicle and pedestrian movements. Marked crosswalks should also be provided at other appropriate points of pedestrian concentration, such as at loading islands, midblock pedestrian crossing, or where pedestrians could not otherwise recognize the proper place to cross.

Crosswalk markings should not be used indiscriminately. An engineering study should be required before they are installed at locations away from traffic signals or STOP signs.

Since non-intersectional pedestrian crossings are generally unexpected by the motorist, warning signs should be installed and adequate visibility provided by parking prohibitions.

For added visibility, the area of the crosswalk may be marked with white diagonal lines at a 45° angle or with white longitudinal lines at a 90° angle to the line of the crosswalk. These lines should be approximately 12" to 24" wide and spaced 12" to 24" apart. When diagonal or longitudinal lines are used to mark a crosswalk, the transverse crosswalk lines may be omitted. This type of marking is intended for use at locations where substantial numbers of pedestrians cross without any other traffic control device, at locations where physical conditions are such that added visibility of the crosswalk is desired or at places where a pedestrian crosswalk might not be expected. Care should be taken to insure that crosswalks with diagonal or longitudinal lines used at some locations do not weaken or detract from other crosswalks (where special emphasis markings are not used). When an exclusive pedestrian phase signal, which permits diagonal crossing, is installed at an intersection, a unique marking may be used for the crosswalk.
TRAFFIC CALMING DEVICES
Operational Controls: Intersections

Signalized Intersections with Pedestrian Crosswalks from MUTCD figures 3-14 and 3-15.

a - Standard crosswalk marking.

b - Crosswalk marking with diagonal lines for added visibility.

c - Crosswalk marking with longitudinal lines for added visibility.

NOTE: See Sec. 3B-15 for line dimensions

a - Crosswalk marking that outlines pedestrian travel paths.

b - Crosswalk marking that outlines the edge of pedestrian travel area.

Typical Crosswalk Markings

Typical Crosswalk Marking for Exclusive Pedestrian Phase
Traffic Calming Devices
Operational Controls: Intersections

Stop Signs
Stop signs are a traditional and much used traffic control device with some success. Overuse of stop signs in locations where a full stop is not warranted has led to lack of respect, encouraging rolling through. Without enforcement many drivers continue to run stop signs and safety problems may not be resolved. MUTCD Section 2B-5 Warrants for Stop Signs and Section 2B-6 Multiway Stop Signs are listed below.

Advantages
- Diverts cut-through traffic that want to avoid stop signs.
- Reduces speeds within 150'-200' of approaches to signs.
- Relatively inexpensive.

Disadvantages
- Increase in vehicular noise, especially where trucks are present.
- Lessens respect for stop signs if there is not enough traffic to warrant stopping.
- Impacts other streets by diverting traffic.

MUTCD 2B-5 Warrants for Stop Signs

Because the STOP sign causes a substantial inconvenience to motorists, it should be used only where warranted. A STOP sign may be warranted at an intersection where one or more of the following conditions exist:

1. Intersection of a less important road with a main road where application of the normal right-of-way rule is unduly hazardous.

2. Street entering a through highway or street.

3. Unsignalized intersection in a signalized area.

4. Other intersections where a combination of high speed, restricted view, and serious accident record indicates a need for control by the STOP sign.
MUTCD 2B-6 Multiway Stop Signs

The "Multiway Stop" installation is useful as a safety measure at some locations. It should ordinarily be used only where the volume of traffic on the intersecting roads is approximately equal. A traffic control signal is more satisfactory for an intersection with a heavy volume of traffic.

Any of the following conditions may warrant a multiway STOP sign installation:

1. Where traffic signals are warranted and urgently needed, the multiway stop is an interim measure that can be installed quickly to control traffic while arrangements are being made for the signal installation.

2. An accident problem, as indicated by five or more reported accidents of a type susceptible of correction by a multiway stop installation in a 12-month period. Such accidents include right- and left-turn collisions as well as right-angle collisions.

3. Minimum traffic volumes:

   (a) The total vehicular volume entering the intersection from all approaches must average at least 500 vehicles per hour for any 8 hours of an average day, and

   (b) The combined vehicular and pedestrian volume from the minor street or highway must average at least 200 units per hour for the same 8 hours, with an average delay to minor street vehicular traffic of at least 30 seconds per vehicle during the maximum hours, but

   (c) When the 85-percentile approach speed of the major street traffic exceeds 40 miles per hour, the minimum vehicular volume warrant is 70 percent of the above requirements.
Turning Restrictions and No Through Traffic

Limitations on turns for particular days at particular hours such as rush hours can have some positive effect. Enforcement, however, is critical for ongoing obedience.

**Advantages**
- Relatively inexpensive.

**Disadvantages**
- Without enforcement, safety problems may not be resolved.
- Some initial driver confusion.
- Diverts traffic - need to be sure it does not compound other problems.

MUTCD 2B-15 Turn Prohibition Signs (R3-1 to 3)

Turn Prohibition signs should be used to indicate the turns that are prohibited or restricted at a particular intersection.

The standard, and minimum, size of the No Right Turn sign (R3-1), the No Left Turn sign (R3-2), and the NO TURNS sign (R3-3) shall be 24 X 24 inches.

Turn Prohibition signs should be placed where they will be most easily seen by drivers intending to turn. Where No Right Turn signs are needed, at least one should be placed either over the roadway or at a right-hand corner of the intersection. If signals are present, the sign may be installed adjacent to a signal face viewed by motorists in the right lane.

Where No Left Turn signs are needed, at least one should be placed over the roadway or at a left-hand corner of the intersections. If signals are present, the sign may be installed adjacent to a signal face viewed by motorists in the left lane. Where No Turns signs are needed, two signs should be used, one at a location specified for a No Right Turn sign and one at a location specified for a No Left Turn sign. If signals are present, a No Turns sign may be placed adjacent to a signal face viewed by all motorists on that approach.
MUTCD 2B-15 Turn Prohibition Signs (R3-1 to 3) - CONTINUED

If advance signs are used, care should be taken that no alley or public driveway exists between them and the intersection where the turning movement is prohibited. At an intersection where one or more approaches to the intersection are limited to one-way traffic, whether signalized or not, the ONE WAY sign shall be used, and may be supplemented by the Turn Prohibition sign.

When the movement restriction applies during certain periods only, the use of Turn Prohibition signs calls for special treatment. The following alternatives are listed in order of preference:

1. Variable message signs or internally illuminated signs that are lighted and made legible only during the restricted hours, particularly desirable at signalized intersections.

2. Permanently mounted signs incorporating a supplementary legend showing the hours during which the prohibition is applicable.

3. Portable signs off the roadway at each corner of the intersection where required, put in place under police supervision only when applicable and removed at other hours.
Due to its low cost and relative lack of controversy, reducing posted speed limits is one of the most common traffic control strategies. Enforcement is key to the success of speed limits. Some communities, such as Bellevue, Washington, have adopted a neighborhood speed watch program where residents utilize radar and report speeders. All speed zones should have policed "set time" speed limit of 15 mph.

**Advantages**
Relatively inexpensive.

**Disadvantages**
Without enforcement, safety problems may not be resolved.

**MUTCD 2B-10 Speed Limit Sign (R2-1)**

The Speed Limit sign shall display the limit established by law, or by regulation, after an engineering and traffic investigation has been made in accordance with established traffic engineering practices. The speed limits shown shall be in multiples of 5 miles per hour.

In order to determine the proper numerical value for a speed zone on the basis of an engineering and traffic investigation the following factors should be considered:

1. Road surface characteristics, shoulder condition, grade, alignment and sight distance.
2. The 85-percentile speed and pace speed.
3. Roadside development and culture, and roadside friction.
4. Safe speed for curves or hazardous locations within the zone.
5. Parking practices and pedestrian activity.
6. Reported accident experience for a recent 12-month period.
MUTCD 2B-10 Speed Limit Sign (R2-1) - CONTINUED

Two types of speed limit signs may be used: one to designate passenger car speeds including any nighttime information or minimum speed limit that might apply, and the other to show any special speed limits for buses and trucks. No more than three speed limits should be displayed on any one speed limit sign or assembly. Where a special speed limit applies to trucks or other vehicles, the legend TRUCKS 40, or such similar message as is appropriate, shall be shown below the standard message or on a separate plate (R2-2). When used independently, the Truck Speed sign should carry a reference to SPEED or MPH.

Minimum speeds shall be displayed only in combination with the posted speed limit (sec. 2B-12).

Advisory Speed signs are treated under section 2C-35.

The standard Speed Limit sign shall be 24 X 30 inches. On expressways the sign should be at least 36 X 48 inches, with 48 X 60 inches prescribed for use on freeways.
One Way Streets

One way streets can be implemented relatively easily by the installation of standard signs. It may be desirable to combine one way systems with other traffic calming devices such as Roadway Weavings, Speed Humps, Textured Paving, and Neck Downs to force drivers to slow down.

Advantages
- Relatively inexpensive.
- Diverts traffic from one direction.
- Pedestrian safety - can lead to a reduction in pedestrian accidents by almost 20%.

Disadvantages
- Tends to increase speeds and volumes unless other traffic calming techniques are employed.
- Reduction in accessibility to homes and shops.
- Initially confusing to drivers.

MUTCD 2B-29 One Way Sign (R6-1, R6-2)

The ONE WAY sign shall be used when required to indicate streets or roadways upon which vehicular traffic is allowed to travel in one direction only. The sign shall be either (a) a white arrow, right or left, on black horizontal rectangle of a standard, and minimum, size of 36 X 12 inches with the words ONE WAY centered in the arrow (R6-1); or (b) a vertical rectangle of a standard, and minimum, size of 18 X 24 inches with black lettering and a right or left arrow on a white background (R6-2). The vertical design has advantages where lateral space is limited.

One Way signs shall be placed on the near right-hand and the far left-hand corners of the intersection at nonsignalized intersections so as to face traffic entering or crossing the one-way street except that intersections of divided highways with median widths of 30 feet or more may be signed as in Section 2A-31. Where the intersection is signalized, the signs shall be placed either near the appropriate signal faces or at the locations specified for nonsignalized intersections. One Way signs should also be placed parallel to the one-way street directly opposite the exits from alleys and other public ways. A One Way sign should always be used, where applicable, and may be supplemented by a Turn Prohibited sign (sec. 2B-15).
TRAFFIC CALMING DEVICES
Physical Diverters: Intersection

Diagonal Diverters
A street diverter connects diagonal sidewalks at an intersection eliminating through vehicular traffic. The street diverter works best on existing one way streets where only one lane of traffic must squeeze around a tight radius. It is possible to create a two lane squeeze by enlarging the radius of the inside curb. Minimum dimensions are 9 1/2 feet wide travel lanes for each lane or 19' wide roadbed with an inside curb radius of 15 to 20 feet. Access for temporary vehicles will require a 25 foot wide roadbed with an inside radius of 35 feet, OR a 15' clear zone through the diverter with rollover curbs. The diverter should be raised to the level of the curb with a minimum width of 4 feet. Be aware of drainage changes and accommodate. Warning signs are needed in advance of the diverter, see warning sign section and adjust to local conditions. Must be illuminated.

Disadvantages
Reduces accessibility of emergency vehicles and to homes.
Initial driver confusion.
Costly to install.
Need to work with drainage and utilities.
Will move through traffic to other streets if not back to the arterial.

Advantages
Eliminates through traffic.
Increases pedestrian safety.
Reduces speeds within 150'-200'.
Provides area for landscaping.

TRAFFIC CALMING DEVICES
Physical Diverters: Intersection

Street Closing
A local street can be closed at one end. The turning area should have a radius appropriate to the types of vehicles expected. Minimum outside radii of 30 feet in residential areas and 45 feet in commercial areas are typically used. Travel lane should be 18' minimum. A planting island with mountable curbs can be included.

Disadvantages
Reduces accessibility of emergency vehicles and to homes, conflicts with public accessibility.
Difficult for snow plowing.
May transfer traffic to another street, benefiting some residents at the expense of others.

Advantages
Eliminates cut-through traffic.
Reduces speeds of remaining traffic.
Provides spaces for landscaping.

MUTCD 2C-37 Dead End Signs (W14-1, W14-2)
The DEAD END sign (W14-1) and NO OUTLET sign (W14-2) are intended for use to warn of a street or road which has no outlet and which terminates in a dead end or cul-de-sac. The DEAD END plaque (W14-1P) and NO OUTLET plaque (W14-2P) may be used in combination with the Street Name (D3) sign at intersections in lieu of or in addition to the W14-1 or W12-2 signs. The W-141P and W14-2P signs shall not be used in lieu of the W14-1 or W14-2 sign where traffic can proceed straight through the intersection into the dead end street. When the W14-1 or W14-2 sign is used, the sign shall be posted a sufficient advance distance to permit the vehicle operator to avoid the dead end by turning off, if possible, at the nearest intersecting street. When signs or plaques are used the number, type and location should be determined by an engineering study.
Figure V-2. Types of cul-de-sacs and dead-end streets.
Dutch "Woonerf" (Living Street)
Several European, Japanese, and Australian communities have utilized the "Woonerf" concept to transfer through streets to make the whole street space usable by pedestrians. The intended driver speed is only 12 to 14 mph. A number of traffic calming devices are combined to slow the driver. Entrances are clearly defined; sidewalks are extended to the whole street usually with bricks or pavers; there is no straight stretch longer than 60 meters before a clear change in directions; corners are rectangular rather than curved; parking is preferred at right angles; landscaping and street furniture is used extensively. There are elements of the Woonerf which can be adopted to U.S. cities, however, the current use and volume of vehicles per household in the U.S. restricts the extent.

Advantages
- Reduces speeds dramatically.
- Eliminates cut-through.
- Increases pedestrian safety.
- Provides extensive space for landscaping and outdoor activities.

Disadvantages
- Very high costs to retrofit, unless part of the original design.
- Must be done as a system to avoid diverting traffic to other non-arterials.
- Reduces accessibility of emergency vehicles and snow plowing.
- May reduce number of parking spaces.
MUTCD 2C-1 Application of Warning Signs

Warning signs are used when it is deemed necessary to warn traffic of existing or potentially hazardous conditions on or adjacent to a highway or street. Warning signs require caution on the part of the vehicle operator and may call for reduction of speed or a maneuver in the interest of his own safety and that of other vehicle operators and pedestrians. Adequate warnings are of great assistance to the vehicle operator and are valuable in safe-guarding and expediting traffic. The use of warning signs should be kept to a minimum because the unnecessary use of them to warn of conditions which are apparent tends to breed disrespect for all signs.

Even on the most modern expressways there may be some conditions to which the driver can be alerted by means of warning signs. These conditions are in varying degrees common to all highways, and existing standards for warning signs are generally applicable to expressways.

Typical locations and hazards that may warrant the use of warning signs are:

1. Changes in horizontal alignment
2. Intersections
3. Advance warning of control devices
4. Converging traffic lanes
5. Narrow roadways
6. Changes in highway design
7. Grades
8. Roadway surface conditions
9. Railroad crossings
10. Entrances and crossings
11. Miscellaneous

Warning signs specified herein cover most conditions that are likely to be met. Special warning signs for highway construction and maintenance operations, school areas, railroad grade crossings and bicycle facilities are dealt with in Parts VI through IX in the MUTCD. If other warnings are needed, the signs shall be of standard shape and color for warning signs, and the legends shall be brief and easily understood.

The determination of the sign or signs to be erected shall be on the basis of an engineering study using the following sections as guidelines.

MUTCD 2C-2 Design of Warning Signs

Generally, all warning signs in this Part shall be diamond-shaped (square with one diagonal vertical) with black legend and border on a yellow background. There are specific exceptions
MUTCD 2C-2  Design of Warning Signs - CONTINUED

to this rule, some of which are noted in the following sections. The allowance of these exceptions shall not be construed as permitting deviations from the standard messages where standard messages are applicable.

All warning signs having significance during the hours of darkness shall have a fully reflectorized background or be illuminated.

The standard size for each warning sign prescribed herein is shown with the illustration accompanying the specification. Where conditions of speed, volume, or special hazard require greater visibility or emphasis, larger signs should be used, with symbol or legend enlarged approximately in proportion to outside dimensions. Sign sizes for various type facilities can be found in Standard Highway Signs.*

To carry proper emphasis among large signs for other purposes, all warning signs on expressways should be not less than 36 X 36 inches.

To permit the use of standard dies and templates the outside dimensions of warning sign should ordinarily be in multiples of 6 inches. Letter heights should be rounded to the nearest inch that will best fit the plate used for legibility and appearance.

MUTCD 2C-3  Placement of Warning Signs

Warning signs shall be erected in accordance with the general requirements for sign position as described in Section 2A-21 to 29 of the MUTCD.

Since warning signs are primarily for the benefit of the driver who is unacquainted with the road, it is very important that care be given to the placement of such signs. Warning should provide adequate time for the driver to perceive, identify, decide, and perform any necessary maneuver. This total time to perceive and complete a reaction to a sign is the sum of the times necessary for Perception, Identification, Identification/understanding, Emotion/decisionmaking, and Volition/execution of decision, and is here referred to as the PIEV time. The PIEV time can vary from about 3 seconds for general warning signs to 10 seconds for high driver judgment condition warning signs. The following Table lists suggested minimum sign placement distances that may be used for three conditions:

* Available from GPO
### TABLE II-1—A Guide For Advance Warning Sign Placement Distance

<table>
<thead>
<tr>
<th>Posted or 85 percentile speed MPH</th>
<th>Condition A high judgment needed ¹ (10 sec. PIEV)</th>
<th>Condition B—Stop condition</th>
<th>Condition C—Deceleration condition to listed advisory speed—MPH (or desired speed at condition)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>10 20 30 40 50</td>
<td></td>
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<tr>
<td>20</td>
<td>175</td>
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<tr>
<td>25</td>
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<tr>
<td>65</td>
<td>850</td>
<td>650</td>
<td>650</td>
</tr>
</tbody>
</table>

1. Distances shown are for level roadways. Corrections should be made for grades. If 48-inch signs are used, the legibility distance may be increased to 300 feet. This would allow reducing the above distance by 75 feet.

2. In urban areas, a supplementary plate underneath the warning sign should be used specifying the distance to the condition if there is an in-between intersection which might confuse the motorist.

3. Distance provides for 3-second PIEV, 125 feet Sign Legibility Distance, Braking Distance for Condition B and Comfortable Braking Distance for condition C as indicated in *A Policy on Geometric Design of Highways and Streets*, 1984, AASHTO, Figure II-13.

4. No suggested minimum distance provided. At these speeds, sign location depends on physical conditions at site.

5. Feet

Condition A—A higher driver judgment condition which requires the driver to use extra time in making and executing a decision because of a complex driving situation; i.e., land changing, passing, or merging. Condition B—a condition in which the driver will likely be required to decelerate to a specific speed. The table is provided as an aid for determining warning sign location. The values contained in the table are for guidance purposes and should be applied with engineering judgment. The placement of temporary warning signs used at highway construction and maintenance sites is covered in Part VI of the MUTCD and the suggested minimum sign placement distances given in the Table above may not apply to that group of signs.

Other miscellaneous warning signs that advise of potential hazards not related to a specific location may be installed in the most appropriate locations since they are not covered in the Table above. These include DEER CROSSING and SOFT SHOULDER signs. Minimum spacing between warning signs with different messages normally should be based on the PIEV times for driver comprehension and reaction.

The effectiveness of the placement of any warning sign should be tested periodically under both day and night conditions.
Traffic Calming on Arterial Roads

Traffic Calming is usually focused on local neighborhood streets. However, many of the heavily traveled streets in Burlington are residential. These streets are intended to move vehicular traffic smoothly, however pedestrians still need to cross safely and drivers need to be encouraged to travel at the designated speeds. Michael Wallwork, an advocate and lecturer on traffic calming, suggests that some elements of traffic calming can be utilized to accomplish speed control and pedestrian safety. Narrow lanes with raised medians and islands, and neck-downs at intersections and mid-block help reduce pedestrian crossing distances. Small radii at intersections and channelization of traffic help reduce speeds and crossing distances. Trees planted near the road edge and in the medians help beautify the streetscape and visually narrow the street which encourages slower speeds.

The pedestrian should be encouraged and accommodated along arterial routes. Sidewalks should be located on both sides of the street with a planting strip between it and the curb. Audible-tactile pedestrian push buttons should become standard to accommodate the visually impaired. Each arterial is unique with its existing and proposed land use, zoning, traffic volumes and neighboring streets. Judgments are needed on which devices would be appropriate, based upon the physical and traffic conditions.
RECOMMENDATIONS

1. Establish a division of the Department of Public Works to concentrate on Neighborhood Traffic Calming.

2. Review, revise as necessary, and adopt the Traffic Calming Planning Process outlined in this report.

3. Review, revise as necessary, and adopt the Warrants for Neighborhood Traffic Calming outlined in this report.

4. Review, revise as necessary, and adopt the Traffic Calming Device descriptions as outlined in this report.

5. Solicit written observations, complaints, and petitions on traffic issues from community members and others to identify problem neighborhoods.

6. Follow through with prioritization of neighborhoods for Traffic Calming, reserving the first position for the Ward Street neighborhood, respecting their participation in the Traffic Calming Pilot Study.

7. Begin a long-term commitment to Traffic Calming, installing permanent devices when warranted, and approved by 60% or more of the neighborhood residents, businesses, landlords, and land owners.
REFERENCES

American Association of State Highway and Transportation Officials, A Policy on Geometric Design of Highways and Streets, 1990. (Commonly known as the "Greenbook").


Florida Department of Transportation, “Pedestrian Planning and Design Training Manual, Draft for Pilot Training Course”


Seattle Engineering Department, “Neighborhood Traffic Control Program”


Wallwork, Michael, P. E., “Traffic Calming”

Yamaoka, Yoshinori, et. al., Editors, The Wheel Extended, The Toyota Quarterly Review, Number 73.