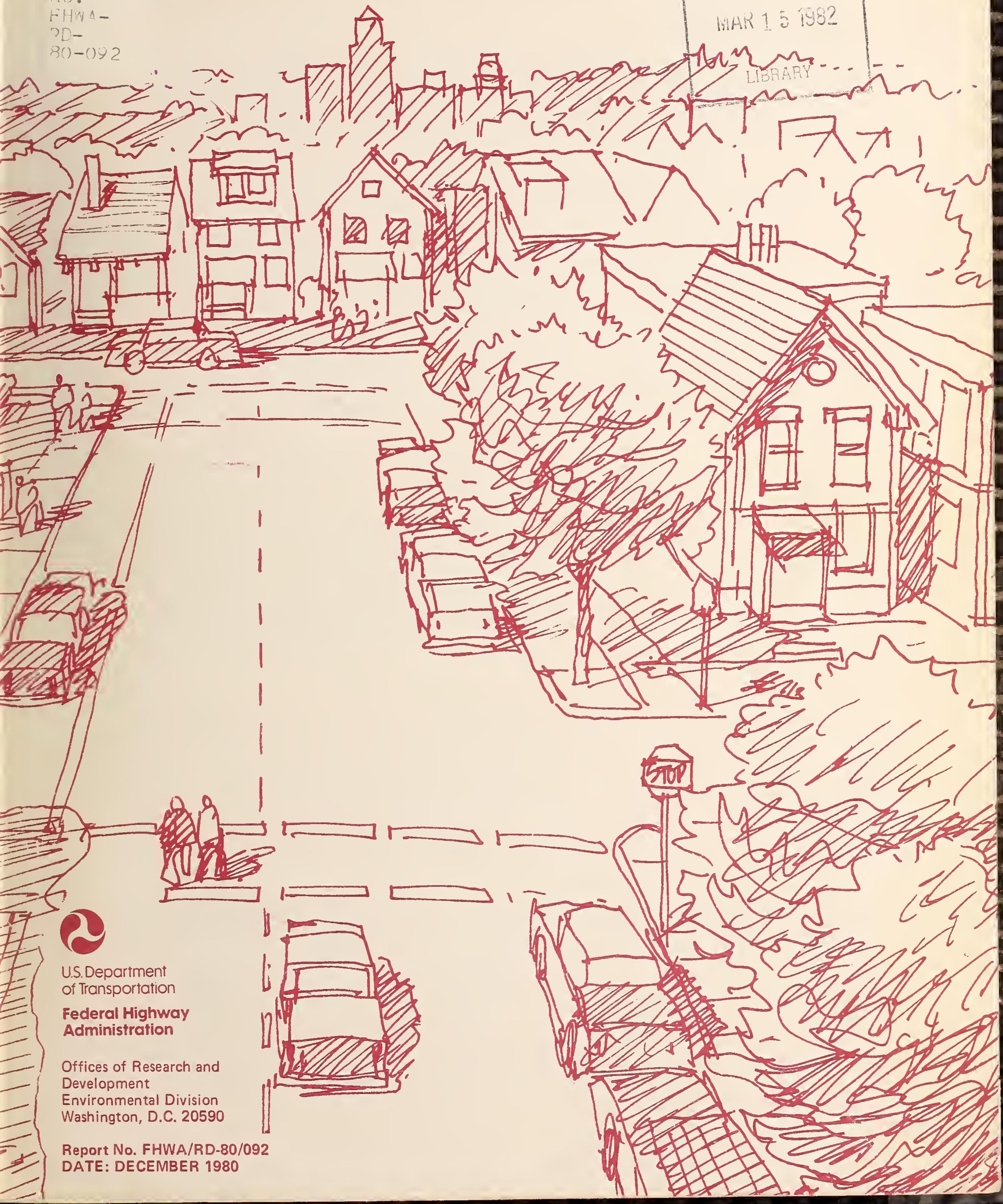
S of the Art Report:
ential Traffic Management



U.S. Department
of Transportation

**Federal Highway
Administration**

Offices of Research and
Development
Environmental Division
Washington, D.C. 20590

Report No. FHWA/RD-80/092
DATE: DECEMBER 1980

FOREWORD

This report assesses the performance of various traffic control devices which affect traffic on existing residential streets (as opposed to initial design features of new subdivisions). Detailed techniques for developing neighborhood traffic control plans including community involvement and technical evaluation elements are given.

This study was conducted in response to a research problem statement submitted by the City of Santa Ana, California. Research in traffic control devices is included in the Federally Coordinated Program of Highway Research and Development as Task 1 of Project 1A, "Traffic Engineering Improvements for Safety." Mr. H. Douglas Robertson is the Project Manager and Mr. John C. Fegan, Contract Manager.

Sufficient copies of the report are being distributed to provide a minimum of one copy to each FHWA regional office, division office and State highway agency. Direct distribution is being made to the division offices.

Charles F. Scheffey
Charles F. Scheffey
Director of Research
Federal Highway Administration

NOTICE

Technical Report Documentation Page

1. Report No. FHWA/RD-80/092	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle ✓ STATE OF THE ART: RESIDENTIAL TRAFFIC MANAGEMENT		5. Report Date December 1980 6. Performing Organization Code
7. Author(s) Daniel T. Smith, Jr. Donald Appleyard et.al		8. Performing Organization Report No.
9. Performing Organization Name and Address De Leuw, Cather & Company Post Office Box 7991, San Francisco, CA 94120 w/ DKS Associates, 405 - 14th St., #610, Oakland, CA 94612 Berkeley Planning Associates, Berkeley, CA		10. Work Unit No. (TRAIS) FCP 31A1724 11. Contract or Grant No. DOT-FH-11-9309
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Highway Administration Office of Research HRS-41 Washington, D.C. 20590		13. Type of Report and Period Covered State of the Art 14. Sponsoring Agency Code
15. Supplementary Notes FHWA Contract Manager: Martha Schwendeman and John Fegan Graphics: Jack Sidener		

16. Abstract

The research program "Improving The Residential Street Environment" deals with control and restraint or management of traffic on local residential streets. This State of The Art report covers current practices in this field through 1978. The report assesses the performance of various control devices to affect traffic on existing residential streets (as opposed to initial design features of new Subdivisions). Included are diagonal diverters, half-diverters, cul-de-sacs, median barriers, speed bumps and undulations, stop signs, rumble strips and many other measures. The report also details techniques for developing neighborhood traffic control plans including community involvement and technical evaluation elements.

17. Key Words Traffic restraint Traffic management Residential traffic control		18. Distribution Statement No Restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 181	22. Price

Form DOT F 1700.7 (8-72)

Reproduction of completed page authorized

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

Contents

1 **Introduction** 1
Neighborhood Traffic Management — A Definition 1
Historical Perspective 3
Purpose of This Study 4
About This Report 4
What Is to Follow 5
Organization of the State-of-the-Art Report 5

2 **Overview of neighborhood traffic management** 7
The Residential Street 7
The Problem 10
Causes of the Problem 11
Goals of Street Improvement and Traffic Management 14
Neighborhood Traffic Management 15
The Need for an Organized Planning Process and Community Involvement 19
Summary — A Note on the State-of-the-Art 20

3 **Neighborhood traffic control devices and systems** 21
Positive Physical Controls 24
Speed Bumps and Undulations 25
Rumble Strips 28
Diagonal Diverters 30
Intersection Cul-de-Sac 35
Midblock Cul-de-Sac 41
Semi-Diverter 41
Forced Turn Channelization 45
Median Barrier 49
Traffic Circle 53
Chokers 56
Other Positive Physical Controls 59
Passive Controls 62
Stop Signs 63
Speed Limit Signs 65
Turn Prohibition Signs 68
One Way Streets 70
Other Passive Controls 73
Controls Dealing wtih Driver Perception and Psychology 75
Lateral Bars 75

Crosswalks 76
Safety Board 77
Odd Speed Limit Signs 77
Other Signs 77
Speed Actuated Flashing Warning 78
System Considerations 79

4 Planning for neighborhood traffic management 85
Introduction 85
Community Involvement 92
Problem Identification and Needs Analysis 92
Generating Alternative Plans 107
Plan Selection 112
Implementing Decisions 121
Evaluating the Control Plan's Performance 125
Modification and Recycling the Process 129

5 Planning and design aspects common to all neighborhood management devices 131
Effects of Physical Barrier Devices on Emergency Service Vehicles 131
  Fire 131
  Police 135
  Ambulance Services and Private Emergency Travel 136
  Refuse Collection and Deliveries 136
  Transit 136
  Maintenance 136
Violations of Traffic Barrier Devices 136
Legal Considerations 138

References 143

Appendices

Appendix A — Citizen Participation Resources and Techniques 147
Appendix B — Selected References on Community Participation Techniques 151
Appendix C — Traffic Operational Measurements for Neighborhood Protection 153
Appendix D — Organization of Needed Technical Data 163
Appendix E — Matrix of Cities and Devices 169

Figures

1. Typical Neighborhood with Traffic Related Problems 11
2. Solutions to Typical Neighborhood Traffic Problems 16
3. Glossary of Neighborhood Traffic Management Devices 17
4. Speed Bump 25
5. British Speed Undulation 26
6. Rumble strip Installations 29
7. Typical Rumble Strip Design 29
8. Temporary Diagonal Diverter — Berkeley, Ca. 31
9. Temporary Diagonal Diverter — Berkeley, Ca. 32
10. Typical Undercarriage Barrier 32
11. Temporary Diagonal Diverter — Berkeley, Ca. 33
12. Temporary Diagonal Diverter — Victoria, B.C. 33
13. Diagonal Diverter — Menlo Park, Ca. 33
14. Diagonal Diverter — Berkeley, Ca. 33
15. Landscaped Diagonal Diverter — Portland, Or. 34
16. Landscaped Diagonal Diverter — Oakland, Ca. 34
17. Landscaped Diagonal Diverter — Richmond, Ca. 34
17a. Diagonal Diverter, Minneapolis, Minn. 34
18. Alternative Diverter Locations 36
19. Implications of Cul-de-sac Location 37
20. Temporary Cul-de-Sac — Los Angeles, Ca. 38
21. Temporary Cul-de-Sac — Palo Alto, Ca. 38
22. Cul-de-Sac — Walnut Creek, Ca. 38
23. Cul-de-Sac — Berkeley, Ca. 38
24. Cul-de-Sac — Berkeley, Ca. 39
25. Cul-de-Sac — Menlo Park, Ca. 39
26. Permanent Cul-de-Sac — Palo Alto, Ca. 39
26b.Permanent Cul-de-Sac — Hartford, Ct. 39
27. Permanent Cul-de-Sac — Palo Alto, Ca. 40
28. Landscaped Cul-de-Sac — Palo Alto, Ca. 40
29. Landscaped Cul-de-Sac — Palo Alto, Ca. 40
30. Midblock Cul-de-Sac 41
31. Landscaped Midblock Cul-de-Sac — Richmond, Ca. 43
32. Midblock Cul-de-Sac with Park — Palo Alto, Ca. 43
33. Permanent Midblock Cul-de-Sac — Berkeley, Ca. 43
34. Semi-Diverter — Pleasant Hill, Ca. 43
35. Semi-Diverter — San Mateo, Ca. 44
36. Semi-Diverter — Walnut Creek, Ca. 44
37. Semi-Diverter Treatment — Walnut Creek, Ca. 44
38. Semi-Diverter — Berkeley, Ca. 44
39. "Star" Diverter 46
40. Partial Diagonal Diverter 46
41. Forced Turn Channelization — Seattle, Wa. 47

42. Channelization to Limit Certain Movements 47
43. Forced Turn Channelization — Richmond, Ca. 47
44. Forced Turn Channelization — Berkeley, Ca. 48
45. Advance Notice of Closed Street — Berkeley, Ca. 48
46. Forced Turn Channelization — San Francisco, Ca. 48
47. Median Barrier — Albany, Ca. 51
48. Median Barrier — Redwood City, Ca. 51
49. Median Barrier — Los Angeles, Ca. 51
50. Median Barrier — Concord, Ca. 52
51. Median Barrier — Concord, Ca. 52
52. Temporary Traffic Circle — Seattle, Wa. 54
53. Temporary Traffic Circle — Berkeley, Ca. 54
54. Temporary Traffic Circle — Berkeley, Ca. 54
55. Temporary Traffic Circle — Berkeley, Ca. 55
56. Permanent Traffic Circle — Seattle, Wa. 55
57. Midblock Traffic Circle — Del Mar, Ca. 55
58. Permanent Traffic Circle — Berkeley, Ca. 55
59. Choker — Berkeley, Ca. 57
60. Choker Design on One Side of a Roadway 57
61. Choker for Speed Reduction — Cupertino, Ca. 57
62. Choker with Angle Parking — San Francisco, Ca. 57
63. Choker — Oakland, Ca. 58
64. Midblock Choker — Lafayette, Ca. 58
65. Typical Island Choker 58
66. Woonerf — Holland 60
67. One-Lane Street Concept 60
68. Central Valley Gutter — Del Mar, Ca. 61
69. Transverse Valley Gutter — Redwood City, Ca. 61
70. Speed and Accelleration Profile for Street before and after Stop Sign Installation 64
71. Turn Prohibition Signs, Peak Hour — Berkeley, Ca. 69
72. One-Way Control Systems 71
73. Typical Channelization for Residential Intersections with Opposing One-Way Movements 72
74. Typical Lateral Striping to Give Impression of Increasing Speed 77
75. Odd Speed Limit Sign — Saratoga, Ca. 77
76. Odd Speed Warning Sign — Saratoga, Ca. 77
77. Attention Getting Warning Sign — Concord, Ca. 78
78. Attention Getting Sign — Walnut Creek, Ca. 78
79. Yield Sign with Supplemental Message — Skokie, Il. 78
80. Peripheral Barrier — Dominant Direction 79
81. Peripheral Barrier — Multi-Direction 79
82. Return Loops 80
83. Anti-Through System — Dominant Direction 80
84. Maze 81
84b. Maze System with Internal Special Generator - Hospital 81
85. Internal Obstruction 82
86. Non-Grid Systems 83

87. Citizen Participation in the Transportation Planning Process 90
88. Description of Participation Techniques Classified by Function 91
89. San Francisco. A Newssheet, **Traffic in the Neighborhoods** 97
90. An Innovative Approach to Soliciting Community Input 98
91. Madrona Neighborhood Questionnaire, Seattle 99
92. Resident Defined Traffic Hazard on Three Streets, San Francisco 103
93. Resident Perceived Noise, Stress and Pollution on Three Streets in San Francisco 105
94. Area Oriented or "Top-Down" Planning Strategy 108
95. Problem Oriented or "Bottom-Up" Planning Strategy 109
96. Example of Arraying Planning Data in Overlays 110
97. Community Meeting for Plan Selection 116
98. Effective Announcement Form For Community Meeting, Seattle, Wa. 117
99. Survey to Determine Resident Preferences Among Proposed Alternatives, Vancouver, B.C. 119
100. Flyer Distributed to Businesses and Residences, Seattle, Wa. 124
101. Survey to Determine if Temporary Devices Should Be Made Permanent, Seattle, Wa. 127
102. Survey to Determine Resident Reaction to Expansion of NTM Program, Vancouver, B.C. 128

Tables

1. Neighborhood Traffic Control Device Characteristics 22
2. Traffic Reduction Due to Use of Speed Undulations in Great Britain 26
3. Traffic Changes on Streets wtih Diagonal Diverters in Seattle, Wash. 31
4. Vehicle Speeds for Various Traffic Circles in Sacramento, Ca. 54
5. Speed Limits on Two Lane Streets in Selected United States Cities 67
6. Urban School Zone Speed Limits 67
7. Community Involvement Purpose by Program Stage 89
8. Techniques and Measures of Assessment and Evaluation 95
9. Street Classification 96
10. Technical Measurements for Neighborhood Traffic Management 154
11. Accident Comparison — West Berkeley Neighborhood Area 159
12. Accident Comparison — LeConte Neighborhood Area 159
13. Typical Construction Costs for Neighborhood Protection Devices (1976 Costs) 160
14. Summary of Cities and Devices Reviewed in State of the Art Search 160

Acknowledgments

The contributions of the many individuals who have aided in the preparation of this report are gratefully acknowledged.

Particular recognition is due officials in State and local jurisdictions who have taken the time to share with us their experiences in and insights to residential traffic management by aiding our research on site inspections, and by providing us with reports, data and photographs relating to traffic control in neighborhoods. Without their help this report would not have been possible.

We also wish to acknowledge the Technical Committees of the San Francisco Bay Area and Los Angeles sections of the Institute of Transportation Engineers for compilations of data on residential traffic control projects in their regions. Special thanks is extended to Los Angeles Committee Chairman Chuck Eccleston who graciously made available his full personal files on the subject matter.

Thanks are also due Terrence Bendixson and Christian Averous of the Organization for Economic Cooperation and Development (OECD) who provided advice on traffic restraint measures in the OECD countries and to the Transportation and Road Research Laboratory in the United Kingdom which shared its latest findings on the subject matter.

Preface

This "State-of-the-Art" report has been prepared for the urban traffic engineer or planner and all those concerned with control of traffic in neighborhoods. Traffic in neighborhoods has been a longstanding concern to the public but a concern to which professionals over the years have been unsympathetic or unprepared to respond. However, in recent times attempts at restraining traffic and its adverse impacts in neighborhoods have proliferated. Some schemes have had noteworthy success; others, though operationally successful, have generated opposition and controversy; others yet have not operated satisfactorily.

For the professionals, these efforts involve significant departures from customary practices — new applications of conventional traffic control devices, use of entirely new types of control devices, and changes in philosophy relative to the role of streets and of the professional in "managing" rather than necessarily "facilitating" traffic. Naturally, when a new element of professional practice evolves from isolated and independent efforts, communications of results from innovators to other practitioners lags. This report is intended to bridge the communication gap, to provide up-to-date information on the details of control devices used in neighborhood traffic management and on the techniques for planning neighborhood traffic control schemes.

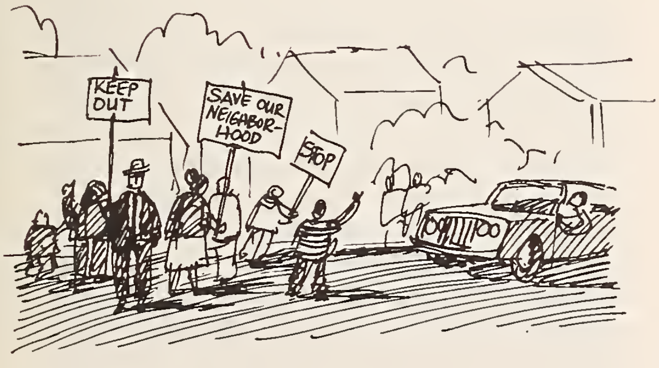
In introducing readers to the findings of our research, the authors wish to affirm our commitment to the objectives of traffic management in residential areas. Sections of this report may seem to belie this. The facts are that traffic management is inherently controversial and numerous traffic management attempts have failed because of inappropriate control devices or breakdowns in the process of planning for them. We have called attention to these conditions at several points in the report. We have not done this to discourage further traffic management programs; we have done so to prepare professionals and the community involved for controversy, and to aid users in coping with problems and pitfalls previously experienced by others.

Residential traffic management is a still rapidly evolving area of professional practice. This report explores the range of current practices; it does not necessarily define the limitations of good practice. Further experimentation and innovation is needed. Do not be afraid to try new measures which seem to be more reasonable and effective solutions to your problems than the devices covered herein.

1

Introduction

In recent years there has been a surge of interest on the part of local jurisdictions and their citizens in halting the progressive erosion of residential environmental quality caused by ever-increasing street traffic. This interest has resulted in some major as well as many smaller experiments in diverting and slowing the pace of traffic in residential areas in the United States and elsewhere. Lessons from these experiments abound, although they tend to be scattered, not widely known or documented, and not comprehensively evaluated. As interest continues to grow with more and more communities seeking ways of resolving the opposing goals of providing mobility while enhancing residential livability, effective planning guidance is needed. This study, **Improving The Residential Street Environment**, seeks to provide that guidance.



Neighborhood traffic management — a definition

The title of this research study "Improving the Residential Street Environment" is an extremely broad one, but the study's actual subject matter is more closely focused. The study and this report concern themselves only with existing residential environments, not new developments; and they address only one aspect of that environment, the ways traffic and traffic related characteristics of streets affect the quality of the residential environment. More importantly, the research centers on changing and improving the residential environment through measures which relate directly to traffic.

One category of such measures is called **residential protection.** Protection measures shield residents from the adverse impacts of traffic without attempting to affect traffic itself. Noise buffers, double glazed windows and view screens are examples of protection measures. Normally, such measures are employed where, unfortunately, residences are located on streets intended to carry substantial volumes of traffic, usually at moderate to fairly high speeds. Another category of measures, **amelioration**, compensates residents for tolerating the undesirable impacts of street traffic by providing other amenities or services. As with residential protection, nothing is done to affect traffic itself. The compensation may attempt to overcome adverse traffic impacts directly (e.g., providing parks along a street on which it is unsafe for children to play because of traffic). Or it may simply offset the adverse traffic impact by providing a higher quality of some other totally unrelated facility or service. Amelioration is normally attempted on streets which, though residential uses are present, have a strong traffic circulation role and on which residential protection measures are infeasible. Or amelioration may supplement residential protection measures. Both of these types of measures, while acknowledged herein, are not researched in depth in this study. The primary focus of the study is on a third type of traffic related measure, **neighborhood traffic management.*** Unlike protection and amelioration, neighborhood traffic management attempts to improve the residential environment by directly affecting traffic thereby cutting off undesired impacts at the source. It does this by limiting the amount of traffic on the residential streets usually by restricting accessibility and continuity or by affecting the behavior of drivers. Behavior patterns induced are ones such that those continuing to use the "managed" streets will not generate the adverse effects they might were the streets uncontrolled, and drivers whose driving styles are not amenable to the demands of a residential environment will choose to use other streets. The predominant behavioral control attempted relates to traffic speed.

Neighborhood traffic management devices are normally employed on local residential streets — streets which are predominantly residential in character and which have the sole intended traffic function of providing accessibility to limited numbers of immediately tributary properties. The rationale for neighborhood traffic management lies in the recognition of the breadth and the limitations of a local residential street's functions. Local residential streets are meant to provide accessibility to limited areas directly dependent upon them; not to all travelers who find it convenient to use them. And serving traffic, even the local traffic which "belongs" there, is only a part, not the whole of their purpose. The neighborhood street is a place where children play, where neighbors meet, an extension of the front yard, a feature which affects the appearance of homes along it and the quality of life within them. Neighborhood traffic management is an attempt to control streets so as to meet real accessibility needs yet keep the traffic service function of these streets in perspective with the other considerations noted above.

Historical perspective

The evolution of techniques for managing traffic in residential neighborhoods has followed two separate but related paths. The first involves the design of street systems for newly developing areas; the second, and the main focus of this report, involves the techniques needed to compensate for defects in earlier designs.

By the 1920's adverse impacts of automobiles on the urban grid pattern street system first became noticeable. Although little was done to remedy problems on the grid streets themselves at that time, the typical suburban street pattern, with a network of high capacity arterials surrounding a set of discontinuous, curvilinear streets, evolved in reaction to the impacts of auto intrusion on grid street neighborhoods.

By 1929, Charles Perry had proposed the formation of "neighborhood units" within which schools, local streets and parks would be pro-

---

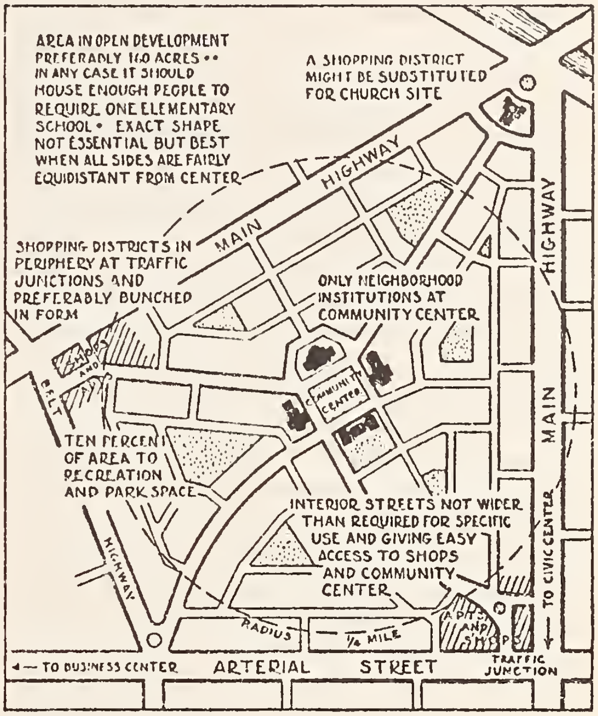
*Synonymous terms in the literature include "residential traffic restraint" and "neighborhood traffic control."

tected from through traffic that was to be confined to the periphery of the unit.[104]* "Children," said Perry, "should never be required to cross a main traffic street on the way to school. If for no other reason, streets of the residential area should rigorously exclude through traffic." Another reason for routing through traffic outside the neighborhood is to set bounds to the district, giving it a "clear identity in people's consciousness."

In the 1930's, subdivisions with long, curving streets were adopted on the grounds of safety, as well as visual relief. Conventional wisdom, expressed most influentially in the **Community Builder's Handbook**, advocated the neighborhood concept with no through traffic and a hierarchy of arterial, collector and minor (access) streets.[105] The minor streets were often cul-de-sacs or loops branching from long, curving collectors which had as few intersections as possible. Cities in general required these streets to be relatively wide, at least 26 feet for minor streets and 36 feet for collectors. Accident research demonstrated that three-way intersections were safer than four-ways and the former were advocated on minor streets.

But despite these concerns for safety, the economic and site constraints, and sometimes the city subdivision regulations did not ensure safety everywhere. The long, wide collectors and arterials encouraged high-speed travel, and as many as half the houses in many subdivisions are to be found on these high speed streets. Their residents have been as vociferous in their complaints about traffic as those in the inner city.

Techniques to deal with traffic problems in already constructed grid systems, as well as the newer subdivisions, have evolved more recently. In the late 1940's and early 1950's, Montclair, New Jersey and Grand Rapids, Michigan installed the first diverters and cul-de-sacs specifically retrofit to protect neighborhoods from through traffic. Other small projects, such as in Richmond, California, followed. At the same time, massive urban renewal projects in cities such as New Haven, Boston, Washington, D.C.



---

*Superscripts indicate bibliographic references alphabetically ordered and located at the conclusion of this report.

and San Francisco allowed cities to create superblocks with pedestrian cores and limited automobile access.

In 1964, the first significant planning guide to specifically address the traffic problem in residential areas was published. Colin Buchanan's **Traffic in Towns** proposed the creation of "environmental areas" in which the pedestrian would be dominant and through traffic excluded. These residential areas were deemed to have an "environmental capacity" which placed limits on the amount of traffic they could absorb. The Buchanan Report has led to residential area traffic limitation plans in several British, Canadian and Australian cities.

In the past decade, numerous isolated attempts aimed purely at traffic management have been made, some meeting with success and others failing. An early history of some of these efforts in Britain and California can be found in Appleyard's **Liveable Urban Streets.**[3] Current interest in the subject can perhaps best suggested by the over 1000 requests for the publication, "Recycling Streets," by Jack Sidener (1976), which presented graphical illustrations of various techniques for neighborhood traffic management.[75]

Purpose of this study

While the public has experienced accelerating sensitivity to problems caused by traffic intrusion in neighborhoods and has become increasingly conscious that they need not continue to accept it — that **something** can be done — there has been little sound guidance to traffic engineers and planners on specific control measures and how they work. Traffic engineering and planning guides for existing streets have traditionally focused upon techniques to increase capacity, and accessibility while maintaining and improving safety. Authoritative guidance on techniques to maintain and improve safety while **limiting** traffic speed, capacity and accessibility has been lacking. Though a substantial number of experiments have been made by local jurisdictions, there has been little effective communication of techniques and results.

Recognizing the void, the Federal Highway Administration has commissioned this study entitled **Improving The Residential Street Environment.** The study has these objectives:

- To identify and evaluate existing information on residential traffic management measures to improve the street environment
- To identify and assess community needs and community acceptability of residential area traffic management techniques
- To develop a manual providing guidelines for professionals and the community in the application of neighborhood traffic management techniques

Beyond these technicalities, the report has a philosophic objective. It is to convince traffic engineers that they have a professional role and responsibility relative to residential streets which is broad, not limited. Dealing with residential streets is a challenging task demanding application of very professional techniques and judgment. In the residential street context, traffic engineering means providing for the full range of residential street activities and functions, not just motor vehicles.

About this report

This "State-of-the-Art" report documents the range of neighborhood traffic management techniques currently attempted in the United States and abroad and, insofar as it is possible on the basis of existing information sources, evaluates the effectiveness of those techniques and the processes through which they were planned and implemented.

Two basic resources have been utilized in compiling this report: an international literature search, and contacts with professionals in jurisdictions across North America. Individuals contacted were persons whom the research team, through prior professional relationships or references, had reason to believe were actively undertaking traffic management experiments in their communities. The State-of-the-Art search has not involved a census or statistically rigorous survey of ongoing traffic management actions in the United States. However, the sheer numbers of individuals contacted, the geographic distribution of jurisdictions in sharing data and experiences, all lend confidence that the information presented herein reasonably represents the current State-of-the-Art. The depth, breadth and consistency of data and experiences reported by these widespread and independent sources support this conclusion.

In this State-of-the-Art document the research team has attempted to go beyond simple presentation of the features of measures which have been tried. Instead, the attempt has been made to analyze successes and failures and the reasons for each, and to postulate elements of good neighborhood traffic management practices and pitfalls to be avoided. However, one of the unfortunate characteristics of the current State-of-the-Art is that communities normally collect very little data before traffic management implementations; and only rarely is data collected afterward. Evaluations of success or failure frequently involve few measurements of effects on traffic. Political decision making — whether the community accepts or rejects the device — is usually the primary criterion. If there are few or no further complaints, the device is judged successful. If there is strong public outcry, the device is often judged a failure and usually removed. In either case it is unusual for the responsible engineers or planners to devote much effort to measuring performance objectively since such data is so little used in the ultimate decision-making process.

As a result of this, though a rich body of experience in neighborhood traffic management has been found, there is a shortage of hard evaluative data upon which to draw firm and generalized conclusions. Fortunately, a small number of communities and organizations have devoted the time and effort to perform detailed evaluative studies which the research team has drawn upon heavily. And though, in many of the other cases, little hard evaluative data is available, parallelism in the results of similar cases and in the insights and experiences related by the professionals involved in them has made further judgments possible. But the reader must be cautioned that except where hard data is presented or referenced, findings and conclusions constitute the current best judgments of the authors based upon the research conducted to date.

What is to follow

This report is an early product of a comprehensive study of neighborhood traffic management. Over the next two years FHWA and the research team will be attempting to fill some of the gaps in knowledge about control of traffic in neighborhoods which have become evident in this State-of-the-Art review. This will be done through a series of case studies across the United States as well as by monitoring neighborhood traffic management activities in other American cities and abroad. The end product of the program will be a comprehensive manual on the planning and design of neighborhood traffic controls primarily intended for professionals but also useful to members of the community. This manual is scheduled to be available by Autumn, 1980.

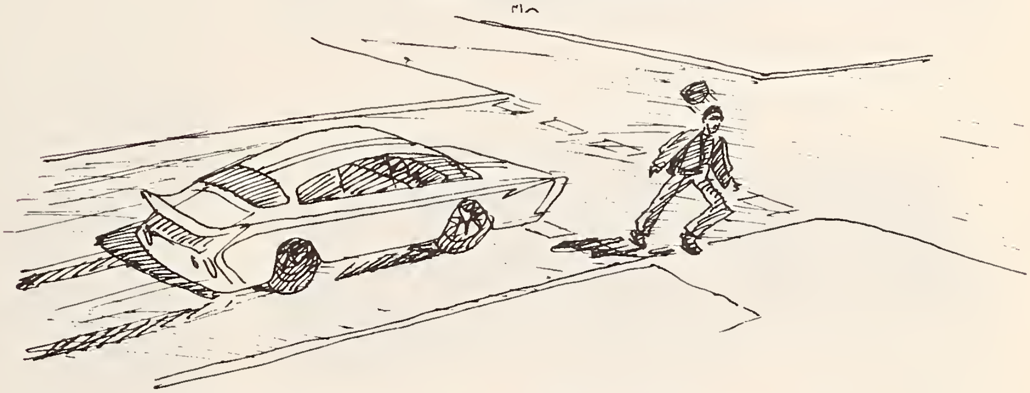
Organization of the state-of-the-art report

Following this introductory chapter, Chapter 2 presents a discussion of residential street traffic issues and an overview of the current State-of-the-Art in neighborhood traffic management. Chapter 3 treats design details and performance evaluations of neighborhood traffic control devices and systems. Chapter 4 discusses the process through which communities plan for and implement neighborhood traffic management schemes, including the professional's role and the role of community participation. In Chapter 5, some in-depth details of further planning and design considerations are presented. A reference bibliography completes the main document and appendices provide additional details on community participation techniques, assessment measures for planning neighborhood traffic control and for organization of technical data.

2

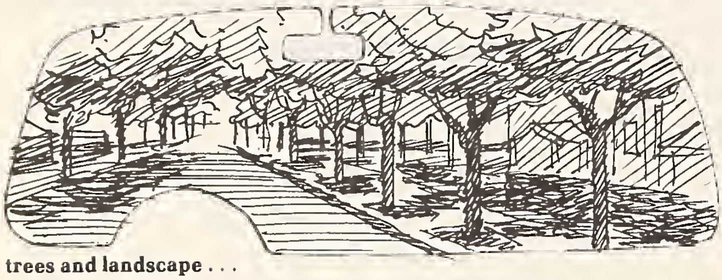
The street environment and neighborhood traffic management: an overview

This chapter presents a framework for understanding problems of the residential street environment and the role of the neighborhood traffic management in solving them. As presented herein, the nature of residential streets is defined; problems and their causes are identified; goals for neighborhood traffic management are established; and the major strategies and devices for achieving the goals are outlined.

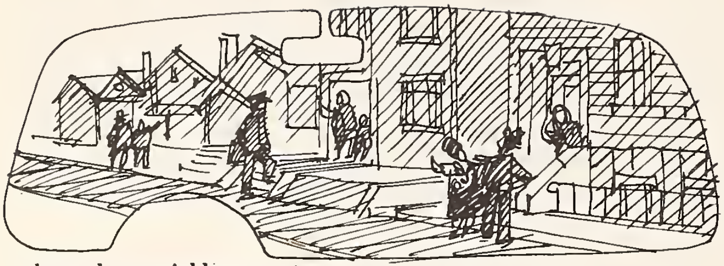


The residential street

A residential street serves many different kinds of people and many different purposes. The sketches which follow highlight some of the more important purposes of residential streets and the activities which take place along them. If the traffic service function of a residential street is overemphasized or motorist's behavior is insufficiently controlled, these other activities or qualities may suffer.



trees and landscape . . .

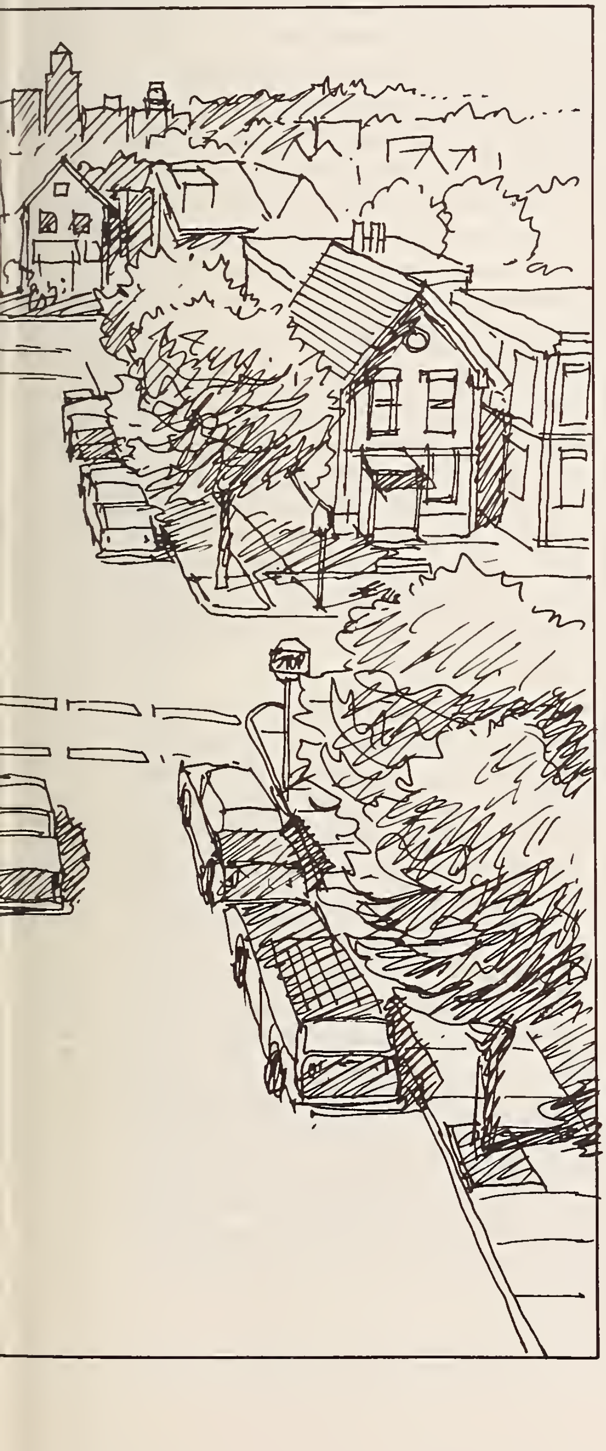


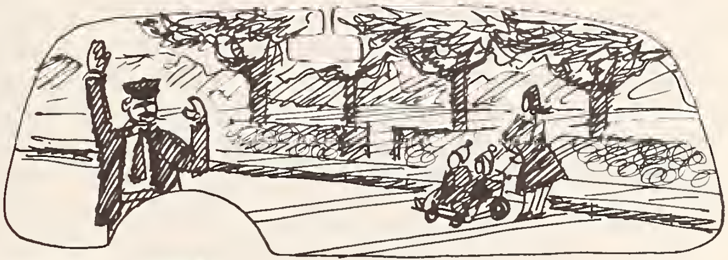
a place where neighbors meet . . .

houses . . .

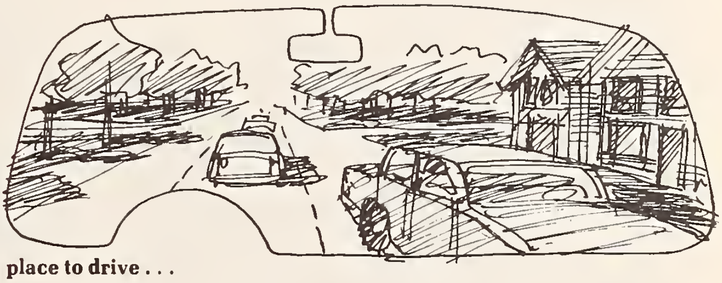
views . . .

A residential street is . . . .



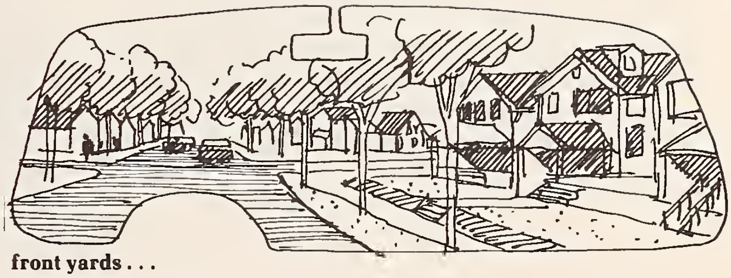


sidewalks, crosswalks . . .



a place to drive . . .

a place to park . .



front yards . . .

The problem

The fact that traffic is a widespread problem in residential neighborhoods is perhaps best documented by the U.S. Annual Housing census of 1973.[85] Of the 56,000 people sampled, 45 percent complained of undesirable "street noise" and 29 percent complained of "heavy traffic" on their streets. These were the most widespread neighborhood problems reported.

Behind the statistics, several specific problems caused by traffic in neighborhoods can be identified:

- **Traffic Accidents** — The occurrence of accidents, and frequently the fear or expectation that accidents may occur, is a significant problem. Much citizen anger and reaction to traffic stems from a desire for safer streets.
- **Noise, Vibration and Air Pollution** — These are aspects affecting the quality of life of neighborhood residents. At their extremes, they can affect the physical condition of structures. At less extreme levels, they represent at least a nuisance within a neighborhood.
- **Traffic Speed**. Speed is a subject of frequent resident complaint. In some cases the speed of all vehicles is a problem; in others, a few hot rodders or shortcutters are the culprits. The negative reaction to speed is often a translation of concern over high levels of noise and fear of safety problems. In other cases, the single high speeding vehicle is seen as an insult by thoughtless drivers to the peace and quiet of the neighborhood.
- **Traffic Volume**. The total amount of traffic is a major cause of complaint. Effects of volume change are perceived most accurately in the middle and lower ranges (under 2000-3000 ADT). As with speed, complaints about high volume are often a reflection of previously cited problems: safety, noise, vibration and air pollution. Complaints about high volumes are also a positive indicator that some of these other problems are perceived to exist.
- **Traffic Composition**. In most cases, it is **through** traffic that residents complain of, though quite often the problem lies with neighborhood residents. Certain **types** of traffic are also a prime cause of annoyance, especially **trucks, buses and motorcycles** which create more noise, fumes, vibrations and perceived hazard than the regular automobile.
- **Appearance, Identity, and Maintenance** — Traffic, by its mere presence, detracts from the appearance of a neighborhood, be the vehicles parked or moving. The presence of traffic can detract from more positive features of a neighborhood, aiding if not causing a reduction in neighborhood identity and cohesion, and reducing the incentive to maintain the neighborhood's appearance.
- **Reduction of Street Activities and "Neighboring"** — These are effects of traffic which are problems of communities as much as problems of individuals. When traffic noise is high, the desire to meet and converse on the street is reduced; where volumes are high, the ability of children to use the streets as play areas — often the only feasible location — is reduced. Other physical activities, such as walking and jogging, are also affected.
- **Impact on Land Use and Social Stability** — The presence of traffic can discourage residential land uses and encourage commercial activity; it can also lead to rapid population turnover and neighborhood instability, though this is not always the case. There is also some evidence that streets with greater auto accessibility may be more susceptible to residential crime (e.g., burglaries).[9]

Some of the more typical and specific neighborhood problems are shown in Figure 1.

As this listing indicates, the traffic problem can be viewed microscopically, affecting individuals, and macroscopically, affecting communities and eventually regions. While the most vocal statements of the problem will usually involve impacts on individuals, those aspects affecting the community as a whole cannot be overlooked.

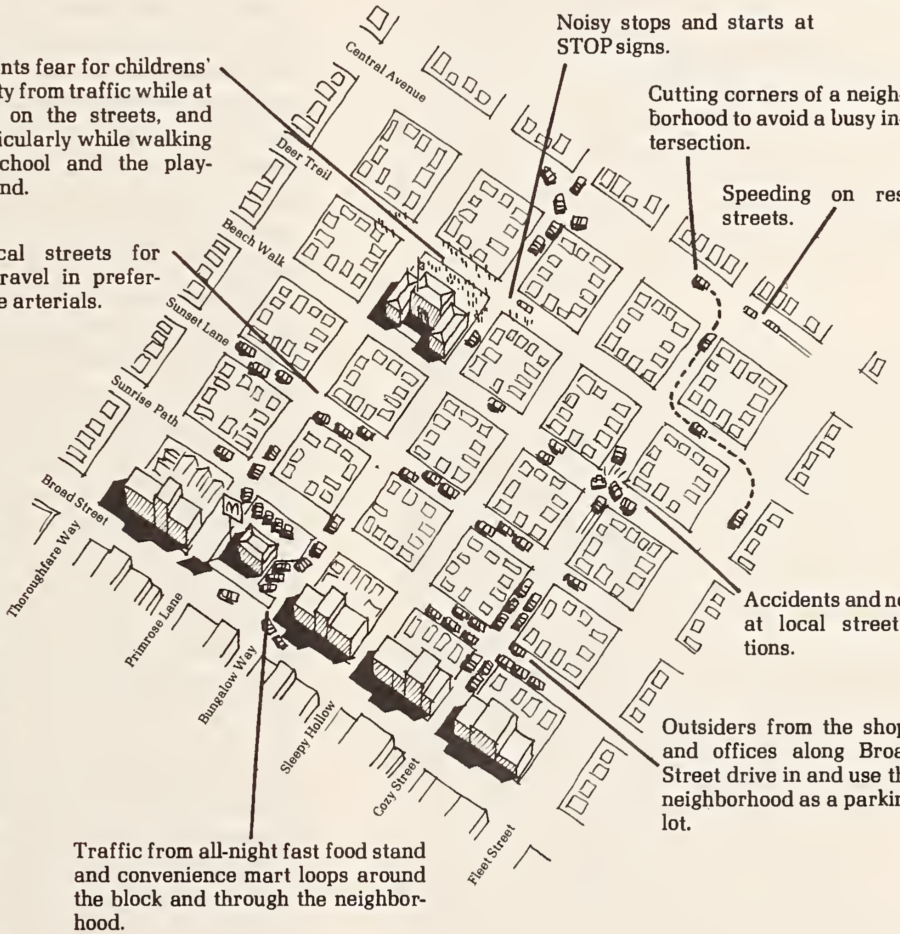
Causes of the problem

Causes of the problem can be classified as either psychological or physical; as will be shown in other parts of the report, the solutions can also be divided in this way.

Psychological Causes

The psychological causes relate to the ingrained expectations of both motorists and residents. Many motorists simply regard any street in any location as, first and foremost, a place to drive. Further, they have certain expectations as to how a street system should operate, and if the street designed to serve their through trip becomes congested beyond their tolerance level, they will seek other paths. Other motorists, also using any street available, use their vehicles as instruments for thrills and pleasure, and have no concern for the effects of the noise they generate.

Neighborhood residents, on the other hand, usually desire a quiet, pleasant and safe place to live. Clearly the conflict of expectations and the psychology of each group is a major cause of the neighborhood traffic problem.



Parents fear for childrens' safety from traffic while at play on the streets, and particularly while walking to school and the playground.

Noisy stops and starts at STOP signs.

Cutting corners of a neighborhood to avoid a busy intersection.

Speeding on residential streets.

Using local streets for through travel in preference to the arterials.

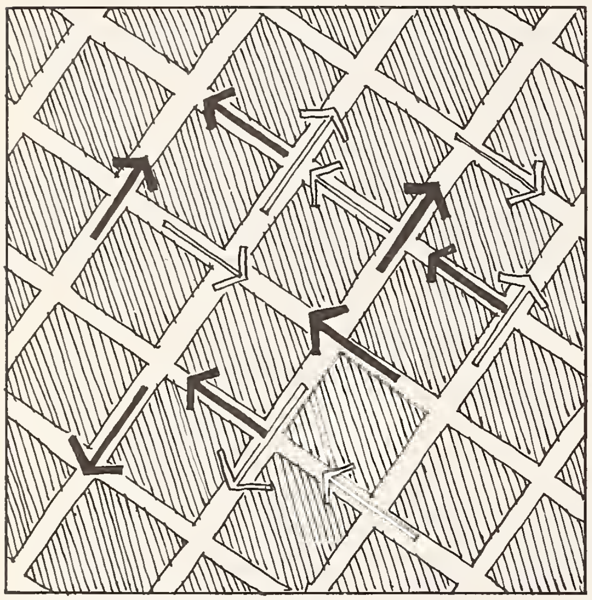
Accidents and near-misses at local street intersections.

Outsiders from the shops and offices along Broad Street drive in and use the neighborhood as a parking lot.

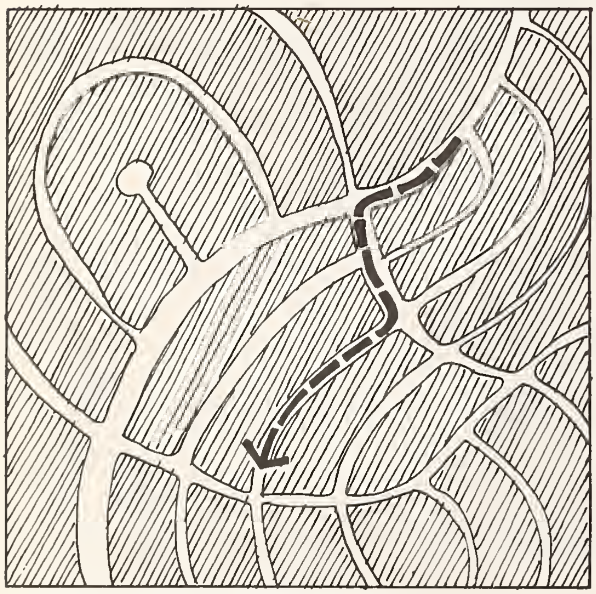
Traffic from all-night fast food stand and convenience mart loops around the block and through the neighborhood.

This is a typical neighborhood. The regular grid pattern permits through traffic to flow freely onto local residential streets. If traffic is congested on the bounding arterials (Central Avenue, Thoroughfare Way, Broad and Fleet Streets) or the traffic signal system provides poor progression along them, drivers will speed through a street meant to furnish access to local residences only. Some of the problems this can cause are noted on the schematic neighborhood plan on the right.

Figure 1. **Typical neighborhood with traffic related problems**



Gridiron patterns allow traffic to diffuse over all streets.



Curvilinear suburban patterns are also subject to through shortcutters.

Physical Causes

Physical causes of the problem relate to the way cities have been designed, the way in which traffic demand has grown. The pattern of the street system, street geometrics, location of major traffic generators, traffic congestion on major streets and nuances of traffic control can all contribute to neighborhood traffic problems. **Gridiron street** systems allow traffic to diffuse in all directions on every street. Although city grids as a rule have clearly defined hierarchies of arterial, collector and local streets, often the streets designed to carry high volumes of through traffic are overloaded. In some of the older city grids, there is often little physical difference from a motorist's standpoint between the designated arterials and collectors and purely residential streets. If an arterial or collector is congested, the adjacent residential street in the grid, a parallel path of virtually equal distance, is an inviting shortcut. Areawide conditions of this nature are one aspect of the physical problem.

Other problems are more site specific and can occur with or without the grid system. A single congested intersection can lead to shortcutting. Often traffic control devices designed to move traffic on an arterial, such as left turn prohibitions, can force traffic onto residential streets. Or the presence of high volume traffic generators within or at the borders of a neighborhood can lead traffic through it.

Street design is another physical aspect of the problem. Suburban residential streets have been constructed to generous standards of width and geometric alignment. Streets which are both wide and contain long straight stretches are most inviting to speeders. Such streets look like traffic channels rather than places where people live. Features which make streets amenable and identifiable as residential places are frequently overlooked in design.

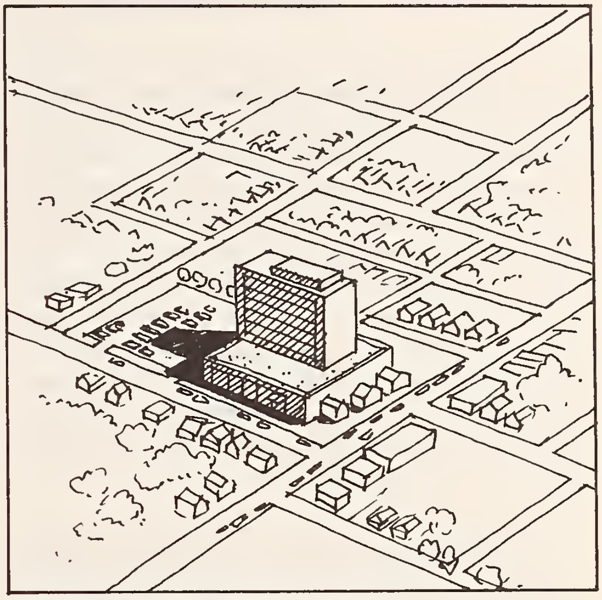
Many residential area problems are caused by location of land use activities which encourages or requires traffic to pass through residential neighborhoods. Where neighborhoods border on significant traffic generators, or where such generators are actually located within the neighborhood, complaints of traffic problems are most intense. Downtowns, shopping centers, hospitals, industrial sites, freeway off-ramps, and transit stations can be the source of problem traffic. At rush hours and occasionally other times, the traffic centered on these places spills over from the major streets into the residential areas. On a smaller scale, streets close to major intersections or neighborhood shopping centers often suffer from shortcutting traffic and those searching for a parking space.

Another problem stemming from poor planning is when arterials and collectors are constructed with residential uses fronting on them. These streets are often specifically intended to serve more traffic and faster traffic than is consistent with an attractive residential environment. Occasionally the same end result occurs when suburban areas grow. A street originally built for access to abutting residences is extended branched and ends up linking cul-de-sacs, loop streets and other local access roads to the main street network.

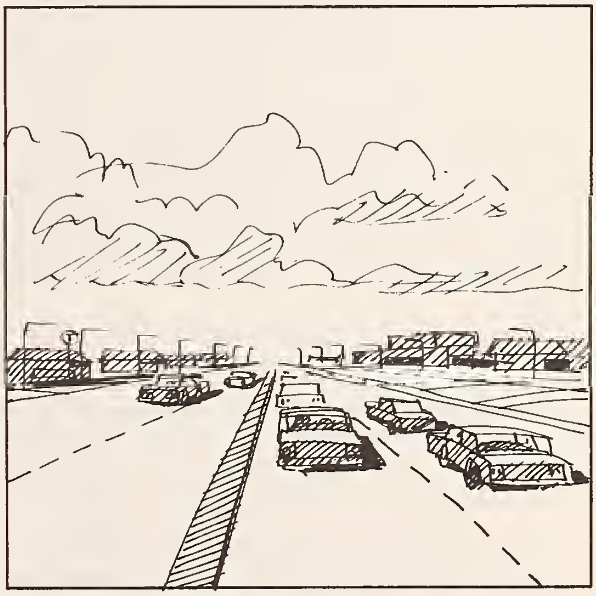
Finally, devices traditionally used to control traffic in neighborhoods are not effective in reducing traffic volume or in slowing traffic down except temporarily. Part of this problem is due to the fact that traffic **management** rather than traffic **facilitation** is still a relatively new concept in traffic engineering.

In summary, the problems of traffic on residential streets can be traced to a conflict between desires of drivers on the street and the expectations of residents along it. Beyond this, the problems can be traced to numerous design deficiencies and operational policies which either fail to take the residential environment into consideration, or which fail to value it as highly as the need to move traffic.

The basic focus of this report, as well as the research that will follow it, is on effective techniques which can help to swing the balance of this conflict in favor of the neighborhoods. As such, the report is concerned more with "retrofitting" existing neighborhoods rather than with proper design for new neighborhoods. Many of the goals and principles contained herein are applicable to new residential developments, but the reader concerned with that problem is better advised to consult current manuals of residential neighborhood design.



Traffic generators within the neighborhood often cause problems.



Long straight stretches on wide suburban streets encourage speeding.

Goals of street improvement and traffic management

The goals of street improvement and traffic management can be structured in different levels. The **primary goal** is the improvement of living and environmental conditions on residential streets. This is the goal of most schemes. However, another set of goals relating needs of motorists and needs of people living on other streets often emerges during the planning process. These may be called **secondary goals** which often impose constraints on the primary goal. Finally, there is the "political" goal of public officials — to give some indication of response and degree of satisfaction to any expressing concern for traffic issues.

Primary Goal

To significantly improve the environmental conditions of as many residents as possible, especially those most vulnerable to traffic impacts. The concepts of **significant improvement, numbers of residents affected** and **vulnerability** of those affected are particularly important aspects of this goal. Implicit are positive changes large enough to be meaningful accruing to as many people as possible, particularly those elements of the population most sensitive to traffic effects and negative impacts limited in degree of severity and numbers of people affected and falling on those least sensitive to traffic effects.

Since traffic has many impacts, the primary goal can lead to a number of subgoals:

To reduce traffic accidents and fear of traffic on neighborhood streets. This goal relates to vehicle accidents as well as subsuming the two more specific goals immediately below.

To maintain reasonably safe access and convenience for local residents, pedestrians, cyclists, and wheelchair users. Adequate and reasonably convenient parking, fairly direct routes, separation of different kinds of traffic in clearly marked zones, reduction of intersection conflicts, the encouragement of predictable behavior, and the provision of optimum information to road users can serve this goal.

To provide adequate and safe open space for children's play and other recreational activities. The street space comprises a substantial percentage (often about 25 percent) of urban land and in the inner city it is sometimes the only available public open space. Use solely by automobiles when traffic flows are light can be seriously questioned. Multiple use possibilities have been demonstrated in the increasingly well known Dutch Woonerven, "residential yards"[66] and in U.S. "play street" applications.[65]

To eliminate unwanted noise, vibration, and air pollution. Peaceful, quiet streets and neighborhoods should be the environmental right of every urban dweller. To the extent that residential uses often take place on streets designated to have a major role in moving traffic (arterials and collectors), this goal must be somewhat compromised. But on purely residential streets, its achievement should take precedence over movement of traffic.

To improve the appearance of the residential street environment and encourage its maintenance by the residents and public agencies. The appearance of a residential street is usually improved when it is treated as a residential place, with thoughtful planting and details that are pleasant and designed for pedestrian use rather than driver use (walking surfaces, seating places, domestic scale signs, and street furniture, etc.). The intrusion of cars and traffic signs on the residential character of the place should be minimized. Good maintenance by residents can be encouraged by creating spaces for which they feel personally responsible, with clearly defined territories.

To encourage neighborhood revitalization and neighborhood stability. The overall purpose of street improvement is neighborhood improvement or at least prevention from deterioration. Traffic restraint may be related to rehabilitation in a number of ways: it may lead to it by improving environmental conditions; it may result from the efforts of residents to revitalize their neighborhood; or it may have no relation (in some cases revitalization takes place despite heavy traffic, in other cases neighborhoods without traffic decline for other reasons).

To reduce crime, particularly street crime and burglaries. No direct connections between traffic and crime have been established. However, studies in Hartford, Connecticut and St. Paul, Minnesota demonstrate that incidence of street crimes tends to be less in neighborhoods with complex and confining street patterns than in ones with open, easily perceived street grids and that traffic management plans which create complex and confining street patterns can reduce the crime rate. Hence, reduction of crime is a goal of traffic management and street improvements.

Secondary Goals

To maintain reasonable access for emergency, transit and delivery services. In cases of emergency, there must be ways in which these services can reach every house in the neighborhood within reasonable time. Transit should be accessible from residences and delivery services should have reasonably direct routes through the neighborhood.

To maintain reasonable access for automobiles with destinations in the neighborhood. Access to each residence should not involve excessively indirect or incomprehensible access routes. Slow but easy movement should be the rule.

To maintain reasonable access for non-residential uses. Local merchants need access, visibility and adequate parking as do local institutions, transit stations, industry, and other highly used facilities. Maintaining access from the major arterial system while protecting the surrounding residences is a means of achieving this goal. Special considerations are needed when non-residential uses are located within a neighborhood.

To mitigate conditions or compensate those on residential streets which must carry heavy traffic. By controlling speeds and traffic composition, making traffic behavior predictable, creating safe and visible pedestrian crossings, controlling emission, building protective barriers, or increasing setbacks, and providing compensating improvements such as street trees, better maintenance, police control, and substitute open space, the lowered quality of these streets can be ameliorated. In some situations financial compensation may be considered.

Political Goals

To relieve political pressure and respond to citizen concerns. This common goal is much more pragmatic and political than those given above. It is to respond, at least in a minimal way, to citizen concerns about traffic on their streets. It may motivate actions which genuinely satisfy citizen's needs or perfunctory measures designed simply to get the residents off the officials' backs.

All the goals listed above appear obvious and reasonable, but achieving acceptable levels of satisfaction for all or most of them is often difficult for there are inherent conflicts between many of them. The most obvious conflict is between the primary goals of **livability** and the secondary goals of **mobility.** Even among the livability goals there can be conflicts. Families with children may desire measures extensive enough to make streets safe as play spaces while just reduction of heavy truck traffic and traffic noise may be enough to satisfy other residents on the street. Residents with auto-oriented lifestyles place more value on accessibility than do others. Sometimes the conflicts lie within the individual residents themselves. Residents espouse livability goals for their own block of their own street, but when driving behave as though mobility goals were of prime importance to them. Hence, the crux of planning for neighborhood traffic management lies in finding tradeoffs and compromises which allow achievement of an acceptable level of satisfaction over a broad range of livability and mobility goals.

Neighborhood traffic management

Traffic management is only one of a number of strategies that can help meet the above goals and improve environmental conditions in residential neighborhoods. Rehabilitation of housing, creation of new open space and recreation areas, planting trees, and townscaping are non-traffic strategies that may well be used to help meet most of the primary goals.

There are also strategies which like traffic management attempt to improve environmental conditions by reducing traffic impacts in neighborhoods. Increasing the capacity of arterial streets, the encouragement of transit use, better land use planning, even the building of freeways could relieve the traffic load on residential streets. Design changes to vehicles, particularly trucks and motorcycles, to reduce their noise and air impacts would also benefit the neighborhood environment. However, traffic management is one of the most **immediate, forceful and low-cost** ways of improving a street's environment.

There are a considerable number of traffic management devices which may solve specific neighborhood traffic problems. These devices normally aim to control the volume and composition of traffic on residential streets and the behavior of the driver, particularly with regard to speed, direction, care and predictability. Devices range from **physical controls** which actually change the street configuration or otherwise physically affect the vehicle, to **passive controls** which induce drivers to act in a desired fashion as the result of perceptual or cogitative reaction to the device. As an introduction to the subject, Figure 2 presents a sampling of the devices and their primary control effects. As a fur-

Median Barriers on a major street prevent left turn entries to the neighborhood or traffic on a local street from crossing from one neighborhood to another.

Circles slow traffic and provide a visual impression of street discontinuity.

Cul-de-Sac prevent entries to or exits from the neighborhood.

Chokers narrow the street at the intersection, slowing traffic and providing safer pedestrian crossing.

Channel forces right turns.

No Right Turn signs prevents use of shortcut.

Semi-diverters prevent traffic from entering the block but permit exits.

Diverters force all traffic to turn at the intersection.

One-Way Out Streets allows exits from the neighborhood but prevent entries.

Figure 2. **Solutions to typical neighborhood traffic problems**

ther introduction, Figure 3 presents an illustrated glossary of typical neighborhood protection devices.

Each of these devices has different effects and different reasons for its use. These effects and usage considerations are far more complex than the simplistic notations shown on Figure 2. In assessing these effects and selecting a control device for a specific situation, the analysts should be aware that these complexities are not limited to the direct effects on traffic. Secondary effects of the devices may be as useful or influential as direct traffic control impacts. For instance, on a street where traffic speed is the primary traffic control problem but where children's play space or landscape features are also lacking, a device (like a cul-de-sac) which creates play space or landscape opportunity might be favored over one which simply controls traffic speed (such as an undulation). Details on the full range of traffic control device effects and considerations in their selection are presented in the following chapters.

Traditional versus New Devices

Many of the devices listed in this report are traditional controls that have been used, mainly on arterial streets, for years. Channelization, median barriers, one-way streets, and stop signs are devices which have been used long enough that they are generally accepted and usually obeyed by the traveling public. Other devices, notably cul-de-sacs and diagonal diverters, are adaptations of features routinely designed into new residential subdivisions. In these cases, while the control may be familiar, the specific applications of the device itself may be new. Still other devices, such as speed humps and traffic circles, represent relatively new approaches. Experience has shown that often, simply because a device is new or unfamiliar, it is resented both by drivers and residents as yet another effort by the government to control their lives. The degree to which this reaction may occur is largely a local phenomenon to be evaluated; if it can be predicted, use of more traditional devices which solve at least part of a problem may be preferable over the theoretically better "new" solution that creates an uproar.

Positive physical controls

Cul-de-Sac

Semi-Diverter

Diagonal Diverter

Figure 3. Glossary of neighborhood traffic management devices

Median Barrier

Traffic Circle

Speed Bump

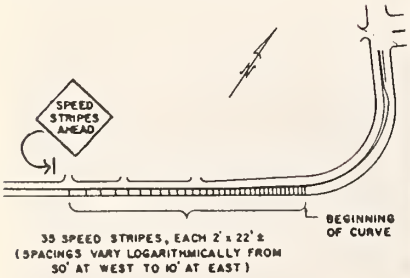
Passive controls

STOP Signs

Turn Prohibitions

Truck Restrictions

Psychological controls

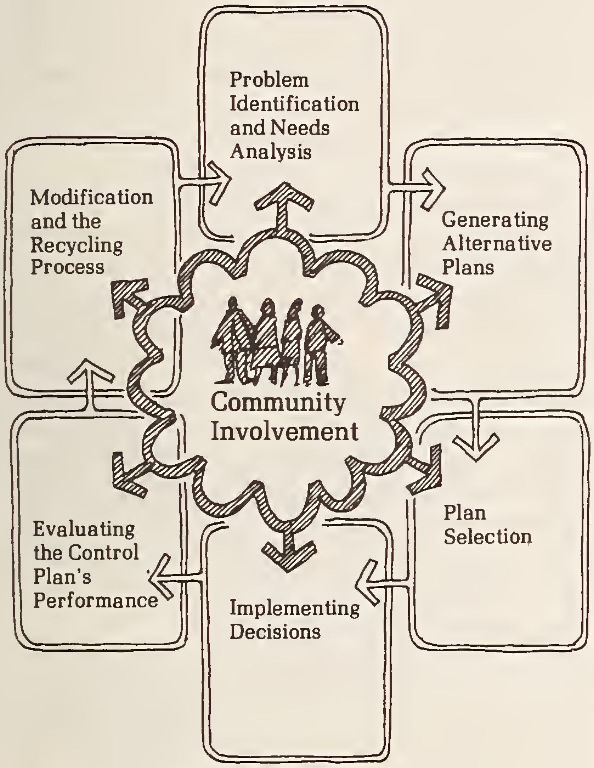


Lateral Striping

Warning Signs

"Gimmick" Signs

Figure 3. **Glossary of neighborhood traffic management devices (continued)**



The need for an organized planning process and community involvement

The complex nature of the residential street, the variety of users and their often conflicting goals, the complexity of control device effects on traffic and the secondary effects of these devices, make it imperative that neighborhood traffic management actions be a well-organized planning process. Such a process should include these basic steps:

- **Problem Identification** — An exploration of the specific nature of the problem or problems, and the issues and individuals involved.
- **Alternative Plans Generation** — Definition of the full range of plausible responses to the identified problems.
- **Plan Selection** — Estimating the likely effects of each alternative and how many people and whom would benefit or not from these effects, and choosing an option which has the most acceptable balance of positive and negative impacts.
- **Implementation** — Preparing the public for what is to take place; then actually constructing or putting into effect the planned traffic control changes.
- **Evaluation** — Observing and measuring how the traffic management system actually operates and identifying features requiring change or fine tuning.
- **Modification** — Adjustments to repair minor functional difficulties or to improve upon the initial planning concept or a larger-scale reconsideration of alternatives — a recycling of the planning process — where the initial scheme has proven unacceptable or ineffective.

The planning process should not be onerous or intimidating. Nor should its details be so overemphasized that the fundamental objectives of the program, traffic management and environmental improvement, are suppressed and the planning process becomes the objective of itself.

Its formality and the extensiveness of activity should be scaled to the needs of the individual situation. But the essential tasks at each step should be accomplished. Observations in the State-of-the-Art review reinforce this point. Where traffic management had severe difficulties, the difficulty was frequently attributable to lack of an organized planning process or to missing an essential element of it rather than to a technical error or to the inherent properties of the control devices and systems utilized.

At the outset, it must be emphasized that solving the neighborhood traffic problem is as much a political problem as it is a technical problem. Many sorry experiences have shown that a neighborhood traffic management plan may or may not succeed if the technical work is not perfect, but it will almost never succeed unless effective and thorough programs of planning and community relations are developed and carried on from the very beginning. Too often, well-meaning engineers have listened to a small group from a community, prepared and implemented a plan, only to face resentment from citizens previously unaware or uncommunicative on the subject. This aspect of the problem has been considered so important that many agencies will undertake a project only if a substantial majority of the affected neighborhood signs a petition requesting or agreeing to the plan. The planning process must provide a structure for effectively integrating community inputs with technical work.

Because the planning process and citizen involvement are critical, Chapter 4 of this report extensively documents the steps in planning for neighborhood traffic management and techniques for citizen involvement which have been successfully used.

Summary — a note on the State-of-the-Art

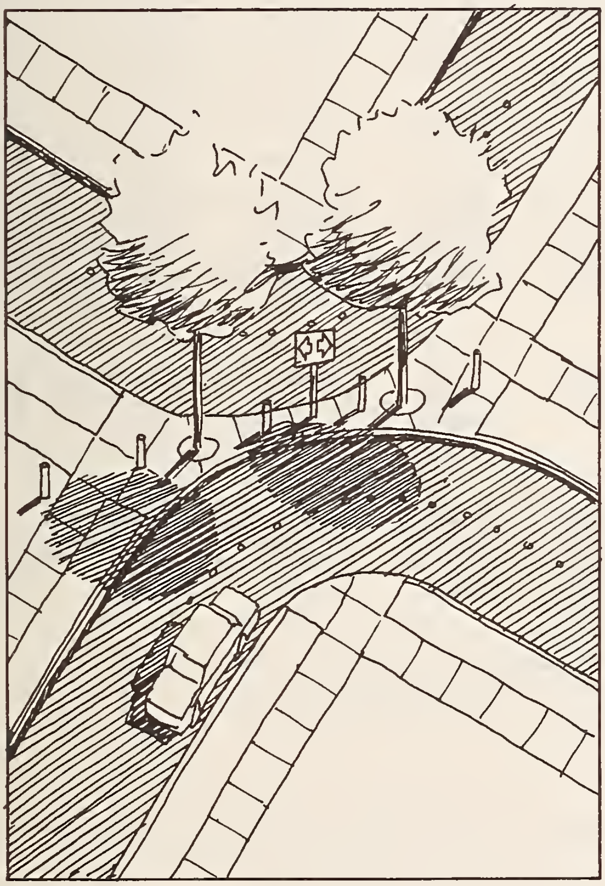
From the foregoing discussion, it should be clear that while the causes of the neighborhood traffic problem are fairly clear, the planning process, both political and technical, can become quite complex. Because the solutions often benefit some people while creating new problems for others, there is often a tendency on the part of political agencies to do nothing for fear of merely adding to their problems.

The most encouraging discovery in the State-of-the-Art research conducted in the preparation of this document is that there are a number of means, both technical and political, of solving the neighborhood traffic problem. Where failures have occurred, more often than not their cause can be traced to a lack of knowledge about the effects of particular devices, about how to involve the public in planning traffic management schemes or about the techniques for communicating what is known to the public.

This document represents the first step in the gathering together of current knowledge and its dissemination. As will become clear from further reading of this report, the State-of-the-Art is still incomplete. There is much still to be learned. However, the devices and techniques described in the following chapters should provide planning agencies with sufficient knowledge to make a positive beginning toward solving their problems. Hopefully it will suffice until the further research to be conducted in this study can fill in some of the gaps in knowledge in the way in which people, as drivers and residents, and the devices interact.

3

Neighborhood traffic control devices and systems



The purpose of this chapter is to provide a detailed description of each of the numerous control devices which might or have been used for a neighborhood protection program. The descriptions follow a highly structured format and include physical characteristics, primary traffic effects, typical construction materials and costs, legal status, and examples of current practice. The basic intention is to illustrate the differences in use, impact and cost that can be expected for each of the devices. As in the previous chapter, the devices have been organized into three generic types: positive physical controls, passive controls, and psychological controls. The fundamental difference in these three categories is the way in which the devices exert control over traffic. Physical devices **force** drivers to take or not take certain actions. Passive controls **command** or **advise** that certain actions be taken or not be taken but, save for the possibilities of law enforcement and traffic accidents, nothing prevents motorists from disregarding them. Psychological controls attempt to **induce** desired behavior patterns and discourage undesired one by playing upon drivers' fundamental perception-reaction traits.

Although physical controls pack the most punch, they also tend to bring with them more and stronger secondary impacts of both desirable and undesirable natures. As a consequence, in many situations the most absolute form of control device will not necessarily be the best choice; a weaker type of device or a mix of device types may be more suitable.

Table 1 provides an index for the individual control device sections and summarizes their

	DIRECT TRAFFIC EFFECTS						
DEVICES	Volume Reductions	Speed Reductions	Directional Control	Change In Composition	Noise	Safety	Emergency & Service Access
Physical Controls							
Speed Bumps	Possible	Inconsistent	Unlikely	Unlikely	Increase	Adverse effects	Some problems
Undulations	Possible	Yes	Unlikely	Unlikely	No change	No problems documented	No problems documented
Rumble Strips	Unlikely	Yes	Unlikely	Unlikely	Increase	Improved	No problems
Diagonal Diverters	Yes	Likely	Possible	Possible	Decrease	Shifts accidents	Some constraint
Intersection Cul-De-Sac	Yes	Likely	Yes	Possible	Decrease	Shifts accidents	Some constraint
Midblock Cul-De-Sac	Yes	Likely	Yes	Possible	Decrease	Shifts accidents	Some constraint
Semi-Diverter	Yes	Likely	Yes	Possible	Decrease	Shifts accidents	Minor constrain
Forced Turn Channelization	Yes	Likely	Yes	Possible	Decrease	Improved	Minor constrain
Median Barrier	Yes	On curves	Possible	Possible	Decrease	Improved	Minor constrain
Traffic Circle	Unclear	Minor	Unlikely	Possible	Little change	Questionable	Some constraint
Chokers and Road Narrowing	Rare	Minor	Unlikely	Unlikely	Little change	Improved ped. crossings	No problems
Passive Controls							
Stop Signs	Occasional	Site red.	Unlikely	Unlikely	Increase	Mixed results	No problems
Speed Limit Signs	Unlikely	Unlikely	Unlikely	Unlikely	No change	No change	No effect
Turn Prohibition Signs	Yes	Likely	Yes	Possible	Decrease	Improved	No effect
One-Way Streets	Yes	Inconsistent	Yes	Possible	Decrease	Possible imp.	No effect
Psycho-Perception Controls							
Transverse Markings	No change	Yes	No effect	No effect	Possible red.	Possible imp.	No effect
Crosswalks	No effect	Unlikely	No effect	No effect	No effect	Ineffective	No effect
Odd Speed Limit Signs	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Novelty Signs	No effect	Undocumented	No effect	No effect	Unlikely	No effect	No effect

Specific details of individual applications may result in performance substantially variant from characterizations in this matrix. See text sections on individual devices for more complete performance data, assessments and qualifications.

Table 1. **Neighborhood traffic control device characteristics — Summary**

DEVICES	OTHER CHARACTERISTICS Construction Effort & Cost	Landscape Opportunity	Site or System Use	Maintenance & Operational Effects Index
Physical Controls				
Speed Bumps	Low	None	Both	Snowplow problems
Undulations	Low	None	Both	No problems noted
Rumble Strips	Low	None	Site	Snowplow problems
Diagonal Diverters	Moderate to high	Yes	Usually system	Vandalism
Intersection Cul-De-Sac	Moderate to high	Yes	Both	Vandalism
Midblock Cul-De-Sac	Moderate to high	Yes	Both	Vandalism
Semi-Diverter	Moderate to high	Yes	Both	Vandalism
Forced Turn Channelization	Moderate	Possible	Both	No unusual problems
Median Barrier	Moderate	Possible	Both	No unusual problems
Traffic Circle	Moderate to high	Yes	Both	Vandalism
Chokers and Road Narrowing	Moderate	Yes	Both	No unusual problems
Passive Controls				
Stop Signs	Low	No	Both	No unusual problems
Speed Limit Signs	Low	No	Site	No unusual problems
Turn Prohibition Signs	Low	No	Both	No unusual problems
One-Way Streets	Low	No	Usually system	No unusual problems
Psycho-Perception Controls				
Transverse Markings	Low	No	Site	No unusual problems
Crosswalks	Low	No	Site	No unusual problems
Odd Speed Limit Sign	Low	No	Site	Vandalism
Novelty Signs	Low	No	Site	Vandalism

key attributes. Because a structured format has been used to allow for understanding the effects of individual devices, certain information pertaining to all devices such as impact on emergency services, device violations, etc. has been presented in a separate chapter, Chapter 5. The information contained in that chapter is vital to a total understanding of the devices.

An attempt has been made in describing each device to evaluate its impacts both desired and undesired. As a general comment on the State-of-the-Art, more has been planned than has been implemented, and more has been implemented than has been evaluated thoroughly. Thus while the problem of neighborhood traffic management is one with widespread and vital concern, less than might be desired is known about the impacts of most of the devices described herein; thus the reader looking for the definitive nature of each device may be disappointed. It is expected that the future stages of this research project will provide the details missing in these descriptions.

Readers of the report are cautioned against using this chapter alone to quickly pick a device which seems to fit their situation. Once a problem is identified, the analyst must determine whether it is site specific (subject to remedy by a single device at a single location) or endemic to a larger area (requiring a system of remedial devices). Systematic solutions are indicated when an entire neighborhood or district requests action on a number of problems or when the "solution" to one site's problem will create a new problem somewhere nearby. Techniques for systemic problems are contained in Chapter 4. The essential point here is that analysts should not take too narrow a view of the problem and jump to a solution simply on the basis of characteristics of individual devices as presented herein.

Solutions to systemic problems require strategic approaches and the characteristics of individual control devices affect their suitability for application in particular strategies. For this reason, the conclusion of this chapter outlines some basic area control strategies for responding to various kinds of systemic problems and the types of control devices which can be used in each particular strategy.

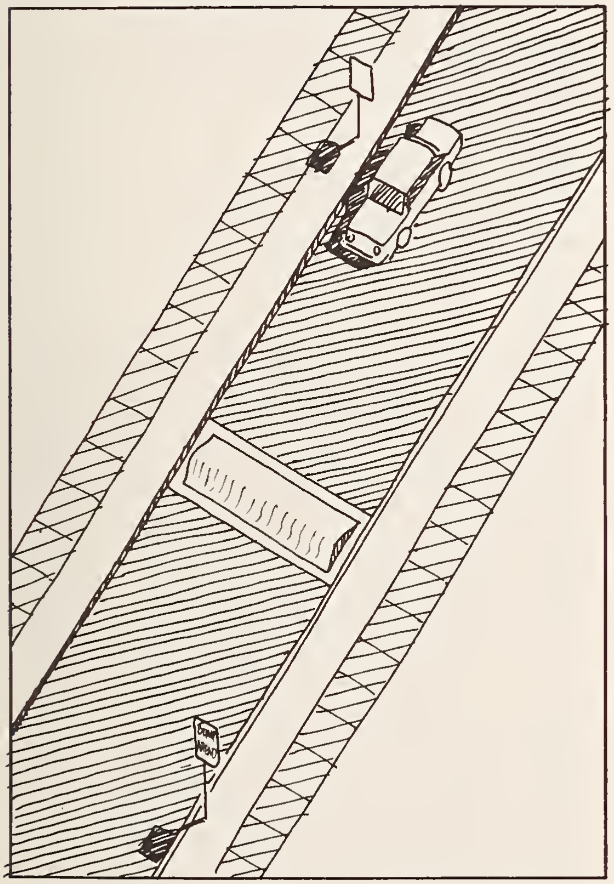
Even when problems and the impacts of logical solutions seem confined to a limited site rather than having systemic effects, there are no hard-and-fast guidelines leading to simple choice of the appropriate device. Each situation to a greater or lesser degree involves a unique set of circumstances: street character, mix of resident types, urban activities abutting, street network setting and geometric considerations. So even if a problem is clearly defined and site-limited, it is advisable to carry out at least a simplified version of the planning and evaluation steps outlined in Chapter 4. Doing so guarantees consideration of all reasonable options. Rote application of a uniform solution for all problems of a similar nature is to be avoided.

The merits of permanent versus temporary traffic control devices are discussed at length in Chapter 4 as a strategic planning consideration. It is essential to recognize that permanent versus temporary installation can have significant implications for many of the factors discussed in this control device chapter — materials, cost and operational and safety performance. In many instances the large disparities of experiences reported herein stem from differences between temporary and permanent installations. And because of the performance implications strategic planning decisions on temporary versus permanent installation may be an important factor in choice of control device.

Positive physical controls

Positive physical controls include speed bumps, rumble strips, median barriers, cul-de-sacs, semi-diverters, diagonal diverters, traffic circles, chokers and other less commonly used devices. Their common characteristic is the use of a physical device to enforce or prohibit a specific action, usually the reduction of either speed or volume. Physical controls have the advantages of being largely self-enforcing and of creating a visual impression, real or imagined, that a street is not intended for through traffic. Their disadvantages relative to other devices are their cost, their negative impact on emergency and service vehicles, and their imposition of inconvenient access on some parts of a neighborhood.

Bumps, Undulations



Speed bumps and undulations

Speed bumps and undulations are one of three physical devices (the others being rumble strips and traffic circles) which have been used for the primary purpose of reducing speed. They are raised humps in the pavement surface extending transversely across the traveled way. Normally they have a height of less than 5 inches (.1 meter). Length in the direction of travel distinguishes "bumps" from "undulations." Bumps are abrupt humps, normally less than 3 feet (1 meter) in length while undulations are more gradual with lengths of 8 to 12 feet (2-4 meters). Bumps have most often been installed on park roadways and private drives and rarely on public streets. A recent innovation, undulations have been installed on public streets in a few jurisdictions.

Figure 4. Speed bump

There are several reasons their use on public streets has been limited. The major one is a real and perceived question as to their safety. A study in San Jose, California, has confirmed these safety problems for certain designs.[94] These results are summarized in the sections which follow. The second reason for their lack of use is that they are not included in the Manual of Uniform Traffic Control Devices (MUTCD) and parallel state traffic control and design guides.[86] As a result, many traffic engineers consider them illegal. Tests have also shown that some designs produce less discomfort at higher speeds than at low ones, in direct contradiction to their purpose.

Figure 5. **British speed undulation. In Toronto (lower view) undulations have been deployed in pairs.**

On a more positive note, a long speed bump, or undulation, has been developed by the Transportation Road Research Laboratory in Great Britain.[95] While the safety aspects have yet to be evaluated, this design appears to have promise for effectively reducing speed.

Primary Traffic Effects

The basic purpose of speed bumps is obviously to reduce speed. However, the actual design of the bumps is critical to their ability to achieve this.

Effect on Traffic Volume. Four trial installations of undulations 12 feet (4 meters) long (in the direction of travel) and 4 inches high (.1 meter) in Great Britain have shown that, though installed to reduce speed, the humps can reduce traffic volumes as well.[79-82] The trial installations consisted of five to nine humps spread over a distance of 1000 to 2700 feet (300 to 810 meters). As shown in Table 1, traffic volumes were reduced by 25 to 40 percent. Another test of this design has taken place in Toronto, Canada. In this test, the undulations were placed in pairs 30 feet (9 meters) apart on two residential streets. No effect on traffic volumes occurred, in part because other protective measures in the neighborhood left these test streets as the only ones with continuity.

Table 2
Traffic reduction due to use of speed undulations in Great Britain

Location	Time Period	Traffic Before	Volume After	%
Cuddleston Way, Crowley, Oxford	24 hrs	NA	NA	-41
Motum Road, Norwich	9 hrs	398	271	-32
Palace Road, Haringey, London	16 hrs	3212	2413	-25
Abbotsbury Road, Kensington, London	16 hrs	8154	5833	-28

Effect on Traffic Speed. Extensive tests of speed versus discomfort (as perceived by drivers and passengers) have been made in two studies in San Jose, California[94] and in Great Britain.[95] The San Jose studies evaluated "short" bumps from 6 inches to 3 feet (.2 to 1 meter) in length and 2 and 3 inches (.1 meter) in height. All of these bumps tested produced either no difference or decreasing discomfort as speed increased. The Great Britain study confirmed this conclusion for short humps. Experiences in the few U.S. cities contacted in the State-of-the-Art search which had tried short bumps support this conclusion. Though none had performed formal evaluations, most withdrew the devices feeling that the higher the speed, the less traffic was impeded by them. Boston, Massachusetts, one of the cities contacted, has retained bumps on public streets though professionals there consider them dangerous and noisy.

The British work has demonstrated that an undulation 12 feet long (4 meters) (in the direction of travel) and 4 inches high (.1 meter) did produce the desired result of speed reduction, with an undesirable comfort index occurring at approximately 20 mph (32 kmph). This design has been tested in four field installations in Great Britain and has reduced the average speed to 15 to 25 mph (24 to 40 kmph), with three tests in the 15-17 mph (24 to 27 kmph) range.[79-82] The installations in Toronto were successful in reducing average speeds from 20-28 mph (32-45 kmph) to 15-18 mph (24-29 kmph); the 85th percentile speeds were reduced from 20-32 mph (32-51 kmph) to 19-21.5 mph (30-34 kmph).[78]

A third study, computer simulation of vehicle response to two parabolic pavement undulation designs, indicates that in theory, undulations can cause drivers to reduce speeds.[64] No field testing of these devices has yet been done in the United States.

Effect on Noise. The San Jose and Great Britain studies produce conflicting results with respect to noise. The San Jose experiment measured noise at the bump itself, thus making extrapolation to noise in the neighborhood somewhat difficult. However, the study estimated that nearby residences would experience a 10 to 20 decibel sound level increase when vehicles struck the bump.[94] The British test cases, which measured noise over an entire day, showed reductions in average noise levels on the building frontage line of 2-5 dBA, primarily due to the reduction in volume.[79-82] U.S. cities which employed the short speed bumps but did not perform formal evaluations usually did characterize the bumps as noisy.

The Toronto tests found that the undulations tend to increase noise when struck.[78] Automobiles striking them at 10-15 mph (16-24 kmph) had a noise level equivalent to 25-30 mph (40-48 kmph) on a flat road; trucks passing over the undulations at 5 to 10 mph (8-16 kmph) had noise levels equivalent to flat road travel at 25-30 mph (40-48 kmph). These tests also indicated that the lower speeds caused the increased noise levels to occur over a longer period of time. It might be concluded that if undulations are as successful at reducing speed as the aforecited speed studies indicate, undulations would probably produce little net change or even a reduction in neighborhood noise levels.

Effect on Air Quality and Energy Conservation. While these effects were not studied, the need to slow slightly for the bumps would tend to have a marginally negative effect on air quality and energy consumption.

Effect on Traffic Safety. The British studies on short and long bumps have not addressed this topic. The San Jose study dealt with it extensively. The study of short bumps showed that they would "present an immediate and specific hazard to some vehicles (bicycles, motorcycles, etc.) and a potential hazard to all vehicles."[94] In lower speed tests of a fire truck, firefighters were thrown 6 inches to 1 foot (.15 to .3 meters) into the air by the bumps. A trained motorcycle officer was thrown 16 feet (5 meters) in another test. A bicycle suffered a bent rim in yet another. These hazards led the San Jose analysts to conclude that short bumps are an unacceptable hazard on a public roadway. State-of-the-Art search contacts with practitioners in local jurisdictions across the U.S. found a majority convinced that speed bumps were dangerous. Practitioners normally cited the San Jose work and isolated tort cases or observed incidents in support of this viewpoint.

Community Reactions to Speed Bumps. The number of installations of speed bumps and undulations are too few to generalize on community acceptance. However, it can be expected that the noise of the bumps would be a problem for people in their immediate vicinity. Some communities which installed short bumps have removed them due to their noise and observed increase in speed.

Uniform Standards and Warrants

Speed bumps are not included in the MUTCD, nor in any corresponding state traffic control and design manuals. Some states have specifically rejected inclusion of speed bumps in such guides.

Undulations have only been used at a limited number of test sites to date. Specific physical standards for the device are set forth in the referenced TRRL report. It is anticipated that authorization and guidelines for their common use on local residential streets in the U.K. will be forthcoming in the near future.

Miscellaneous

Conventional speed bumps are reported to interfere with winter snow plowing operations. Undulations, however, because of their less abrupt profile, seem unlikely to cause such problems. No interference with snow plowing operations has been reported in the case of the Toronto undulations.

Examples of Current Practice

Figure 4 shows a typical short bump used in many private facilities. Figure 5 is the British undulation currently being tested in England and Toronto.

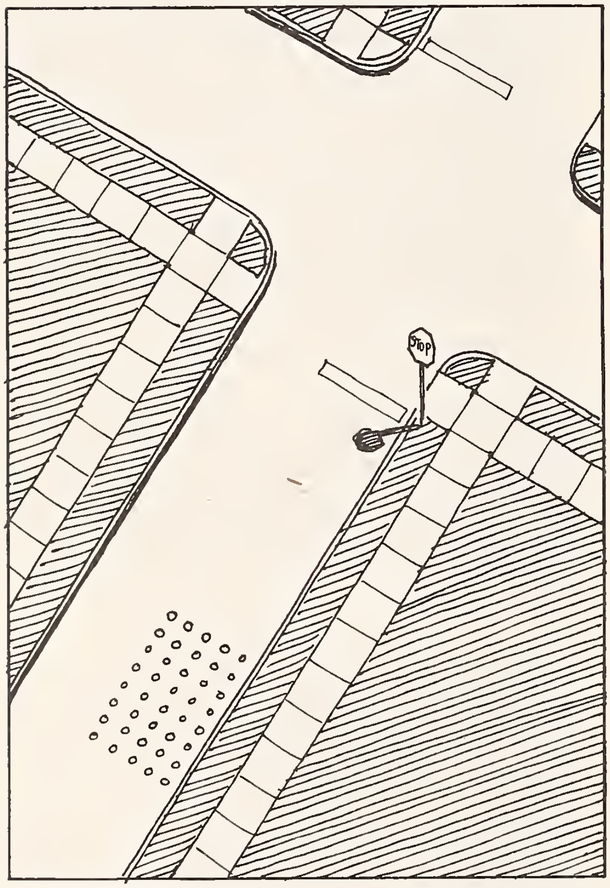
Rumble strips

Rumble strips, patterned sections of rough pavement, were developed in the 1960's as a means for alerting drivers to the presence of a dangerous condition or a specific control device. While used primarily on freeways and arterial streets, they may have potential as a speed reduction device in neighborhoods.

Primary Traffic Effects

Effects on Traffic Volume. None

Effects on Traffic Speed. The studies which have evaluated the effects of rumble strips on speed show their effect to be mainly at the upper end of acceptable speeds in residential areas. A test of ¾" (.01 meter) chips in Great Britain showed that 1-foot long (.3 meter) strips caused discomfort at about 25 mph (40 kmph).[10] A test of similar material in Contra Costa County reduced speeds 450 feet (135 meters) away from an intersection from 41 to 37 mph (66-59 kmph).[45] Other tests of ¾" (.01 meter) chips in Minnesota showed speeds 300 feet (90 meters) in advance of intersections to slow from 31 to 28 mph (50-45 kmph).[60] Clearly, these latter tests show small effects at speeds above those desirable in neighborhoods. It is unclear if these strips would cause sufficient discomfort in neighborhoods to affect speeds. A test of ½" (.01 meter) high strips, 6 inches (.2 meter) wide and two feet (.6 meter) apart installed in three test locations in Calgary, Alberta showed reductions in average speed of 1-4 mph (1.6-6 kmph) with the resulting speeds being in the 21-28 mph (34-45 kmph) range.[58] Another test in Ottawa, Canada produced a negligible impact on speed.[57] In San Francisco, rumble strips ¾" (.01 meter) to 1½" (.04 meter) in height reduced speeds from 5 to 15 mph (8-24 kmph) with the post-implementation 95th percentile speed ranging from 16 to 30 mph



Rumble Strips

(26-48 kmph).[49]

Effect on Traffic Safety. The studies show that the strips have had a noticeable positive effect in reducing accidents when placed in advance of a stop sign. At a T intersection in Contra Costa County, California rumble strips cut the accident rate by 60 percent.[45] Subsequent overlaying of the strips due to repaving brought about a return to the previous pattern, again demonstrating the strips' effectiveness.[46] Accident experience at nine rural intersections in Illinois decreased by 32-30 percent.[39] Again, these are arterial studies; effects in lower speed residential areas have not been determined. No specific instances of bicyclist safety problems resulting from rumble strips have been reported. However, difficulties caused bicyclists by types of raised pavement markers sometimes used in rumble strips are well documented.

Effect on Traffic Noise. Noise levels have been measured only inside the car in the U.S. studies noted above. The Contra Costa study observed that the ¾" (.01 meter) chippings raised noise levels from 92 to 100 db, with closed windows. Other studies have suggested more modest increases in the 2-3 db range. In the Calgary and Ottawa experiments, the strips were removed due to complaints of noise.[57-58] San Francisco limits application of rumble strips to streets of less than 2500 ADT (due to problems with noise on busier streets).

Effect on Air Quality and Energy Conservation. None demonstrated.

Community Reaction to Rumble Strips. The studies in the two Canadian cities both produced negative citizen reactions to the noise levels generated by the strips.

Typical Construction Materials

- ¾" (.01 meter) chippings sealed in concrete or patterns of Botts dots

Typical Construction Costs

- $200-400 per approach

Uniform Standards

While not treated in the MUTCD, rumble strips are a recognized device in basic traffic engineering reference tests.[113, 114] However, no

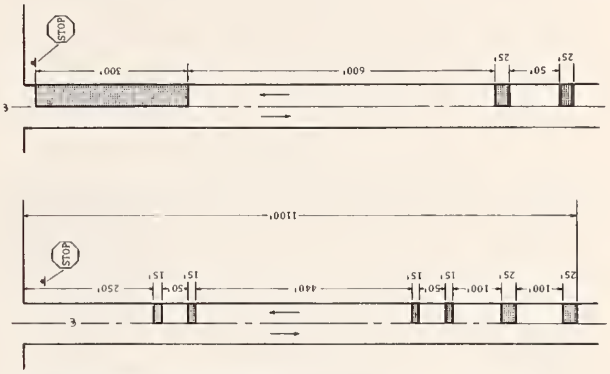
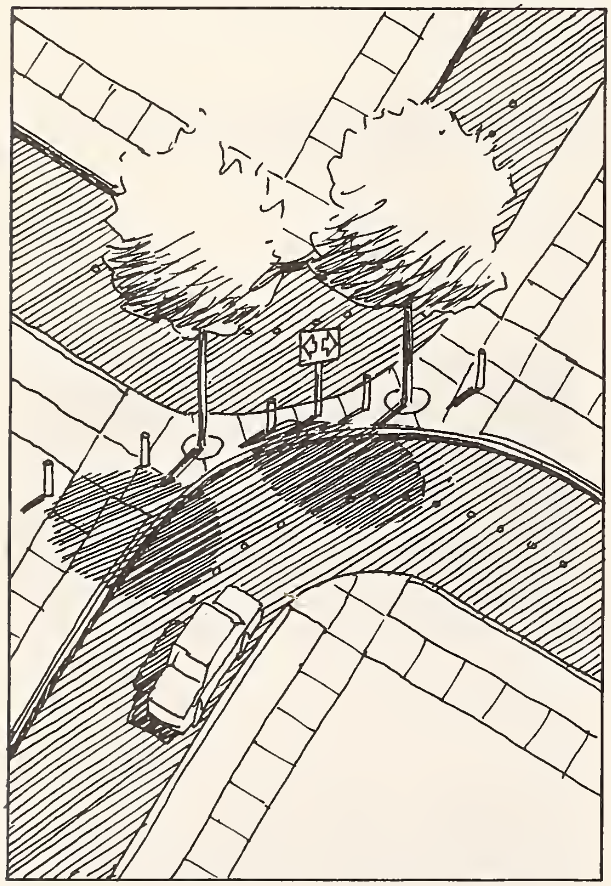


Figure 6. **Typical rumble strip design** — conventional warning strip application.

Figure 7. **Rumble strip installations** — for neighborhood speed control.

specific warrants or design standards are given. Examples of designs currently in use are shown in Figures 6 and 7.



Diagonal Diverters

Diagonal diverters

A diagonal diverter is a barrier placed diagonally across an intersection to, in effect, convert the intersection into two unconnected streets, each making a sharp turn. As such, its primary purpose is to make travel through a neighborhood difficult, while not actually preventing it. In actual application, this device is often best used as part of a system of devices which discourage or preclude travel through a neighborhood. Used alone, they will affect only the two specific streets involved.

Primary Traffic Effects

The primary purpose of a diagonal diverter is to reduce traffic volume. It is effective in reducing traffic as a single site application only when the neighborhood it is intended to protect is a limited one. If the neighborhood is larger, with other continuous residential streets parallel to the "problem street," installation of a single diagonal diverter may merely shift through traffic to another local street rather than bounding arterials and collectors. Single site applications of diverters where multi-site approaches are needed has been a common pitfall in the use of diverters to date.

The basic advantages of a diagonal diverter over a cul-de-sac is that, by not totally prohibiting the passage of traffic, it tends to reduce the out-of-direction travel imposed on local residents and maintains continuous routing opportunities for service and delivery vehicles. It also does not "trap" an emergency vehicle and can be designed to permit the passage of some emergency vehicles through the diverter.

Effect on Traffic Volume. Studies to date which have evaluated the traffic effects of diagonal diverters have been primarily system studies; thus the impact of a single installation is difficult to quantify. One of the earliest installations, in Richmond, California in the early 1960's was credited with an overall 16 percent reduction of traffic on neighborhood streets.[91] Seattle, Washington has performed the most comprehensive evaluation of this device and has found that, in a system of devices, traffic on streets with diverters can be reduced from 20 to 70 percent depending on the system of devices in the area, as shown in Table 3.[70-73] In these studies, traffic on non-diverted streets increased as much as 20 percent. Obviously **the amount of traffic reduction in any case is highly dependent on the amount of through traffic at the problem site originally.**

Table 3

Traffic changes on streets with diagonal diverters in Seattle, WA

Street	Daily Traffic Volume Before	Daily Traffic Volume After	% Change
Republican Street west of 17th Avenue	1580	1250	-21
Republican Street east of 17th Avenue	880	380	-57
East Prospect Street	1000	300	-70
16th Avenue at East Prospect Street	860	340	-60
18th Avenue at East Prospect Street	500	270	-46
East Highland Street at 17th Avenue	840	290	-65

Evaluation of diagonal diverters has not been quantified in other cities where they have been tried, but intuitive and judgmental evaluations suggest that they are effective in reducing but not totally eliminating through traffic. In general, a pattern of devices that turns a neighborhood with a grid-style street pattern into a maze tends to be successful whereas systems which use diverters together with devices such as traffic circles or stop signs are less successful. Diagonal diverters tend to be less successful in areas where heavy pressure on surrounding arterial streets make the diverter-created maze of local streets still preferable to some drivers.

Effect on Traffic Speed and Noise. None of the research documents collected in this study have formally evaluated the effect on traffic speed or noise. General comments from citizens and agency staff suggests that diverters are most effective as speed control devices only in their immediate vicinity, within about 200-300 feet (31-61 meters) of the device. However, they are not primarily installed for this purpose. On the other hand, diverters may eliminate from the street a driver population which had formerly used it as a speedy through route. As a result, the net effect on speeds experienced along the street may be substantial.

Diagonal diverters impose no specific operational effects that would affect noise other than through shifts in volume of traffic and changes in speeds. Changes in noise levels can be estimated from techniques contained in NCHRP Report 174.[84] Occasional tire squeal due to motorists attempting to take the turns too fast may be noted.

Figure 8. Temporary diagonal diverter — Berkeley, CA.

Effect on Traffic Safety. Seattle, Washington and Richmond and Berkeley, California have evaluated accident experience before and after the installation of diverters. Each study showed a significant reduction in the number of accidents in the neighborhood; however the actual number in each case was quite small. The Berkeley experience showed that, in parallel to traffic volume shifts, accidents were shifted to arterial streets where a more effective program for dealing with them would be possible. As traffic volume decreased in all cases on the local streets, it is probable that the accident **rate** is not appreciably affected by diverters.

Community Reactions to Diagonal Diverters

Appleyard's studies in the Clinton Park neighborhood of Oakland, California found residents on diverted streets substantially more satisfied with their neighborhood than residents on other streets.[3] Reaction to diagonal diverters generally revolves around whether specific individuals feel they benefit or lose by the device. Residents generally tolerate the slight inconvenience in access which this device creates; they are less tolerant when the device adds traffic to their street. They are often less tolerant of the device in another neighborhood than they are in their own since they perceive those from a driver's rather than resident's perspective. Voting patterns for two initiative ordinances to remove diverters in Berkeley substantiate this. In areas of the city where few diverters are located, a majority of voters voted for removal. Areas of the city where most of the diverters are located voted overwhelmingly to retain them.

Figure 9. **Temporary diagonal diverter — Berkeley, CA.**

Desirable Design Features

For a diagonal diverter, the following features should be incorporated for a safe and effective design:

- **Visibility.** The device should have a high target value to be easily visible both during the day and night. Features such as painted curbs and rails, button reflectors, black and yellow directional arrow signs (MUTCD sign WI-6), street lighting and elevated landscaping can produce a highly visible diverter.
- **Delineation.** Centerline pavement striping supplemented in those areas where weather permits by pavement buttons are useful in further identifying the proper driving path.
- **Safety.** In addition to the visibility items, materials that do relatively little damage if hit are desirable. These would include shrubs rather than trees for landscaping; breakaway sign poles; and mountable curbs if the device contains additional material besides the curb to prevent violations. Temporary barricades of wood and asphalt berm can also be both safe and effective.
- **Emergency Passage.** Designs which permit emergency vehicles to pass while restricting auto passage are desirable. Since an open emergency vehicle gap is an open invitation for other vehicles to pass through as well, some physical control of the passage may be necessary. Undercarriage barriers, which allow emergency vehicle passage while intercepting lower slung cars have been employed with some success. Designs employing gates or chains are less desirable, since they require emergency vehicles to either stop and open the gate or to "crash" through it. Efforts should be made to insure that parked vehicles do not block the emergency passage.
- **Drainage.** A design which stops short of the existing curbline will usually allow existing drainage patterns to be maintained, thereby reducing overall costs.
- **Violation Prevention.** Clearly the device itself should prevent normal traffic from passing through. Additional wooden or steel posts along the adjacent properties may be needed to prevent drivers from driving on lawns, driveways or sidewalks in deliberate violation of the device.
- **Pedestrians, Bicycles and the Handicapped.** Provision should be made for the continuity of bicycle routes around the diverter. Use of sidewalk ramps for bicyclists can also aid persons in wheelchairs. Extension of sidewalks across the diagonal can provide a safe pedestrian crossing.

Figure 10. Typical undercarriage barrier in diverter's emergency vehicle gap

- **Maintenance.** A design minimizing maintenance would minimize the use of plants requiring irrigation. Non-living material would also reduce costs, so long as the design did not inherently act as a collector of litter.

Typical Construction Materials

Temporary Diverters:

- Asphalt Berm
- Concrete Blocks
- Wooden Barricades
- Concrete Bollards with connecting boards or chains
- Steel Posts or U-bars with reflective devices

Permanent Diverters:

- Standard Steel Guardrail
- New Jersey (Concrete) Barrier
- Concrete or asphalt curb — with or without landscaping or continuing sidewalks

Typical Construction Costs

- Temporary Diverters $500-2000
- Landscaped Diverters $1000-12000 and upwards
- Additional fire hydrants $1500-2500

Uniform Standards

Diagonal diverters are not specifically listed in the MUTCD or parallel state traffic control and design manuals. However, they may be defined as a channeling island and may be constructed of and marked with devices shown in the MUTCD or other design manuals. Diverters are specifically recognized as a form of traffic control channelization in basic traffic engineering texts such as **Fundamentals of Traffic Engineering.**[113]

Examples of Current Practice

The physical design of a diagonal diverter can range from extremely simple and inexpensive to costly landscaped permanent fixtures. Figures 8 through 17 show several variations on the theme. Figure 9 is the most simple design. It consists of standard concrete bars placed across the intersection and supported by painted pavement markings and warning signs. The installation is inexpensive, and can be bypassed by fire vehicles if properly designed. It can be violated by a determined motorist. Figure 9 shows the use of concrete bollards as a diagonal diverter, with

Figure 11. **Temporary diagonal diverter — Berkeley, CA.**

Figure 12. **Temporary diagonal diverter — Victoria, B.C.**

Figure 13. **Diagonal diverter — Menlo Park, CA.**

Figure 14. **Diagonal diverter — Berkeley, CA.**

Figure 15. **Landscaped diagonal diverter — Portland, OR.**

Figure 16. **Landscaped diagonal diverter — Oakland, CA.**

Figure 17. **Landscaped diagonal diverter — Richmond, CA.**

Figure 17a. **Diagonal diverter — Minneapolis, Minn.**

a low concrete block which permits passage of trucks and fire vehicles while prohibiting cars to pass. Bicycles and motorcycles can also easily pass through this design. Figure 10 shows a close-up of the undercarriage barrier.

Figure 11 shows the use of bollards and connecting boards as a diverter. This design suffers from the lack of emergency passage, which could be designed as with Figure 10. The figure shows the use of centerline for added delineation, and space at the curb for drainage and bicycle passage.

Figure 12 shows the Victoria, B.C. technique for creating temporary diagonal diverters. The design is inexpensive and provides a highly visible target for the motorist to avoid. Note also the use of wooden posts in the pedestrian area to prevent violation of the barrier.

Figure 13 shows another low cost, more permanent type of diverter. The chain is reflectorized for target value, and can be removed, with some difficulty and delay, by emergency personnel. Planters surrounded by metal poles and raised traffic bars are used in an attempt to add aesthetics, though it appears everything but the kitchen sink has been thrown into this installation. The overall effect is a needlessly cluttered intersection with little visual impact at a distance; yet it does perform its intended function.

Figure 14 shows the use of standard guardrail as a diverter. While low on aesthetic appeal, the white-painted rail is easily visible to drivers.

Figures 15 through 17 are three examples of more permanent landscaped diverters. Figure 15 shows a technique of maintaining pedestrian continuity through the intersection. Figure 16 is an example of simple landscaping which may be somewhat hazardous, since the large rocks do present an obstacle to vehicles jumping the curb, and no warning signs or markings are present.

Figure 17 shows examples of diverters which perform their intended task and also add a measure of psychological deterrent to through traffic. The landscaping, when viewed by drivers from a distance, gives the impression of a street closed to through traffic, an impression not well presented by a number of the other diverters. Note that Figure 17a's design also retains existing drainage patterns by leaving a gap between the diverter and the original curb and gutter. Raised centerline markings provide emphasized delineation for motorists, and posts prevent avoidance of the device through use of the sidewalk or private land.

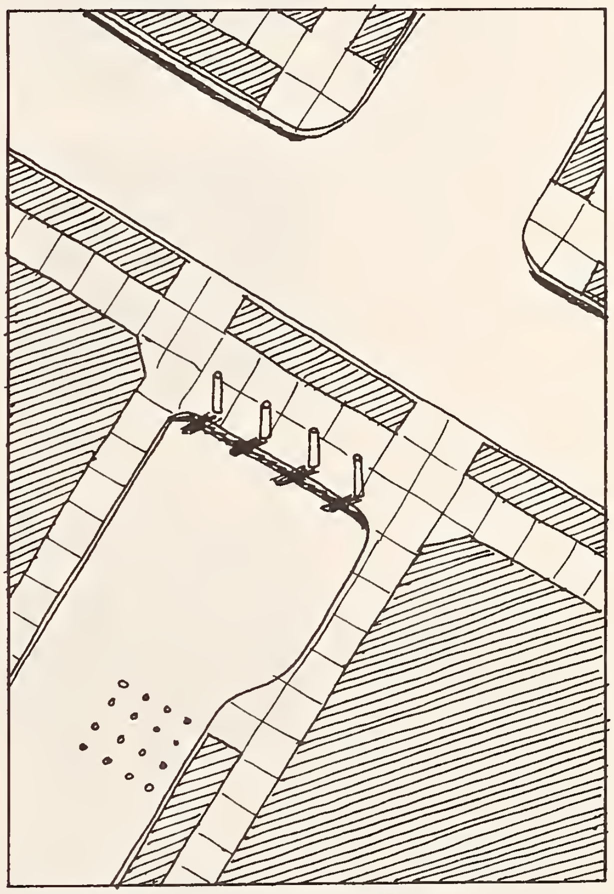
Intersection cul-de-sac

By definition, an intersection cul-de-sac is a complete barrier of a street at an intersection, leaving the block open to local traffic at one end, but physically barring the other. As such, a cul-de-sac represents the most extreme technique for deterring traffic short of barring **all** traffic from the street in question.

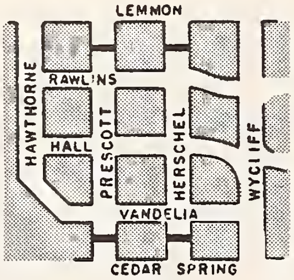
Primary Traffic Effects

Since a cul-de-sac is completely effective at its task of preventing through traffic, the choice of where and whether or not to use it depends largely on other aspects of traffic movement. For example, a cul-de-sac is less desirable in the vicinity of fire stations or police or ambulance bases where emergency vehicle accessibility must be given high priority. It is less desirable than other devices in areas where the potential for multi-alarm fires might exist, since fire departments often wish to maximize the flexibility of vehicular movement in these places. In locations where a heavy traffic generator is near, a full barrier may be the only solution to preventing shortcutting. On the other hand, the design of the cul-de-sac must often allow side or rear access from a local residential street to a high traffic volume generator fronting on an arterial; in this case, a mid-block cul-de-sac, discussed in the following section, may be more appropriate. A cul-de-sac may be desirable adjacent to a park or school where the vacated street can be converted into additional play area. Finally, a cul-de-sac may be considered as a last resort in locations where obstinate drivers violate other less effective devices.

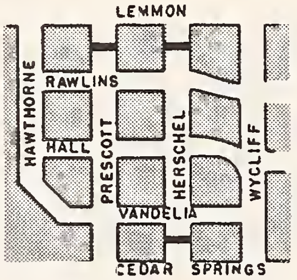
Effect on Traffic Volume. Studies which have evaluated the effect of a cul-de-sac on traffic volume have all shown them to reduce it effectively. Cul-de-sacs at the ends of two streets one-half mile (.8 km) long in Berkeley, California reduced ADT from 9000 to 600 in one case, and from 5700 to 1300 in another.[8] Two block sections in Palo



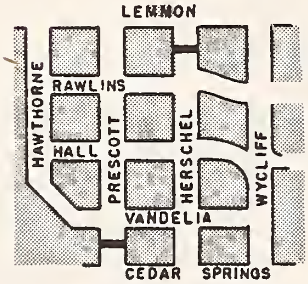
Cul-de-Sac/Street Closures



Alternative 1



Alternative 2



Alternative 3

Source: **Reference 55**

Figure 18. **Alternative diverter locations**

Alto, California were reduced to 200 vpd.[61] In Bethesda, Maryland volumes were reduced to 150 vpd.[96] Experiments with three cul-de-sac plans in Dallas, Texas neighborhoods, shown in Figure 18, reduced traffic within the neighborhood from 10,700 to 3500 for Alternative 1, 3800 for Alternative 2 and 4600 for Alternative 3.[55] In these and other cases, the cul-de-sac clearly limited traffic almost exclusively to that generated locally. Exceptions are the occasional vehicle which unknowingly enters a blocked street and then must maneuver to leave it, and those few vehicles which deliberately violate the barrier.

Effect on Speed and Noise. A cul-de-sac is not a speed attenuating device; thus no evaluations have been made of this measurement. However, if the device eliminates a driver population which had previously used the street as a speedy through route, its ultimate effects on traffic speeds experienced on the street may be substantial. Noise has been found to be reduced as a function of the reduction in traffic volume and speed.

Effect on Traffic Safety. Safety evaluations of cul-de-sacs beyond those systemic studies noted in the diagonal diverters section have not been uncovered in the course of this study.

Effect on Emergency and Service Vehicle Access. The cul-de-sac or complete barrier of a street is the neighborhood protective device that is most objectionable to emergency and service personnel. While designs have been developed with emergency vehicle passageways, even these can be rendered ineffective by cars parked in front of the opening. More so than a diagonal diverter, a complete barrier can cause considerable interference in the proper placement of vehicles combating a fire. They also limit the number of approaches to and maneuverability at a fire scene.

Police vehicles giving chase to a suspect can occasionally be inhibited by a cul-de-sac with or without an emergency vehicle passage. Where no emergency passage is provided, emergency vehicles can become "trapped" by a full barrier, requiring slow and difficult maneuvering to return to a through street. Cul-de-sacs rarely disturb public transit, since transit routes usually do not pass through local streets, but clearly, a cul-de-sac would interfere with any such routes. School bus and garbage routes can usually be rerouted to bypass these types of barriers with little inconvenience.

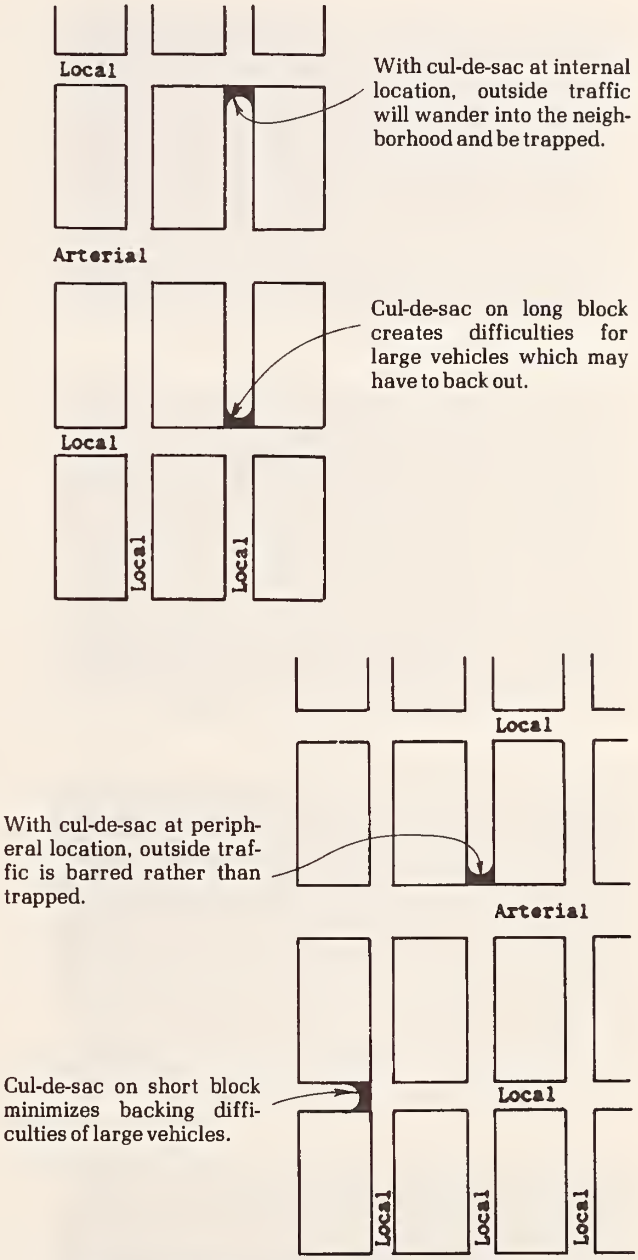
Community Reactions to Cul-de-Sacs. Communities have generally responded positively to cul-de-sacs particularly where a number of such treatments have been installed in a neighborhood. They have been less well received where they merely shift traffic from one street to another. Some resentment occurs if a long detour for access is caused by a series of barriers. Specific problems have also occurred when a barrier is placed next to a residence with its main entrance on one street and its garage on the other. A mid-block treatment can often solve this problem.

Desirable Design Features

A successful cul-de-sac design should incorporate the following features:

- **Location.** Where possible, the barrier forming the cul-de-sac should be placed at an intersecting through street rather than in the interior of a neighborhood. Location in this manner minimizes the inadvertent entrance into the closed street and subsequent maneuvering to exit.

  Because limited turning space on retrofit cul-de-sacs (see below) may force large vehicles to back out, such cul-de-sacs should not be employed on relatively long blocks. Reference sources vary widely in recommendations for maximum cul-de-sac length in new subdivisions: 250-500 feet, **The Urban Pattern;**[107] 400-600 feet, **Residential Streets;**[89] 1000-1200 feet or 20 single family units, **Community Builders Handbook.**[105] Although this guidance is ambiguous, it is suggested that retrofit intersection cul-de-sacs not be employed on blocks exceeding 500 feet. Figure 19 summarizes considerations in cul-de-sac location.
- **Turning Radius.** A typical minimum turning radius standard for cul-de-sacs in new subdivisions is 35 feet (10.5 m). This permits free 180° turning movements by autos and smaller trucks and maneuvering space for larger vehicles. When an existing residential street, perhaps only 36-40 feet wide is made a cul-de-sac, only an 18-20 foot turning radius can be



With cul-de-sac at internal location, outside traffic will wander into the neighborhood and be trapped.

Cul-de-sac on long block creates difficulties for large vehicles which may have to back out.

With cul-de-sac at peripheral location, outside traffic is barred rather than trapped.

Cul-de-sac on short block minimizes backing difficulties of large vehicles.

Figure 19. **Cul-de-sac location implications**

Figure 20. Temporary cul-de-sac — Los Angeles, CA.

Figure 21. Temporary cul-de-sac — Palo Alto, CA.

Figure 22. Cul-de-sac — Walnut Creek, CA.

Figure 23. Cul-de-sac — Berkeley, CA.

provided in the existing traveled way. Most auto drivers will be unable to execute continuous 180° turns in such situations. Bulbing the turning area beyond the existing curblines should be considered where feasible. Parking bans on the approaches to the turning area can also help ease turning movements. If turns are too difficult, motorists will inevitably use private driveways for their maneuvers.

The need for an adequate turning radius is greatest at cul-de-sacs located within a neighborhood where inadvertent entrances to a block are more likely to occur. They are needed less where the barrier is at an arterial, and few strangers are likely to enter the block. In most existing neighborhood street situations it will be impractical to provide turning radius for large single unit and articulated trucks at cul-de-sacs.

- **Visibility.** The most important visibility aspects for cul-de-sacs are at a distance from the device itself. Landscaping or other clearly visible provisions should identify the fact that the street is not a through street. "Not a Through Street," "Dead End" (W 14-1)* or "No Outlet" (W 14-2) signs should be clearly visible at the block entrance to prevent inadvertent entrances.

  Visibility requirements for the design itself depend on the nature of the location. Locations with inherently low surrounding volumes need little in the way of visibility. Devices adjacent to arterials should be highlighted with reflectorized paddles or button reflectors. Designs with emergency vehicle passage should include standard "Do Not Enter" (R 5-1) signs.

- **Drainage.** As with diagonal diverters, designs of full barriers can maintain existing curb and gutters, minimizing costs associated with revising drainage flow.

- **Violation Prevention.** In cases where a barrier is placed in the face of even modest community or driver opposition, the lawn, sidewalks, and driveways adjacent to the barrier may require protection by wood or metal posts to prevent

---

*Parenthetical references are device identification nomenclature from the **Manual on Uniform Traffic Control Devices.**

circumvention of the barrier.

- **Pedestrians, Bicycles and Handicapped.** Designs with emergency passage provision should also provide for these non-motorized travelers. Without emergency passage, special ramps for bicycles and wheelchairs may be needed if sufficient numbers of them are present. As with diagonal diverters, pedestrian continuity can be aided by extending sidewalks across the end of the barrier.
- **Maintenance.** Landscaped designs which provide for no irrigation requirements or for plantings similar to adjacent parkways can minimize maintenance requirements.

Typical Construction Materials

All materials listed in the diagonal diverter section can be equally well used for cul-de-sacs.

Typical Construction Costs

- Temporary Barrier $500-2000
- Landscaped Barrier $1000-12,000
- Additional fire hydrant $1500-2500

Uniform Standards

Permanent cul-de-sacs are a standard treatment in the design of new residential developments. Retrofit treatments are not currently recognized in the MUTCD, but can be constructed of materials and techniques present in many design manuals. Basic traffic engineering reference texts do acknowledge the use of retrofit cul-de-sacs for residential traffic management.[113]

Examples of Current Practice

The physical design of cul-de-sacs, as with all structural protective devices, can vary from inexpensive and simple to expensive and fully landscaped. Figures 20 through 29 present a sampling of typical treatments. Figures 20-22 represent the least costly approach to closing a street. Wooden barricades or asphalt berms, as in Figures 20 and 21, represent a reasonable first step or temporary technique for closing a street. The asphalt berm in Figure 21 includes provision for emergency vehicles with an undercarriage barrier to automobiles.

Figure 22 represents a political as well as a technical solution. In this case, the connection between two ends of a street was never made in the first place. The crude fence thus effectively

Figure 24. **Cul-de-sac — Berkeley, CA.**

Figure 25. **Cul-de-sac — Menlo Park, CA.**

Figure 26a. **Permanent Cul-de-sac — Palo Alto, CA.**

Figure 26b. **Permanent Cul-de-sac — Hartford, CT.**

Figure 27. **Permanent cul-de-sac — Palo Alto, CA.**

Figure 28. **Lanscaped cul-de-sac — Palo Alto, CA.**

Figure 29. **Landscaped cul-de-sac — Palo Alto, CA.**

accomplishes its purpose.

Figure 23 shows the use of chain link fence as a cul-de-sac tool. The fence was used to extend an existing school play-yard.

Figures 24 and 25 show the use of bollards and planters as part of a barrier. In each case, provision is made for emergency vehicles, although removal of the chain in Figure 25 is somewhat awkward.

Figures 26-28 represent more permanent and elaborate treatments. Figure 26a, a device still under construction, shows intelligent use of planters, provision of emergency passage which is easily mountable by bicycles, undercarriage barrier to discourage violation by autos, specific connection of ramps across the device for bicycles and wheelchairs, an attractive mounting of the "Do Not Enter" sign, and provision for drainage in accordance with the pre-existing pattern. Figure 26b, similar in concept but with wooden planters rather than the inset concrete planter wells, was observed to experience a high violation rate due to the absence of any physical device discouraging use of the emergency vehicle passage.

Figure 27 shows a similar emergency passage treatment, but no plant materials requiring maintenance. The low fence and bench constructed of redwood make a visually attractive device.

Figure 28 shows a cul-de-sac with the vacated portion of the street converted to a landscaped mini-park.

Finally Figure 29 shows a typical traffic engineering technique which can aid the neighborhood as well as simplifying a complex intersection. At this former six-leg intersection, a minor leg has been blocked to create both of the desired effects. Note that sidewalk ramps, provided for continuity of bike lanes, are visible in the foreground.

Midblock cul-de-sac

A cul-de-sac placed within a block, rather than at one end, performs the same function as an intersectional cul-de-sac with two small differences. A midblock location can be chosen so that the residence at a corner will have easy access to the attached garage without the need to travel several blocks to avoid the barrier. Midblock cul-de-sacs shorten the distance a large vehicle which can't turn around would have to back-up as compared to intersection cul-de-sacs applied to the same streets. It has the disadvantage of being less apparent to the motorist on the through streets, so that occasional vehicles will turn into the blocked street and then have to work their way out. Traffic effects, design features, typical construction materials and costs, and legal status are similar to those listed in the previous section.

A midblock barrier can be especially useful in locations where a high traffic generator borders a residential area. As shown in Figure 30, the barrier can permit access to the generator from an arterial street while protecting the neighborhood from through traffic.

Figures 31-33 show three techniques for constructing midblock cul-de-sacs. Figure 31 shows the use of a fully landscaped median to physically block the street, as well as making clear from a distance that the street is not intended for through traffic. Figure 32 illustrates a special case where an adjacent park was extended into the former right-of-way with the aid of a cul-de-sac treatment. Neither of these designs provide passage for emergency vehicles.

Figure 33 shows a more elaborate treatment providing a buffer between residential and commercial districts, with some widening of the roadway to provide an adequate turning radius. Siting of the cul-de-sac to provide access to driveways is well shown in this figure, as is the provision for emergency vehicles.

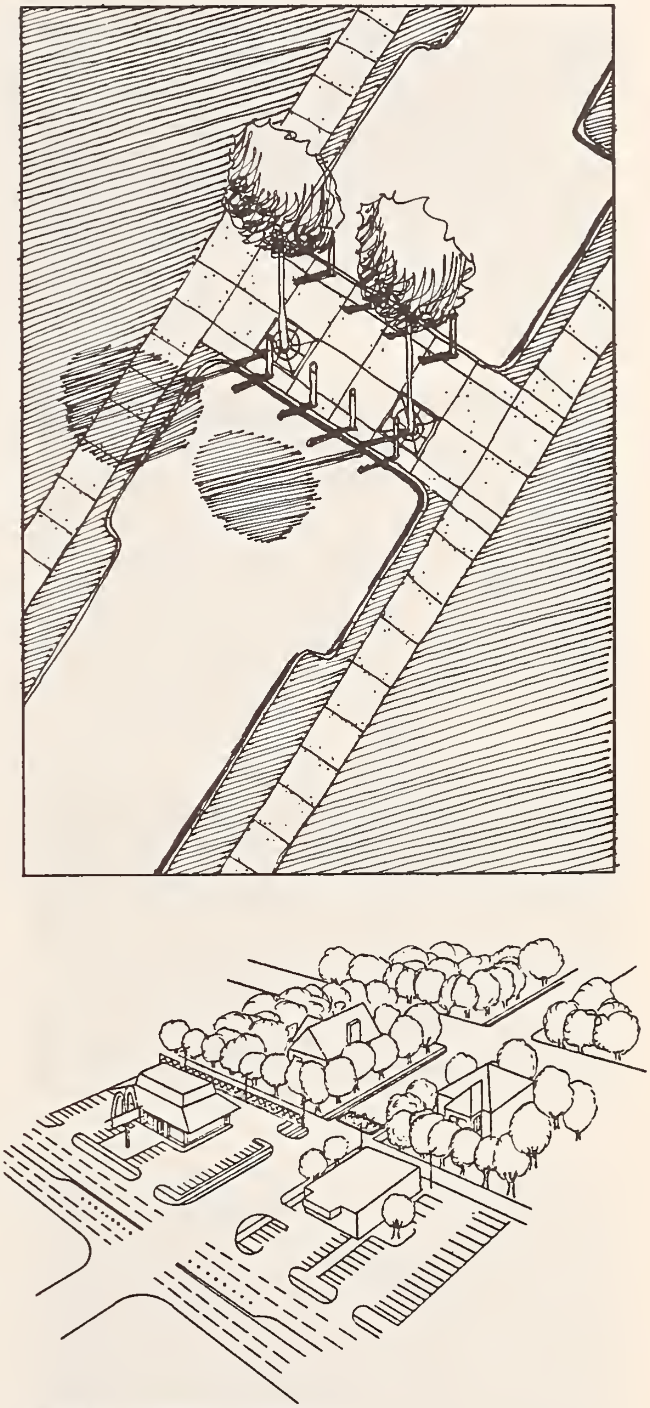
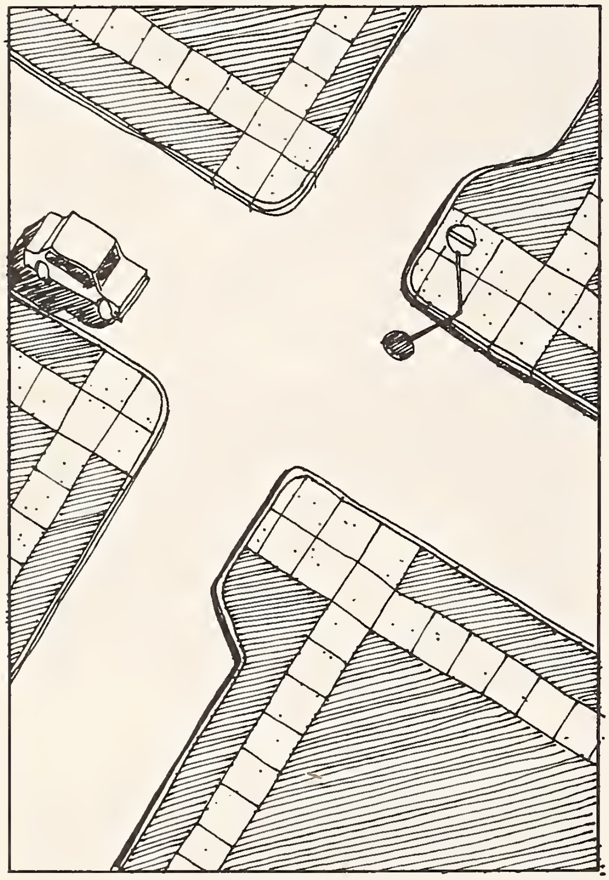


Figure 30. **Midblock cul-de-sac**
Source: **Reference 55**

Semi-diverter

A semi-diverter is a barrier to traffic in one direction of a street which permits traffic in the opposite direction to pass through. In a sense, it

Semi-Diverters



is a "Do Not Enter" signal to drivers, providing an added level of warning and physical reinforcement to motorists beyond what a simple sign would do. Because they block only half of a street, semi-diverters are easily violated, particularly on low volume streets. At the same time, they provide a minimal impediment to emergency vehicles. Experience has shown that they work best in areas where neighborhood traffic management is generally well-accepted by the public.

Primary Traffic Effects

The primary purpose of a semi-diverter is to reduce traffic volume; it has little value as a speed reduction device. Its best use is when one direction on a street is used as a shortcut. A pair of semi-diverters can be used at opposite ends of a pair of blocks to effectively discourage traffic in two directions.

The semi-diverter's main advantages over full barriers or cul-de-sacs are a reduction of interference with local traffic and a minimization of impact upon emergency and service vehicles. Its major disadvantage is in the ease of violation, particularly at midblock and internal neighborhood locations where the temptation to violate the barrier rather than maneuver and retrace one's path is usually too great.

Effect on Traffic Volume. Evaluation studies to date have shown that semi-diverters can make significant reductions in volume though residents may often focus on the violation level rather than the reduction level. Studies of a neighborhood in San Francisco, where semi-diverters were placed at opposite ends of block pairs, showed an average reduction on four streets of 40 percent to an average of 1000 vpd.[67] Other semi-diverters have shown similar effects, though few have been quantified. A study in Berkeley, California showed a 30 percent violation rate of total movements approaching the barrier from the wrong direction; however, this was only 7 percent of the volume previously using the street.[21]

Effect on Traffic Speed and Noise. Since a semi-diverter is not a speed reduction device, data has not been gathered that would measure its effect. However, if it diverts drivers who formerly used the street as a speedy through route or shortcut, the actual change in speed experienced after installation may be substantial. Effects on noise levels are directly related to the reduction in traffic volume.

Effect on Air Quality and Energy Consumption. As with most devices considered herein, the air quality changes in the micro-environment are miniscule since most auto-related pollutants which affect neighborhoods are responsive to changes in emissions on a regional basis rather than that in a small, localized area. Energy consumption can be assumed to be somewhat increased due to slightly longer distances and added stops on arterial streets.

Effect on Traffic Safety. In San Francisco a study evaluating safety of semi-diverters observed a 50 percent reduction in the number of accidents over a 4-month period.[67] This period is probably too short to be accepted as statistically significant. The apparent reduction in accidents also parallels the almost 50 percent reduction in volume, suggesting that semi-diverters had no real overall effect on the rate of accident occurrence per unit traffic. Experience in Berkeley suggests that rather than a reduction in total accidents, a shift of accident location to major streets may have occurred.[21] Still, even if just a locational shift, this effect should be counted as a benefit because accidents are moved from local streets where they are extremely disturbing to residents to arterials and collector streets where they can be dealt with more effectively using normal traffic safety measures.

Community Reactions to Semi-Diverters

People living on streets with a semi-diverter have been generally favorable to them. The major negative reactions have been due to the observed violations and lack of enforcement to prevent them.

Desirable Design Features

- **Location.** A semi-diverter is best located at the end of a block to prevent entrance and permit exit. Diverters located in a way such as to prevent exit are easily and frequently violated. Experience suggests that semi-diverters in midblock locations are also more frequently violated than end-of-block placements, though they still have some effectiveness.

Figure 31. **Landscaped midblock cul-de-sac — Richmond, CA.**

Figure 32. **Midblock cul-de-sac with park — Palo Alto, CA.**

Figure 33. **Permanent midblock cul-de-sac — Berkeley, CA.**

Figure 34. **Semi-diverter — Pleasant Hill, CA.**

Figure 35. **Semi-diverter — San Mateo, CA.**

Figure 36. **Semi-diverter — Walnut Creek, CA.**

Figure 37. **Semi-diverter treatment — Walnut Creek, CA. (Note evidence of avoidance route on lawn at right)**

Figure 38. **Semi-diverter — Berkeley, CA.**

- **Visibility.** Since the semi-diverter tends to be a somewhat small device, care should be used to insure visibility, particularly at night. "Do Not Enter" (W 5-1) signs, painted curbs, and reflectorized signs and construction materials are useful for aiding visibility. "Not a Thru Street" signs are needed at the entrance point of a block to prevent inadvertent entrance and subsequent maneuvering to get out.
- **Violation Prevention.** Constriction of the traveled way in the direction in which traffic is permitted to pass the diverter can make violations difficult.
- **Emergency Passage.** This is inherently permitted by the design of the device. As long as sight distance is good, it is quite acceptable for emergency vehicles to travel in either direction on the "open" side of the semi-diverter. However, if traffic is queued on the "open" side, awaiting a gap in cross street traffic, emergency vehicle passage can be delayed.
- **Bicycles and the Handicapped.** Care should be taken to provide a legal bypass for bicycles and wheelchairs; otherwise cyclists in particular will dangerously violate the device by riding "wrong way" on the open side.

Typical Construction Materials

Materials used for diagonal diverters are equally usable for semi-diverters.

Typical Construction Costs

- Temporary Semi-Diverters $300-1200
- Landscaped Semi-Diverters $1000-8000

Uniform Standards

Semi-diverters are not included in the Manual of Uniform Traffic Control Devices. Like other diverters, they define an area which is not in the traveled way and can be comprised of elements included in the MUTCD and other design manuals. Semi-diverters are recognized as residential traffic control treatments in some basic traffic engineering reference texts.[43]

Examples of Current Practice

Figures 34-38 show some design techniques for semi-diverters. Figure 34 illustrates the placement of a guard rail semi-diverter at an intersection with a major arterial. This is perhaps the most effective treatment, since the narrowing of the local street makes right turns from the arterial (in violation) most difficult. Figure 35 shows the use of a guard rail semi-diverter at the intersection of two local streets. Pavement bars painted white are used to give added emphasis to the presence of the barrier.

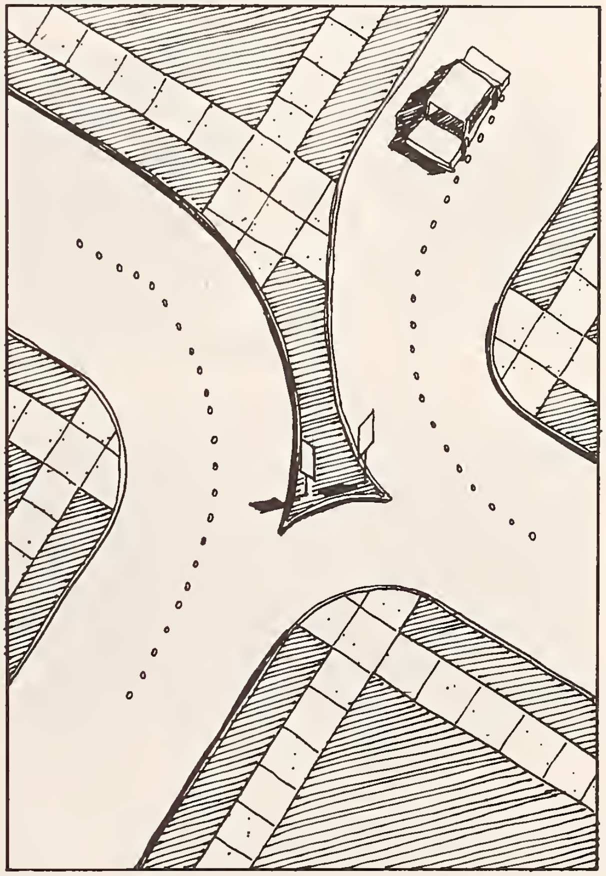
Figures 36 and 37 show another inexpensive treatment; in this case, a standard design for the New Jersey concrete median used for freeways and high-speed facilities is used as the barrier. This is a somewhat unforgiving design when struck by a vehicle, particularly when struck from the side by a vehicle on the arterial street. Figure 37 shows signs and pavement markings on the arterial street to guide arterial traffic safely away from the diverter. In addition, the prominent tracks on the lawn at the right of the figure dramatically show the extent of driver attempts to circumvent the device. Clearly, additional posts or barriers are needed to prevent such violations.

Finally, Figure 38 shows the use of bollards as a semi-diverter in a midblock location. All of these illustrations are temporary or low cost designs. More elaborate landscaped fixtures similar to illustrations shown for diverters and cul-de-sacs are possible.

Forced turn channelization

Forced turn channelization usually takes the form of traffic islands specifically designed to prevent through traffic from executing specific movements at an intersection. Its basic function is the same as a diagonal diverter — to make travel on local streets difficult, but not prevent it entirely. Generally this technique is best used at an intersection of a major and a local street, where the major street is basically unaffected by the channelization, or even has its traffic flow qualities enhanced, while through traffic on the local street is prevented. Employed in such locations, it prevents traffic flow from one neighborhood to another across the major street. It can also be used on purely local streets to permit turning movements other than those possible with a diagonal diverter. However, it is more

Forced Turns



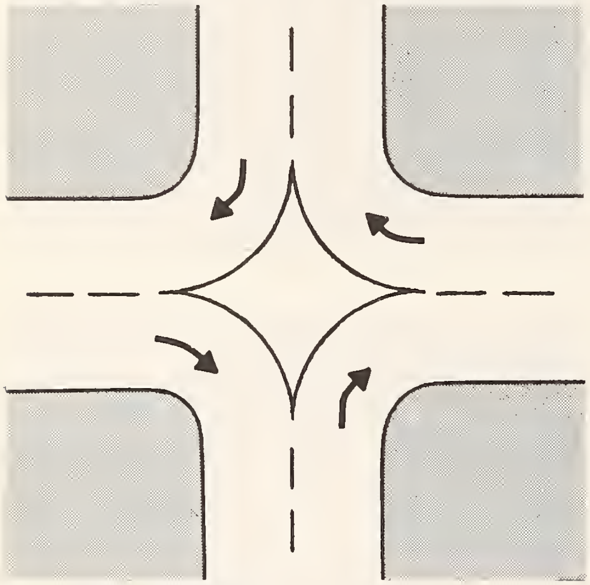


Figure 39. "Star" diverter

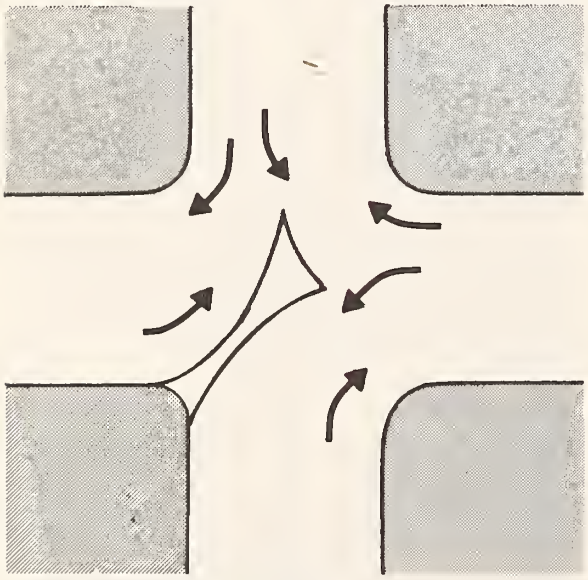


Figure 40. Partial diagonal diverter

likely to be violated within a neighborhood, since the threat of enforcement is minimal.

Primary Traffic Effects

As noted above, the primary purpose of forced turn channelization is to make travel through neighborhoods difficult, while not preventing it entirely. As shown in Figures 39-44, forced turn channelization can take numerous forms and must usually be customized to deal with specific traffic movements to be prevented. Because channelization has become a well-accepted and well-used traffic control device, it tends to have a higher level of obedience than the other partial restrictions, particularly when used on an arterial street.

Effect on Traffic Volume. Documented studies of this device generally show that their success depends on whether or not the movement prevented is a significant one. For example, an evaluation of a neighborhood in Seattle using so-called "star" diverter, which permits only right turns on all approaches, had little effect on overall volumes.[70] Channelization on a street in Palo Alto, California reduced volumes to 1000 vpd, while increasing them on surrounding residential streets.[61] The channelization in Figure 43 in Richmond, California is effective in preventing traffic from passing through a neighborhood to access a major shopping center.

Effect on Traffic Speed and Noise. Channelization tends to have a minimal direct effect on speed, other than the required slowing for turning. But if it diverts a driver population which had previously used the street as a high speed through route, the actual change in speeds experienced on the street may be marked. The amount of noise reduction is parallel to the amount of traffic volume and speed reduction.

Effect on Air Quality and Energy Consumption. While this technique does add some slowing and accelerating, as well as added distance on other routes, the effect is considered to be negligible.

Effect on Traffic Safety. Studies have not evaluated the safety effects of these devices, primarily because their effects tend to be masked by other traffic actions. However, numerous traffic engineering studies have shown that channelization tends to increase the safety of locations where the design adds clarity and simplicity and is easily understood.

Community Reaction to Channelization. Programs involving channelization have generally been acceptable to communities where proper planning and communication has occurred. Specific problems have come from specific individuals or high volume traffic generators whose access has been impaired. Citizens have also complained where the design did not adequately prevent violations from occurring.

Desirable Design Features

General practices in the area of channelization including design of effective turn radii, merging distances and visual clarity, are applicable to this device. Other desirable features include:

- **Visibility.** Channelization will usually be constructed of some type of raised material, either curb and gutter, concrete bars, or asphalt berm. Painting the devices white will add to the visibility, as will standard signs ("No Right Turn," (R 3-1); "No Left Turn," (R 3-2); etc.) indicating the turns permitted and/or prohibited. Since channelization is generally limited in size and close to the traveled way, the number of signs and other vertical visibility indicators should be limited to minimize physical targets and maintenance while maximizing visual target value.
- **Delineation.** Striping parallel to the device and continued (dashed) through the intersection aids in the clarity of the design.
- **Safety.** Minimizing the "clutter" of excessive signs can minimize the potential for fixed object accidents. However, sufficient signing should be present to avoid inadvertent violation of the intent of the channelization.
- **Violation Prevention** is best done by assuring that the channelization covers a significant part of the intersection, thereby narrowing the area where illegal turning movements can be made.
- **Emergency Passage.** High speed emergency passage is generally difficult to provide for without also providing for easy violation of the

Figure 41. **Forced turn channelization — Seattle, WA.**

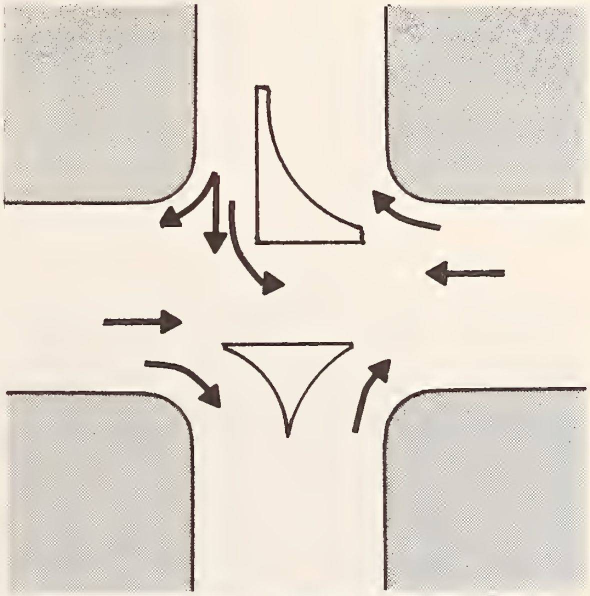


Figure 42. **Channelization to limit certain movements**

Figure 43. **Forced turn channelization — Richmond, CA.**

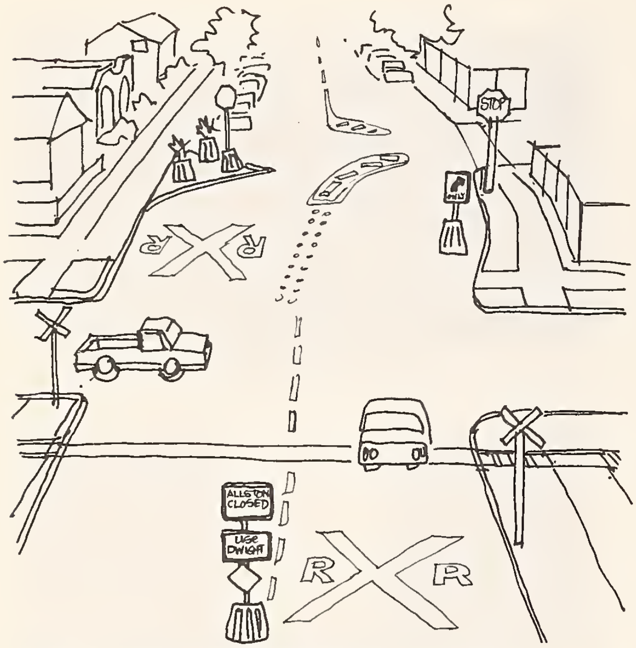


Figure 44. Forced turn channelization — Berkeley, CA.

Figure 45. Forced turn channelization — Berkeley, CA.

Figure 46. Forced turn channelization (ineffective design) — San Francisco, CA.

intent of the device. However, emergency vehicles can usually maneuver around such channelization without severe delay. Channelization using raised bars or asphalt berm can be traversed by emergency vehicles with some difficulty and discomfort, particularly to firefighters riding on the outside of an apparatus.

- **Pedestrians, Bicycles and the Handicapped.** Special care should be given to providing routes for bicycles through a channelized area; otherwise, cyclists will tend to make their own way, often in violation of the channelization and sometimes at a hazard to themselves. Islands designed to give adequate refuge for pedestrians should also provide for ramps for wheelchairs.

Typical Construction Materials

- Concrete Blocks
- Asphalt Berms
- Curb and Gutter (Islands)
- Pavement Buttons

Typical Construction Costs

- Asphalt Berm and concrete blocks $200-1500
- Islands $1000-10,000

Uniform Standards

Channelization is a well-accepted MUTCD device, which recognizes the use of all the above materials for use in control of turning movements.

Examples of Current Practice

The design of forced turn channelization is a task which must respond to unique conditions of each location. Thus, the approach of customizing each design must be used. Figures 39-46 present only a few of the possible techniques.

Figure 39 is a diagram of the Seattle "star." The design of the island permits only right turns from all approaches.

Figure 40 represents a hybrid of the star and the diagonal diverter, providing for more turning movements than either. Figure 41 shows an actual installation.

Figure 42 shows a diagrametic use of raised islands to prohibit certain movements. The shape of the islands can limit or permit certain desired movements, depending on the specific situation.

Figure 43 shows the use of islands at an entrance to a major shopping center. The islands force traffic leaving the center to turn, thus avoiding the neighborhood in the background. They also force traffic from the neighborhood to use another entrance to the center. The overall effect is to limit the use of the local street as a shortcut. Note that the design makes no special provisions for bicycles, though pedestrians are well served with signal actuation buttons on the median island.

Figure 44 shows the use of bars and buttons to force all traffic to enter or leave a major traffic generator (a city maintenance yard); through traffic is not permitted. While not inherently an absolute barrier to traffic, the design has resulted in effective reduction of traffic. Clearly, this design is dependent on community acceptance and obedience rather than on physical constraint of traffic movements.

Figure 45 shows a simpler forced turn channelization comprised of centerline striping and raised bars.

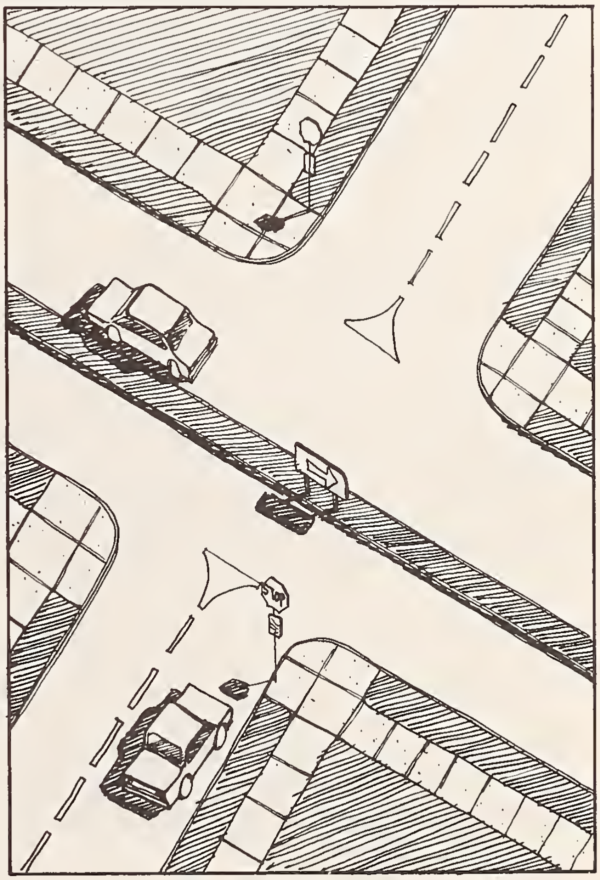
Figure 46 shows the wrong way to design channelization. The island is so short that it is easily and frequently violated.

Median barrier

The median barrier is a standard traffic engineering device generally used to improve flow on a major arterial street. It has been used to limit the number of places where left turns can be made, thus concentrating turns at places where they can be better controlled, often with turn pockets and signals. Median barriers also limit the number of places where through traffic on local streets can flow from one neighborhood to another.

The median barrier is one of the few devices which can aid arterial flow and neighborhood protection at the same time. By restricting the number of through and turning movements at an intersection, a median barrier can be as effective as a full or partial barrier or diverter in reducing traffic on residential streets. Since the median barrier is an accepted arterial treatment, it is less likely to arouse opposition than other more obvious physical treatments. In terms of planning, the designer or planner need

Median Barriers



only consider the needs of the neighborhood as well as the arterial in choosing where to create breaks and turn pockets in the median.

A median barrier is most effective in locations where through traffic is prevented from crossing on a number of local streets; otherwise, the effect would be to merely shift traffic from one local street to another. Often, maintaining median continuity across several local streets is not possible on arterials with commercial developments since this type of land use usually requires numerous breaks in the median. The possibility of designing midblock pockets for U-turn opportunities in such areas could be considered. However, the advisability of this adjustment will depend on the traffic characteristics of the arterial in question. Median barriers do not necessarily require extra pavement width; concrete bars placed across an intersecting street on the centerline of an arterial can serve the function quite well.

Primary Traffic Effects

Neighborhood traffic management related purposes of a median barrier are to prevent left turns onto and from a minor street, to prevent traffic on a minor street from crossing a major arterial, to improve arterial flow, and secondarily, to reduce speed. In conventional applications, median barriers also help prevent head-on collisions of opposed direction traffic. Median barriers have been shown in numerous studies to have a beneficial safety effect as well.

Effect on Traffic Volume. The use of the median barrier as a protection device has been best documented in Gothenberg, Sweden.[26, 30] Median barriers were used on a loop road around the central business district, resulting in a traffic reduction of 70 percent on streets inside the loop and an increase of 25 percent on the circumferential street. In the United States, the emphasis in the use of this device has related to their effects on arterial streets, rather than on the neighborhood. However, they have clearly had a beneficial, if unquantified, effect on reducing volumes on some local streets.

Effect on Traffic Speed and Noise. Median barriers have been infrequently used to control speeds on small radius curves on arterial and residential streets. By preventing traffic on the outside of the curve from crossing the centerline to "straighten out the curve," the median barrier emphasizes the degree of curvature and causes traffic to slow. A study in Richmond, California on a 150 foot (45 meters) radius showed that the installation of 1½" (.03 meter) high concrete bars reduced average speeds from 22 to 16 mph (35-26 kmph).[92] Installations on 170-275 foot (51-83 meter) curves in Concord, California reduced speeds on the outside of the curve by 8-10 mph (13-16 kmph), but had no effect on speeds on the inside of the curve.[53] Curves with radii greater than 300 feet (91 meters), with safe speeds in excess of 30 mph (48 kmph), will generally be unaffected by this treatment.

Median barriers which reduce accessibility to neighborhood streets may exclude a driver population which formerly used the streets as speedy shortcuts. In this sense they might substantially change speeds experienced along residential streets.

No evaluation of the impact of median barriers on noise has been discovered in the data gathered in this study. To the extent that they reduce traffic volume or speed, noise is likely to be reduced.

Effect on Air Quality and Energy Conservation. The use of median barriers has a marginally positive effect on air quality and energy conservation when they improve the quality of flow along an arterial street. Some of these benefits can be lost, however, if turning movements become so concentrated at specific locations that excessive delay and waiting time occurs to turning vehicles. However, as with all of the devices discussed herein, the effect on air quality on local streets is primarily related to over all traffic emissions in the region and little affected by small changes in localized emissions.

Effect on Traffic Safety. Studies of median barriers have shown that they improve the safety of the arterial street, and that the improvement is inversely proportional to the number of openings permitted in the median.[17] The effect on safety of local streets has not been quantified, but a reduction in accidents proportional to reductions in traffic can be presumed.

Desirable Design Features

Details of effective design for median barriers are contained in most state design manuals. Warrants and design details are also contained in two NCHRP documents: NCHRP Report 93, "Guidelines for Median and Marginal Access Control on Major Roadways";[37] and NCHRP Report 118, "Location, Selection, and Maintenance of Highway Traffic Barriers."[38] These publications are concerned primarily with the barriers effect on the arterial streets. Desirable design features in regard to protection of local streets include:

- **Location.** Location of a median barrier should include consideration of prevention of through traffic and shortcutting; however, it must also provide access to high traffic generators bordering a neighborhood. Where these generators exist, some other type of device may be appropriate.
- **Visibility.** Visibility is rarely a problem since arterial streets where medians are placed are usually well lit. Use of reflectorized buttons and "No Left Turn" (R3-2) signs can improve visibility of the median from the local street.
- **Safety.** The two key items for a safe median design involve end point design and pedestrian protection. Design of the end point should minimize damage to a vehicle that strikes the end of the barrier. Techniques such as mountable curb, burying of guard rail ends, and a tapered end for the New Jersey concrete barrier are effective. Signs, light poles and other fixed objects should be located as distant as possible from the end of the barrier. Diverging striping in advance of the barrier is also effective.

  Protection for the pedestrian can be accomplished by use of sufficiently wide medians to give the pedestrians "trapped" on the island a relative feeling of safety. Standard minimum design widths of four feet generally do not meet this objective; 6 feet (1.8 meters) is a more desirable goal. Additional protection may be provided through the use of guard rail around the pedestrian area; however, such a design adds another fixed object

Figure 47. **Median Barrier — Albany, Ga.**

Figure 48. **Median Barrier — Redwood City, CA.**

Figure 49. **Median Barrier — Los Angeles, CA.**

near the travel path, with an inherent potential for fixed object accidents. The probabilities for both fixed object and vehicle-pedestrian accidents on a median should be considered when this added level of protection is provided. Traffic signals designed to be actuated on the median for the separate sides of a roadway also improve pedestrian safety while minimizing delay to the motorist.

- **Emergency Passage.** Emergency passage across a median barrier is provided at regular median openings. In addition, mountable curbs or ramps and paved emergency vehicle passages can be provided.

Typical Construction Materials

Common construction materials include raised concrete islands, concrete bars, asphalt berms, "New Jersey Barrier" with or without a raised island, and standard guard rail with or without a raised island.

Uniform Standards

Median barriers are a recognized MUTCD device and are provided for in State design manuals.

Examples of Current Practice

Figures 47 and 48 show two typical uses of raised median islands to limit turning movements to right turns only. Figure 48 adds visibility emphasis through use of a Right Turn arrow. The latter technique has little value in regions where snow is a problem; a "Right Turn Only" sign could aid visibility in all cases.

Figure 49 illustrates the use of concrete bars in a painted median to prohibit left turns.

Figures 50 and 51 show the use of concrete bars and asphalt berm to reduce speed. As noted, these devices are only partially effective on curve radii of less than 300 feet (91 meters).

Figure 50. **Median Barrier — Concord, CA.**

Figure 51. **Median Barrier — Concord, CA.**

Traffic circles

Traffic circles are another arterial treatment which have recently gained increasing usage in residential areas. Originally used mainly in European and eastern U.S. cities at complex intersections, smaller circles are now being tried mainly as speed control devices. They also have some impact on traffic volume. In this latter use, they have little impact unless used as part of a group of circles or other devices that slow or bar a driver's path.

In such situations, volume reductions result from psychological rather than physical impacts on traffic. Their presence when viewed from a distance gives an impression of obstruction to traffic. If drivers have encountered real barriers at other points in the community, they are likely to believe that the circle is yet another one and change routes before they get close enough to see what it actually is.

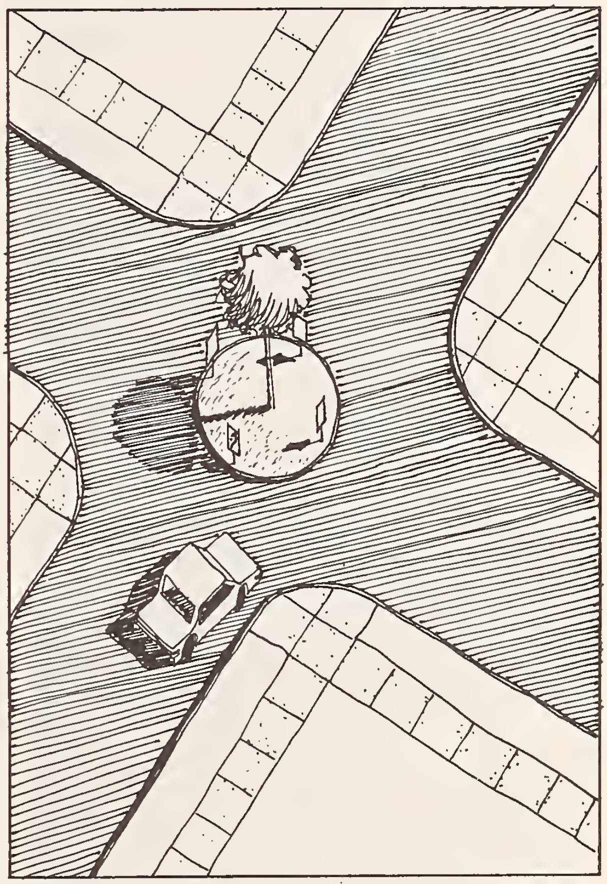
Actually, traffic circles have little effect either on traffic volume or speed. But they do give the neighborhood a feeling that "something has been done." As with other devices, the perception rather than the reality of an impact may be most useful.

Primary Traffic Effects

Effect on Traffic Volume. The studies which have examined traffic volume effects of traffic circles have also included other devices in their proximity; thus the effects of circles on volumes is not presently quantifiable. Professional statements on this effect have been largely subjective, and in some cases biased toward a particular selling point. The case for circles as a volume reducer is thus not clear.

Effect on Traffic Speed. The effect on vehicle speed has been shown to be related to the size of the circle, the distance from the circle at which speeds are measured, and the presence or absence of additional obstructions at the intersections.

A study in Sacramento[101] tested the effects of varying the size of the circle on traffic speed using temporary circles made from sand-filled barrels, supplemented by "Keep Right" signs. "After" measurements were made one week follow-



Traffic Circles

Figure 52. Temporary Traffic Circle — Seattle, WA.

Figure 53. Temporary Traffic Circle — Berkeley, CA.

Figure 54. Temporary Traffic Circle — Berkeley, CA.

ing the change in circle size at distances 50 and 300 feet (15 and 91 meters) from the intersections. Speed differentials 300 feet (91 meters) from the intersections were negligible; however, the larger circles were shown to be effective within 50 feet (15 meters) of the intersection, as shown in Table 4.

Table 4
Vehicle speeds for various traffic circle sizes in Sacramento, CA; 50 feet from intersection

Circle Diameter		85th Percentile Speed	
Feet	Meter	MPH	Km/H
No Circle		26 - 38	42 - 61
14	4	26 - 28	42 - 45
16	5	24 - 28	38 - 45
20	6	21 - 24	34 - 38
24	7	20 - 21	32 - 34

Another study in San Francisco[49] confirmed that within 300 feet (91 meters) of an intersection, the circle has little effect; however, speeds were reduced to 16 mph (26 kmph) at the intersection.

Other studies have shown less effect. A temporary circle in Saratoga, California showed that a circle reduced speeds by 3 mph (5 kmph) from an 85th percentile speed of 32 mph (51 kmph) at a distance of 85 feet (26 meters) from the intersection.[68] An unquantified study in Berkeley, California indicated that the circles of 10-20 feet (3-6 meters) in diameter had little effect on speed.[21]

Effect on Noise, Air Quality, and Energy Consumption. No studies have evaluated these effects. It can be deduced that the effects in the areas are marginal as they relate to small effective changes in speed.

Effect on Traffic Safety. While no formal statistics exist on traffic circle safety, considerable observations have been made of unsafe practices caused by circles. They present an increased hazard to pedestrians by bringing vehicles, some at relatively high speeds, nearer to the curb where the pedestrians are waiting. The deflection they cause to an automobile can also impinge upon a bicyclist's path. Observations have also been made of vehicles striking curbs or jumping over them into lawns when diverted by circles. Vehicles are frequently observed passing to the left of a circle when completing a left turn. Each of these are unsafe actions which can be directly attributed to the device itself. The lack of substantiating accident statistics tend to speak more to the short time of usage and usage on low volume streets rather than necessarily indicating inherent safety of the devices.

Community Reaction to Traffic Circles

Community reaction to traffic circles has been mixed. Some people, particularly those in the immediate vicinity of a circle, perceive a reduction in the speed of traffic. Others perceive them to have no effect or to act mainly as a nuisance. The mixed reception makes prediction of the acceptance of this device rather difficult at this time.

Desirable Design Features

- **Location.** Traffic circles should not be located where a clear pedestrian or bicycle demand may create conflicts as noted above.
- **Visibility.** The circle itself should be made of materials with a high target value for both day and nighttime visibility. "Keep Right" (R4-7) signs should be visible on all approaches.
- **Delineation.** Centerlines should be used on each approach to guide traffic around the circle.
- **Safety.** Crosswalks should be located out of the influence zone of a circle. Parking restrictions should be placed adjacent to the intersection to minimize conflicts with parked vehicles.
- **Size.** The circles should be large enough to impact speed, as shown in Table 3, but they must permit trucks and fire engines to make all necessary turning movements.

Typical Construction Materials

Temporary Circles:	barrels or concrete bollards
Permanent Circles:	bollards or curbed island with or without landscaping

Figure 55. **Temporary Traffic Circle — Nighttime Photo — Berkeley, CA.**

Figure 56. **Permanent Traffic Circle — Seattle, WA.**

Figure 57. **Midblock Traffic Circle — Del Mar, CA.**

Figure 58. **Permanent Traffic Circle — Berkeley, CA.**

Typical Construction Costs

Temporary Circles $500-2000; Landscaped Circles $1000-10,000

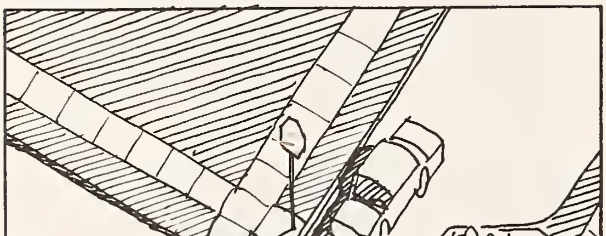
Uniform Standards

Traffic circles are not a specific entry in the MUTCD. However, they may be considered to be channelizing islands and are in common use as a traffic control device.

Examples of Current Practice

Figures 52-54 show three examples of temporary traffic circles. Figure 52 illustrates the use of barrels; in this layout, however, the circle is so small and appears so obviously temporary as to have a minimal effect. Figures 53 and 54 illustrate the use of bollards and connecting boards to create circles of larger size. All three make use of the "Keep Right" (R4-7) sign to aid visibility. Figure 55 shows a desirable feature for all neighborhood control devices, a high level of nighttime visibility. Figures 56-58 are examples of landscaped circles on local streets. Figure 56 is in need of added delineation with centerlines and pruning of shrubbery to reveal the "Keep Right" sign. Figure 57 shows the use of a midblock circle constructed as part of the original street plan. Figure 58 shows a high level of delineation; it also shows posts on each corner as a guard to the sidewalk and lawn.

Chokers/Narrowing



Chokers

A choker is a narrowing of a street, either at an intersection or midblock, in order to reduce the width of the traveled way. While the term usually is applied to a design which widens a sidewalk, it also includes the use of islands which force traffic toward the curb while reducing the roadway width.

Observations have shown that a choker's greatest value may be in the pyschological or perceptual area rather than in its direct effect on traffic. Widened sidewalks increase pedestrian crossing safety and safe areas for people to walk or play, or they may provide added area for landscaping. Often their greatest impact is in improving the appearance of the neighborhood, rather than reducing traffic.

Primary Traffic Effects

Effects on Traffic Volume. Studies to date have shown that chokers are effective only when they either reduce the number of lanes of travel, or where they add friction to a considerable length of street. A study in Fullerton, California showed traffic reductions of 15-30 percent (from 7900 to 6900 on one section and 13,000 to 9500 on another) along a collector street where an island type of choker was used as shown in Figure 65.[28] Locations in San Francisco, California showed reductions in traffic in conjunction with a street plan that narrowed the traveled way and permitted angle parking. Other locations, where intersectional "bulbs" were constructed showed unquantifiably small effects on volume.

Effects on Speed. One study of the effect of chokers on speed in San Francisco showed that they had an insignificant impact.[49] A study of an Ottawa, Ontario street showed that chokers could reduce average speeds by 1-4 mph (1.6-6 kmph) with resulting speeds in the 30 mph (48 kmph) range.[57]

Effects on Noise, Air Quality, and Energy Conservation. No studies have evaluated chokers in these terms. However, the effects can be deduced to be insignificant.

Effects on Traffic Safety. Bulb type chokers can improve the safety of an intersection by providing pedestrian and drivers with an improved view of one another. They also reduce pedestrian crossing distance thereby lowering their exposure time to vehicles.

Typical Construction Materials

Chokers are generally constructed as bulbs by a reconstruction of existing curbs. Island type chokers can be either curb and concrete islands, or concrete bars or buttons.

Uniform Standards

Chokers can be considered to be either normal extensions of the existing curb or channelizing islands as defined in the MUTCD and parallel design manuals.

Examples of Current Practice

Figures 59-65 show examples of current chok-


Figure 59. Choker — Berkeley, CA.

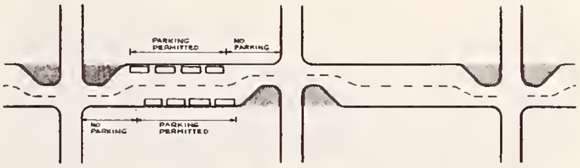


Figure 60. Choker design on one side of a roadway. Location on alternate sides at successive intersections creates serpentine alignment.


Figure 61. Choker for speed reduction — Cupertino, CA.


Figure 62. Choker with angle parking — San Francisco, CA.

er usage. Figure 59 illustrates the use of concrete bars to reduce the roadway width as well as the need to consider the turning radius of fire vehicles.

Figure 60 illustrates the concept of constructing bulbs on one side of a street and moving traffic towards the opposite curb. In places, this design can be more economical than choking both curbs. Alternating the side of the street bulbed can also create a serpentine alignment and view-screening effect over a distance, indicating that the street is not intended for through traffic. The design's weakness is in directing vehicles toward an existing curb, creating the potential for accidents for vehicles jumping the curb.

Figure 61 illustrates the use of concrete buttons and bars as a choker to reduce high speed turning of a sharp corner in a residential neighborhood. This design combines choking with the "median on curve" and "forced turns channelization" devices discussed previously.

Figure 62 is an example of using chokers to shield an entire block providing added sidewalk area as well as angle parking. Narrowing of the traveled way to one lane in each direction is the most important feature of the design. Figures 63 and 64 are examples of choker designs which have little effect on traffic but add visual amenities to the street.

Figure 65 is an island choker design used effectively in Fullerton, California.

Figure 63. **Choker — Oakland, CA.**

Figure 64. **Midblock Choker — Lafayette, CA.**

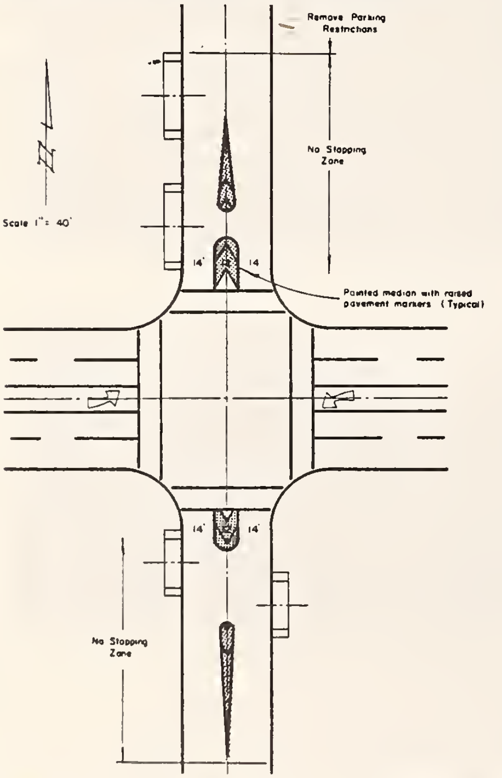
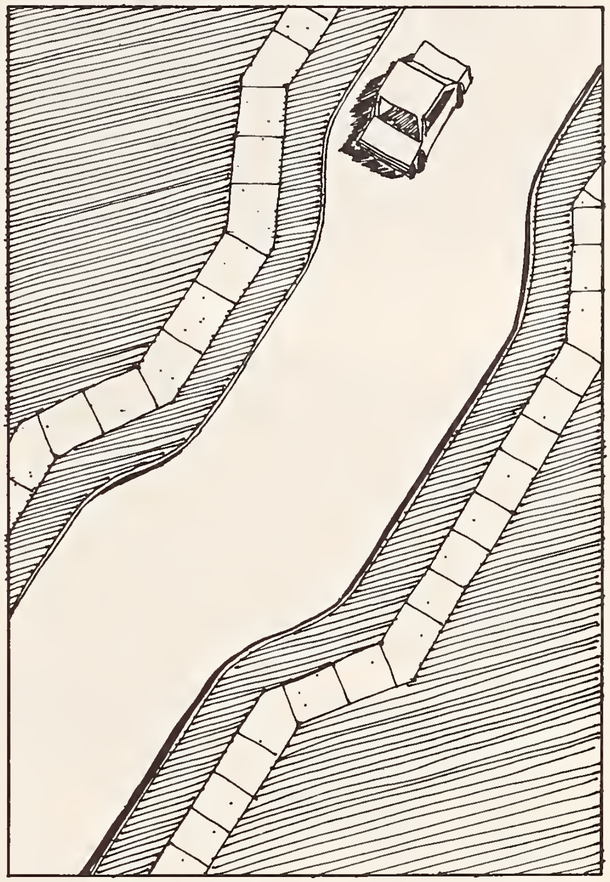


Figure 65. **Typical Island Choker (City of Fullerton, California Design)**

Other positive physical controls

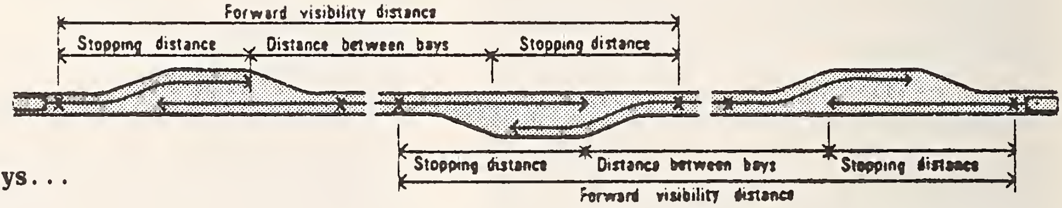
Among the other positive physical controls which have been tried, or which exist by default, are residential pedestrian and play streets, extreme narrowings, full street closures, gates movable by automobiles, rough pavements and valley gutters. Each of these devices may have some utility to residential street traffic management programs.



In Delft, Holland there has been an active program to convert residential streets into pedestrian-dominated "residential yards" (they are called woonerf).[66, 19] The program has emphasized pedestrian priorities on these streets, but has stayed with "integrated" solutions, where vehicles and pedestrians are mixed. Sidewalk and curbs are eliminated as shown in Figure 66, but the whole street surface is paved for pedestrians. The street is designed so that the drivers must attend "incessantly to the fact that the car is only one of the users and a guest to other functions having priority." The streets are broken up in their length with planters, walls, benches, barriers, and mounds. The profile where a car can drive is no more than 6 feet (2 meters) for two-way traffic with a widening for passing every 100 feet (30 meters) and usually shifts every 125 feet (38 meters). Changes of route are overaccentuated by pavement pattern contrasts to appear more abrupt than they really are. One-way streets are not advocated because cars are tempted to drive at higher speeds. At crosswalks where children play, additional narrowing, bumps, and thresholds are used. Parking spaces are designed and limited so that only vehicles of up to 22 feet (7 meters) by 6 (2 meters) can enter these areas. (Greater width, probably 9 feet [3 meters] would be necessary if the concept were to be applied in the U.S. because of the wider vehicles in use here.) Right-angle parking spaces are preferred because they demand more attention from the driver and can be used better by children when they are empty. Parking spaces are limited to clusters of six or seven. The planners have been especially aware of the multi-functional nature of the traffic control devices. This treatment is notable as being completely opposite to the usual United States emphasis of separating vehicles and pedestrians. The key to its success appears to be a combination of narrow traffic ways, short blocks, and emphasis on drivers' awareness on sharing of the right of way.

Figure 66. Woonerf — Holland
Source: Royal Dutch Touring Club ANWB.

On Straightaways . . .



on Curves . . .

and at Intersections.

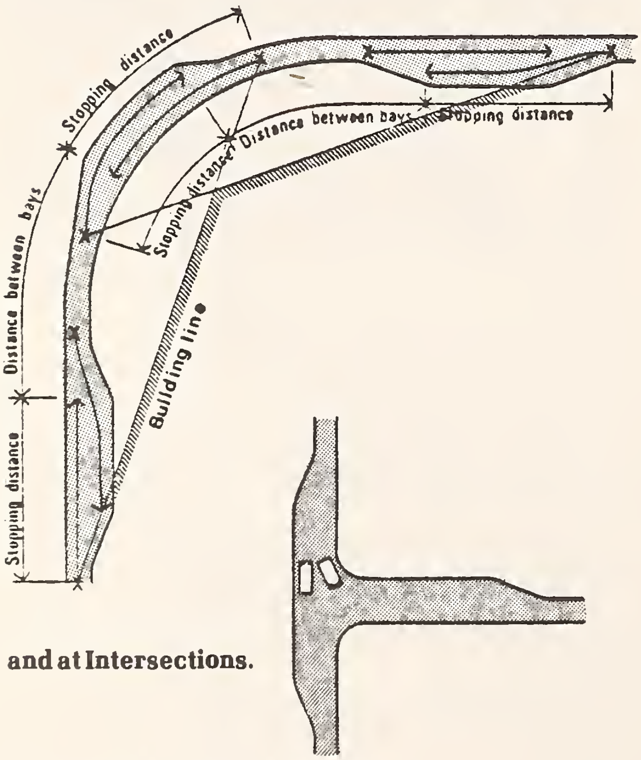


Figure 67. One Lane Street Concept. Location and spacing of passing turnouts
Source: Reference 108

Officials in The Netherlands are extremely enthusiastic about the effectiveness of their woonerfs. But the radical reconstruction necessary to convert the typical U.S. residential street to a woonerf configuration would be extremely costly. In fact, cost is probably prohibitive except for the possibility of "showcase" applications. By contrast, in The Netherlands woonerven can be created at a cost only incrementally above periodic maintenance costs. This is because most residential streets, curbs and sidewalks there are constructed of paving blocks bedded in sand. Due to settlement, all the blocks are taken up and reset at intervals of six years or so. At such a time there is little extra cost involved in resetting the blocks in patterns characteristic of a woonerf rather than of a normal street — only costs for design, street furniture and plantings are extra.

In Britain, another type of radical street reconstruction scheme has been studied though not yet applied. This involves an extreme narrowing of the traveled way to a single vehicle lane of about 13 feet (4 meters).[108] Used bidirectionally, the street would have occasional turnouts for vehicles in opposed directions to pass one another. Excess street space is converted to sidewalk or landscape areas or used for parking bays where needed. As a protection against head-on collisions, the narrowed sections are installed only at locations where sight distance is adequate. Despite this, it appears that the design enhances the possibility of driver error leading to such collisions. The psychological effect of the extreme narrowness, the need to stop for opposed traffic and the inability to pass same-direction traffic, are held likely to discourage use by through traffic and limit speed. As with woonerven, construction cost may preclude generalized use of this treatment in the U.S. But both these type treatments which very positively control streets while leaving them open offer obvious advantages for emergency and service access over the barrier concepts presented previously in this report.

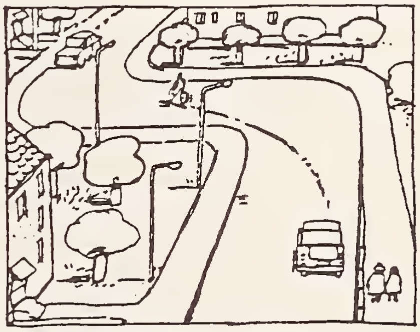
A similar narrowing scheme in which chokers (see prior section) are used to confine the roadway to a single bidirectional lane at discrete points rather than for sections of some length has been used somewhat in Europe. Often these are specifically designed too narrow for large trucks but wide enough for normal autos to pass. No performance data on these has been obtained.

Temporary play streets are common in some East Coast American cities, notably Philadelphia and New York which each had 150 in 1975.[65] These streets are temporarily closed during specified hours in the summer vacation. Many are operated with supervisors and temporary equipment. The surface of the street is marked to facilitate the conduct of various games. They are usually sponsored by block associations or community organizations. Many are on one-way streets, and there must be assurance that the street closing will not adversely affect delivery, parking, or cause problems of diverted traffic. The size of these programs speaks both to the level of need and the capacity of these street systems to function with so many street closures. Most of these streets are in low-income neighborhoods, and the main objectives are to reduce accidents and provide youngsters with play space during the summer.

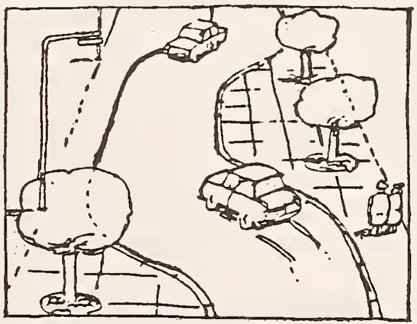
Total closure of streets is another physical control which has been practiced to a greater extent in Europe than in the United States. Generally, the total elimination of automobiles from a street has been limited to central business dis-

Figure 68. **Central Valley Gutter — Del Mar, CA.**

Figure 69. **Transverse Valley Gutter — Redwood City, CA.**



In Sweden, sweeping switchbacks . . .



and tight kinks are considered for speed control. But vehicles "straightening out the curve" are a concern.

tricts, rather than residential areas. In the United States, such a proposal in residential areas would of necessity be limited to areas where vehicular access to homes and garages was not absolutely necessary. Areas with alleys to provide access might be suitable for such treatment.

Gates are another physical technique which has had little application to public streets in the United States. Mechanical gates have been used to control access to private parking facilities and elaborate architectural gates have been used at the entrances to exclusive residential areas. In Windsor Park, Great Britain there has been some success with movable gravity-closed gates which are opened by the car softly striking the gates themselves.[2] The design is rather crude. The driver must judge how hard to hit the gate so as to open it yet not bounce back to hit his car. The potential for children being hidden by the swinging gates is high. Despite this they have operated to the satisfaction of residents and have been without accidents for 30 years. There would appear to be potential for improving upon this design, assuming that legal implications can be satisfied.

Introducing curvatures on a previously straight alignment has been discussed as a physical speed control device. In San Francisco's ill-fated Richmond district traffic control project, chokers were installed on opposite sides of alternate blocks to create a serpentine alignment. However, due to public controversy the devices were removed before performance measures could be taken. Swedish reference sources suggest the possibility of introducing sweeping curvatures or tighter kinks ("knixars") into the roadway alignment as speed control measures.[115] But they warn of possible associated safety problems. Even farther fetched is the British "Z-track" concept.[2] Still in the paper stage, this concept involves the use of curbs or other barriers to contort the roadway alignment, actually in the approximate shape of the letter N rather than Z, so that a vehicle must actually back down the crossbar in order to continue.

Two existing devices which tend to control traffic as an unintended by-product of their presence are valley gutters and rough pavement. As shown in Figures 68 and 69, valley gutters may run parallel or perpendicular to the direction of travel. In either case, they appear to be somewhat effective in reducing speeds in their immediate vicinity. Likewise, roads with rough surface, possibly in need of repaving, have a speed reducing effect. In neither case can it be suggested that streets should be designed to include valley gutters and rough pavement in order to reduce speed; however, the effect may be reasonable argument for delaying repaving of purely residential streets.

Passive controls

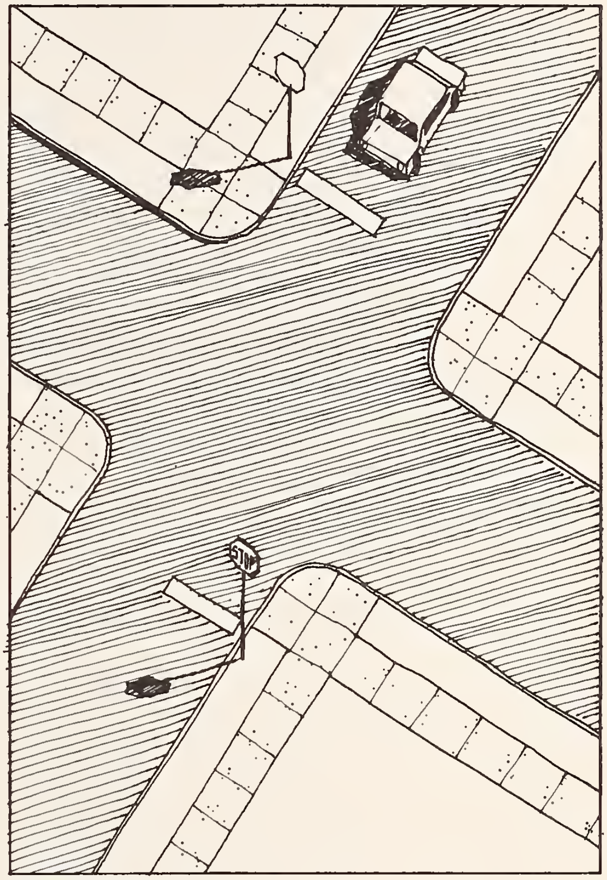
Passive controls involve the use of regulatory signs to inform the driver that a specific action is not permitted, while not physically preventing the action. As such, passive controls are more easily violated than most physical controls. Their advantages include the fact that some can be in force during only portions of the day thus retaining total access for residents during the remainder of the day. They also impose fewer constraints on emergency vehicles, which can ignore them when necessary with little problem or hazard. Experience has shown that even with the violations, some passive controls produce a significant improvement in the level and effect of residential traffic.

Passive controls are most effective in areas where general respect for all types of traffic control is high, where there is a reasonable expectation of enforcement, or where there is little driver resentment of the specific device. Where any of these conditions do not exist, for example, where numerous stop signs are used in opposition to major traffic flows or where a turn prohibition is installed and no reasonable (from the driver's viewpoint) alternative exists, violations of the device can be expected.

Signs which have been used (or may have application) in the protection of neighborhoods include Stop, speed limit, turn prohibition, one-way, "School, Slow," "Do Not Enter," "Not a Through Street," "Dead End," "Local Access Only," and truck restriction signs. Traffic signals also have potential as a passive neighborhood protection device.

Stop signs

The basic purpose of stop signs is to assign right-of-way at intersections with significant volumes or safety problems; warrants for the installation of stop signs for these purposes have existed for many years; yet, stop signs are persistently requested by citizens in order to control speed or reduce volume. A number of studies have tended to show that they have little effectiveness in these areas.



Stop Signs

Primary Traffic Effects

Effect on Traffic Volume. Studies show that in order to have a significant effect on volume, a street must be stopped at virtually every intersection. Even so, stop signs are not always effective at diverting volume. A series of stop sign installations in a Saratoga, California neighborhood showed that traffic patterns changed somewhat, but overall traffic entering the neighborhood increased over a one-year period, at least in part due to new homes.[22] An area-wide stop sign program in Palo Alto, California temporarily reduced neighborhood traffic until arterial congestion caused volumes on local streets to return to former levels. Before and after studies on a street in Seattle, Washington showed insignificant diversion.[71] Two successful applications were made in Glendale, California where traffic volumes on a former through street were reduced by 60 percent to 1850 vpd,[29] and Covina, California[16] where installations on two streets one-fourth mile (.4 km) in length, were claimed to be effective in reducing volume. Numerous other examples, mostly unsuccessful or marginally successful have been noted. It can be safely generalized that where local streets offer significant savings in time over arterial and collector routes or allow avoidance of congestion points, STOP signs will do little to effect traffic reductions. But when the local street's advantage over other routes is marginal they may be enough to shift traffic.

Effect on Traffic Speed. For many years, traffic engineers have received requests from citizens for the installation of stop signs to reduce

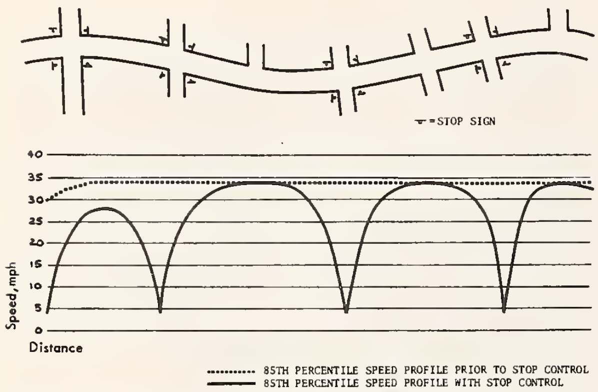


Figure 70. **Speed profile for street before and after stop sign installation**

speed. The traditional answer is that stop signs are not intended or effective as speed control devices, but are intended and should be used for right-of-way assignment. Statistics on stop sign effectiveness tend to bear out the traditional response. The signs affect speed in the immediate vicinity of the sign, as shown in Figure 70, but between intersections they are either ineffective or produce the contrary effect. For example, a study in Palo Alto showed that in an area with numerous stop signs and a prima facie 25 mph (40 kmph) speed limit, the average speed 300 feet (91 meters) in advance of the signs exceeded the limit at 41 out of 60 sites; the 85th percentile speed exceeded the limit at 57 out of 60 sites.[77] Studies in Walnut Creek, California showed that speeds increased after installation of stop signs;[93] studies in Pleasanton,[62] El Monte[27] and La Mirada, California[47] and Troy, Michigan[7] showed no effective difference in speeds after stop sign installation. A study in Saratoga, California showed an average reduction in speed of less than 3 mph (5 kmph) at six intersections following the installation of stop signs.[22] The general conclusion from these studies must be that stop signs have little overall effect on speed, except within approximately 200 feet (61 meters) of the intersection.

Effect on Traffic Noise, Air Quality and Energy Consumption. Stop signs tend to increase noise in the vicinity of an intersection by adding acceleration and braking noise, normally more than cancelling the noise reduction effect of any decreases in traffic speed. None of the studies evaluated quantitatively addressed this specific component of noise. While the deceleration and acceleration which stop signs induce does tend to increase air pollutant emissions and fuel consumption, these changes are inconsequentially small at low volume residential street intersections.

Effect on Traffic Safety. The traditional traffic engineering belief is that STOP signs not warranted by traffic volume conflicts or specific site safety conditions (such as inadequate sight distance) would tend to **increase** traffic accidents. However, evidence to date on the safety effects of STOP signs placed for volume and speed reduction purposes is somewhat mixed. Isolated studies in Pleasanton[62] and El Monte,[27] California showed increases in the number of accidents in the range of 500-600 percent. A larger study in Palo Alto, California showed little change in the accident rate.[77] However, a study of 57 new four-way stop intersections in Philadelphia showed that accidents were reduced from 273 to 35 in a one-year period.[34] A study of 38 intersections of major streets in St. Paul, Minnesota showed that conversion from 2-way to 4-way control reduced the accident rate by 56 percent; however, these intersections had volumes in excess of what would be expected on a residential street.[97] Another study of 15 intersections in Concord, California showed a 70 percent reduction in accidents after the installation of 4-way stop signs, many with volumes below the warrants of the MUTCD.[54] Without detailed inspections of the individual sites, it is difficult to assess reasons for the mixed results or why the traditional traffic engineering belief is not more convincingly supported in the empirical data. It seems probable that at some of the intersections where safety decrements were measured, placement of the signs in poor visibility positions and lack of supplementary markings account for the accident experience rather than fundamental characteristics related to the warrants. It also seems probable that the cases where safety experience was improved include instances where traditional warrants for stop installation were actually met. Further cases which experienced safety improvements likely include intersections with conditions borderlining traditional warrants.

Citizen Reactions to Stop Signs. Stop signs have a very positive image with most citizens, who often see them as a solution to "near miss" as well as actual accident problems. They are also perceived as being beneficial to speeding problems. Negative reactions to stop signs come mainly from residents at the corners who are subjected to additional noise from stopping and accelerating vehicles and from motorists who perceive they are being stopped needlessly.

Uniform Standards and Warrants. Stop sign details and warrants for installation are included in the MUTCD.[86] However, the warrants relate to right-of-way assignment and response to site safety conditions and the MUTCD specifically advises that stop signs should not be used for purposes of speed control.

Obedience to Stop Signs. Numerous studies have been prepared regarding the degree to which stop signs are obeyed.[22,77,7,20,23] As a general summary, when not required to stop by cross traffic, only 5-20 percent of all drivers will come to a complete stop, 40-60 percent will come to a "rolling" stop below 5 mph (8 kmph), and 20-40 percent will pass through at higher than 5 mph (8 kmph). The study in Berkeley, California showed that signs placed on arterials and collectors for the purpose of speed reduction were the most flagrantly violated.[21] Thus, stop signs placed in violation of the standard warrants tend to be resented and to some extent ignored by drivers, whereas signs placed for right-of-way purposes tend to be more usually respected.

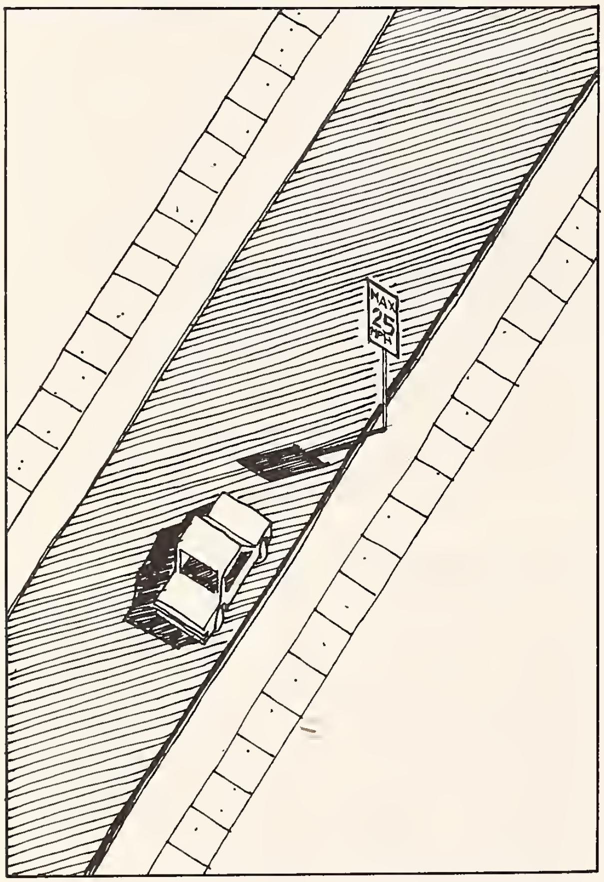
Speed limit signs

Speed limit signs are a regulatory device intended to inform motorists of an absolute or prima facie speed limit imposed by the governing agency. Traditionally, they have been established on the basis of the existing 85th percentile speed on the street or highway in question. In residential neighborhoods, speed limits are usually established on a prima facie basis, and signs are installed only when a problem or neighborhood request occurs. As a basis of comparison, Tables 5 and 6 show a range of neighborhood and school zone speed limits for cities of various sizes.[100]

Effects on Traffic Volume. None

Effect on Traffic Speed. Studies evaluating the effect of speed limit signs on speed have been largely confined to arterial streets and high speed highways. Performance in the high speed highway cases is considered non-relevant to the residential street situation and not discussed in the assessment below. Findings in United States and European arterial surface street speed limit studies differ. In the United States, studies have generally shown that speed limit signs have very little impact on driver speed on surface arterials. A study dating to 1948 in Champaign and Ur-

Special Signs/Speed Limit Signs



bana, Illinois concluded that:[98]

- Traffic consistently ignores posted speed limits, and runs at speeds which the drivers consider reasonable, convenient, and safe under existing conditions
- Drivers do not operate by the speedometer but by the conditions they meet
- The general public gives little attention to what speed limits are posted
- The general public has a false conception of speed.

In 1956-58, speed limits were raised on 22 miles (35 km) of streets in St. Paul, Minnesota. Speeds which had previously exceeded the 30 mph (48 kmph) limit were basically unchanged by 35 and 40 mph (56 and 64 kmph) limits.[4] A study in 1960 of 34 speed zones in various U.S. locations in which limits were raised in 30 and lowered in four showed the following:[50]

- Where speed limits were raised, the 85th percentile speed decreased by 0.2 mph (.3 kmph). Motorists observing the posted limit increased from 38 to 84 percent.
- Where speed limits were lowered, the limit had little effect on traffic behavior, and voluntary observance of speed limit signs decreased about 10 percent.

A study in Indiana in 1961 of posting speed limits at the border of urban areas found that the 85th percentile speeds were slightly higher after speed limit signs were posted.[25] A study on local streets in La Miranda, California in 1967 showed that 25 mph (40 kmph) signs did little to slow drivers, with 86 percent driving in excess of the limit.[31] Comparisons of similar collector streets in Ottawa, Canada showed that speed limits of 25 mph (40 kmph) and 30 mph (48 kmph) resulted in 85th percentile speeds of 35 mph (56 kmph), regardless of which limit was posted.[59] A test of speed warning signs in Warren, Michigan which advised motorists of the proper speed to travel in order to clear a signal found that these signs too had little effect.[35] By contrast, a test of this system in Germany, where the speed was mandatory rather than advisory, was successful. A study of odd numbered speed limits (19, 21, 22 mph) (30, 34, 35 kmph) in Saratoga, California also had no significant effect. The only positive application of speed limits on urban streets has been in limited cases where speed limit signs were posted on streets previously without limits.[56]

Little formal documentation on the effectiveness of speed limit signing on local residential streets was found in the State-of-the-Art search. Yet traffic engineers contacted uniformly expressed total lack of confidence in this device as a solution to local residential street problems. One documented study which was found, performed in La Mirada, California, firmly supports the common traffic engineers viewpoint. The data summarized below shows that speed limit signing had virtually no effect on distribution of traffic speed even after reinforcement by means of a police speed enforcement campaign.

In Europe speed limits have generally been effective in reducing speeds on streets, though not always have the reductions been to the limit. Studies in Great Britain, Ireland, Belgium, France, Germany, the Netherlands and Switzerland all showed reductions in the 85th percentile speeds.[74,43] Like the U.S. work, most of these studies were on roads with collector, arterial or surface highway functions, not local residential streets.

Explanations for the discrepancy in U.S. and European results on arterial/collector streets are speculative. It has been conjectured that Europeans consider conformance to a speed limit to mean traveling at or below the limit while Americans (drivers and enforcement officers) tacitly consider traveling at speeds 5 to 10 mph above the limit as being compliant. If true, this basic difference in the meaning of a limit could obviously be a factor. Or it may simply be the case that American drivers rely more on their own judgment of safe and reasonable speed than the posted limits while Europeans are more strongly influenced by the signs.

Very recent German studies have specifically considered the effect on residential streets of low speed limits — 30 kmp (just under 19 mph). Results reported are sketchy but seem more conformant to American experience than to prior European reports. Studies in Wiesbaden and Hamburg have found that local street drivers do not alter their speed as a result of speed limit

Table 5

Speed limits on two lane streets in selected U.S. cities[100]

Speed Limit MPH	(Km/H)	Number of Cities Reporting Indicated Limits Population 100,000 +	Population 50,000-100,000	Population 25,000-50,000	Total
20	(32)	1	1	2	4
25	(40)	23	29	16	68
30	(48)	37	29	8	74
35	(56)	12	28	11	51
40	(63)	4	5	1	10
45	(71)	4	6	2	12
50	(79)	3	2	0	5
55	(87)	1	0	0	1
60	(95)	0	1	0	1
65	(103)	4	5	0	9
70	(111)	2	0	0	2
		91	106	40	237

Note: Data taken before 55 mph speed limit

Table 6

Urban school zone speed limits[100]

Group	Percent of jurisdictions reporting indicated limit MPH(Km/H) 15(24)	20(32)	25(40)	30(48)	Other	Total
States	42	15	12	0	31	100
Cities over 100M	30	31	27	2	10	100
Cities 50-100M	26	27	36	1	10	100
Cities 25-50M	33	33	24	3	7	100

SPEED DATA

Location and Date	Range	Percentile Speed 50	85	97	10 Mile Pace Speed	% All Samples
Mansa Drive Near Avlon						
Morning:						
3-17-66 6:30-9:00 A.M. Th. Before 25 MPH speed sign.	20 – 43	30	37	40	27-37	70%
1-19-67 6:30-9:00 A.M. Th. After 25 MPH speed sign, & before speed enforcement.	19 – 41	31	35	39	25-35	77%
8-17-67 6:30-9:00 A.M. Th. After speed enforcement.	22 – 39	30	35	39	25-35	75%
Afternoon:						
3-17-66 3:00-6:00 P.M. Th. Before 25 MPH speed sign.	20 – 43	30	34	40	25-35	83%
1-19-67 3:10-6:00 P.M. Th. After 25 MPH speed sign, & before speed enforcement.	20 – 43	30	35	40	24-34	72%
8-17-67 3:00-6:00 P.M. After speed enforcement.	19 – 45	30	36	39	27-37	78%

signs. Bremen, Karlsruhe and Nuremberg rejected local street speed limits of this type because of ineffectiveness of the control. Berlin, Hanover, Cologne and Munich have introduced such local street speed limits in individual cases but regard their effectiveness with scepticism. 116

Effect on Noise Air Quality and Energy Consumption. If as suggested above, it is concluded that the limit signs would have little or no effect on traffic speed or volume, the device would not be expected to have any effect on noise, air quality or energy consumption.

Effect on Traffic Safety. Excluding effects of speed limit changes on high speed highways (e.g., the reduction to the 55 mph limit in the U.S.), effects on traffic safety have been reported only in the surveys conducted in Europe. In all of those cases studied, speed zoning produced a reduction in accidents.[74]

Uniform Standards and Warrants. Speed limit signs are a recognized control device in the MUTCD and guidelines for establishing limits are presented in basic traffic engineering references and in the laws of the various states.

Community Reaction to Speed Limits. If speed limit signs posted are significantly lower than prevailing traffic speed, residents normally place some hope in them or in subsequent enforcement. However, if the posted limits are within a few miles per hour of the previously prevailing traffic speed, they really don't address the resident's problem and are viewed with derision. And since many residents feels that speeds of 25, 30, or 35 mph (limits which, judging from Table 4, are in force on roughly 80 percent of the residential street situations in the U.S.) are too fast for their street, the basic issue is not whether the signs are effective but the way in which the speed limits themselves are set for local streets in the U.S.

Turn prohibition signs

Turn prohibitions involve the use of standard "No Right Turn" (R 3-10)* or "No Left Turn" (R 3-2) signs, with or without peak hour limitations to prevent undesired turning movements onto residential streets. They are best used at the periphery of a neighborhood rather than within it, a use which will prevent traffic from entering a neighborhood altogether and which will also result in a lower rate of violation.

Turn prohibitions have the significant advantage of being effective only during specified hours of the day, if desired. If shortcutting is occurring only in one or both peak periods, restricting turns only during these periods can allow residents full accessibility during the remainder of the day.

Since turn prohibitions are clearly a passive device, their success will depend on their general acceptance by the affected drivers. In areas where regulations are frequently flaunted or poorly enforced, they will have relatively little effect. Their effectiveness may also be reduced if turns are not permitted or provided for on alternate arterial-collector routes or present a significant perceived delay to drivers. Thus improvement to an arterial condition may be a prerequisite to the successful installation of turn prohibitions.

Primary Traffic Effects

Effect on Traffic Volume. Turn prohibition signs have been shown to have a significant effect in reducing turning volumes, though some violation in the range of 10-15 percent of the original turning volume may be expected. Their effect is thus significant, though less than positive physical barriers. Actual traffic reduction potential depends on the percentage of total traffic on the street which the turning movement to be prohibited comprises. Jurisdictions using turn prohibitions for neighborhood traffic management have reported results in different ways, complicating clear assessment herein. Studies in Montgomery County, Maryland report that peak hour turning prohibitions reduced volumes by as much as 90 percent in one case, and to volumes of 40 vpd in another.[96] Another neighborhood controlled by signs in this county showed only one street with volumes in excess of 2000 vpd. In Hawthorne, California turn prohibitors successfully protected one street from 800-900 vph which were bypassing a signalized

---

*Parenthetical nomenclature refers to MUTCD designations.

intersection. However, lack of a comprehensive neighborhood signing program resulted in the traffic being diverted onto other local streets rather than onto arterials.[33]

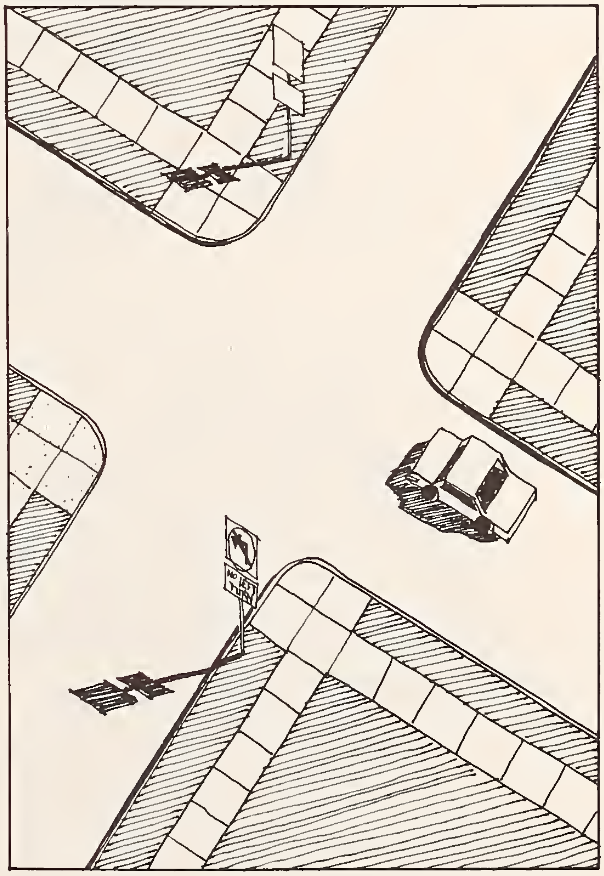
Effect on Traffic Speed. No direct effects on traffic speed are expected. However, to the extent that the device may exclude from the street a driver population which had formerly used it as a speedy through route, significant changes in speeds experienced are possible. No studies of speed effects on the "protected" streets have been reported by jurisdictions using this device.

Effect on Noise, Air Quality and Energy Consumption. Noise reductions are proportional to reductions in volume. Effects on air quality and energy consumption can be presumed negligible.

Effect on Traffic Safety. The traditional rationale for turn prohibitions has been to improve traffic flow and safety along arterial and collector street corridors. Though none of the jurisdictions using turn prohibitions for neighborhood traffic has reported studies of safety effects, there is no reason to believe the device's site safety performance is any different than when used for conventional traffic control purposes. However, as with conventional applications, there is the possibility that the prohibitions will force motorists to make turns at less safe locations or by means of hazardous maneuvers. Hence, in considering any installation of turn prohibitions, whether for conventional traffic engineering purposes or for neighborhood traffic management, the analyst should determine that safe and reasonable alternatives to the proposed prohibited movement do exist.

Figure 71. **Turn prohibition signs, peak/hour — Berkeley, CA.**

Turn Prohibitions



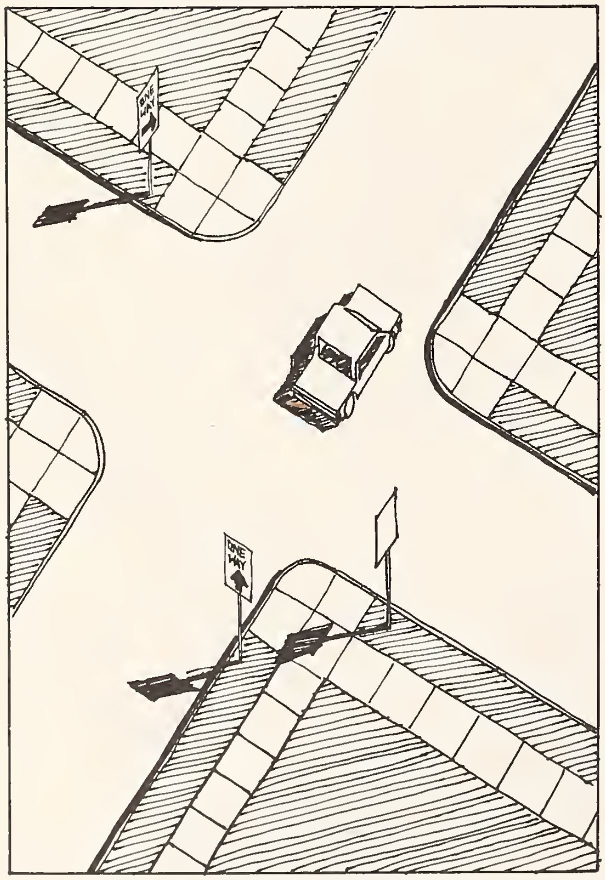
Desirable Design Features. The basic requirement for this or any other sign is visibility. The City of Hawthorne found that 36" by 48" (.9 by 1.2 meter) signs were required, though the more standard 24" x 30" (.6 by .9 meter) are usually acceptable. Signs and pavement markings in advance of the turn can also aid visibility.

Uniform Standards and Warrants. Turn prohibition signs (right and left) are officially recognized MUTCD devices.

One-way streets

One-way streets can be used in two ways to protect a residential area. The traditional technique is to develop a one-way couplet to increase capacity in an area; if effective, the improved operations can draw some traffic formerly using local streets onto the new arterial streets. In a residential area, however, this technique is rarely effective, since at least one of the one-way streets is usually residential in character. As a result the one-way couplet simply transfers the penalty of traffic from one or several lightly impacted residential streets to a single one which becomes severely impacted.

A more successful though less frequently used technique is the use of one-way streets to make travel through a neighborhood difficult, if not impossible. Two basic techniques of accomplishing this aim are shown schematically in Figure 72. At the top of the figure is a typical two-way residential street grid. The central portion shows the technique of turning the local street pattern into a type of maze through the use of short sections of one-way streets. The design allows for local access, somewhat circuitously, but inhibits through movement. The lower portion of the figure shows a technique of providing a limited number of entrances to a neighborhood and making most streets into one-way exits. The maze pattern tends to spread the local traffic onto a number of streets, while making access quite difficult for some blocks. The limited entrance patterns tends to concentrate local entering traffic onto a few streets, but provides easier and more intelligible access patterns. Both techniques can effectively discourage through traffic.



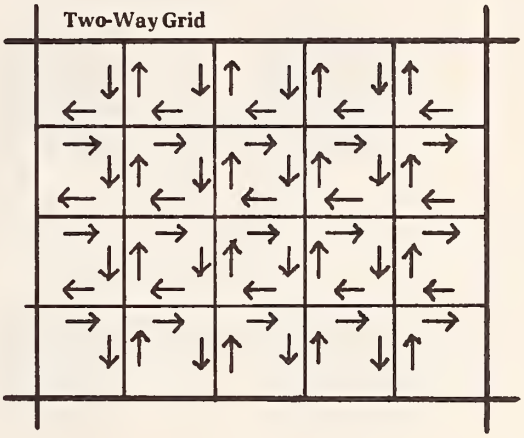
One-way Streets/Do Not Enter

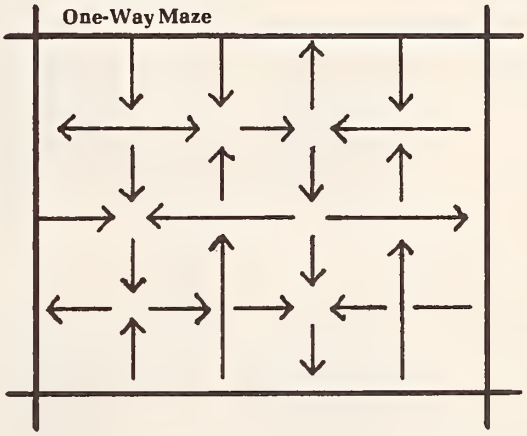
Temporary or reversible one-way streets have been used in applications to provide increased peak direction capacity and improve flows. The possibility of doing exactly the opposite of this — temporary or reversible one-way streets aimed in the direction opposite of peak period dominant flow direction — might also be considered as a possible neighborhood traffic management application.

The use of one-way streets has the great advantage of being a standard control that is well-accepted by the public. It also provides a minimum impedance to emergency vehicles, which can easily and safely violate the signs. When converted to one-way operation, narrow streets where parking had been prohibited can often gain an added parking lane, thus providing an added benefit to residents. As with many non-physical controls, one-way street systems are subject to deliberate violation, but experience shows a rather low violation rate, perhaps due to the fact that any violation will occur over a period of several seconds or minutes — whatever the time is needed to traverse an entire block or blocks — whereas other devices require only a short and fast period of violation. Violation of one-way streets is more likely to be pointed out to the motorist by residents and pedestrians than are violations of other devices.

Primary Traffic Effects

Effect on Traffic Volume. One-way streets used to create discontinuities in a street system have shown a high level of effectiveness. A neighborhood in East Bethesda, Maryland using the technique, reduced maximum hourly volumes to less than 150 vehicles on all streets.[96] In Kansas City, Kansas, a reduction of 20-30 percent was observed after certain blocks in a neighborhood were made one-way.[44] The City Center of Bologna, Italy[76] has been successfully designed to this concept, as have neighborhoods in Toronto and St. Louis, in Barnsbury and Pimlico, London and Nagoya, Japan.[3] On the other hand, a single street in San Jose, California was converted to one-way without maze or other treatment to the rest of the neighborhood.[18] The result was no impact to shortcutting in one of the peak hours and diversion to another local street in the other peak hour. This example illustrates


Two-Way Grid


One-Way Maze

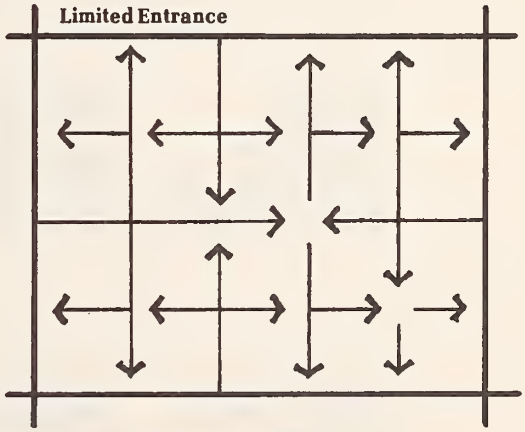
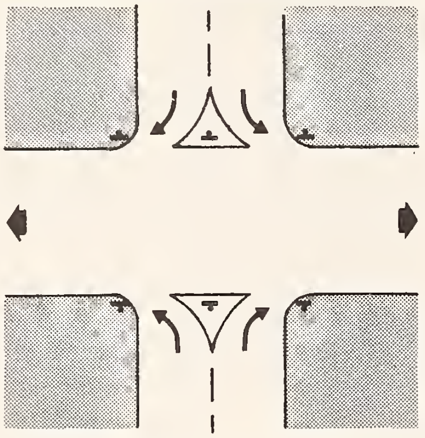
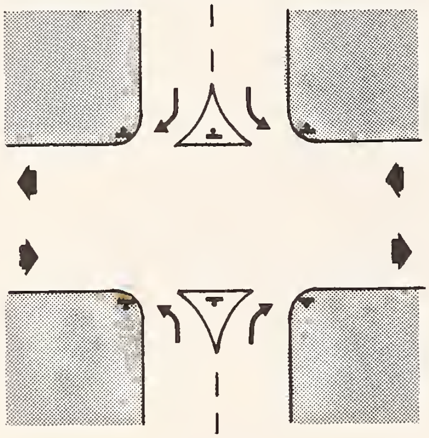

Limited Entrance

Figure 72. One-way control systems

Converging one-ways meet diverging one-ways



Converging one-ways meet two-way cross street



Converging one-ways meet one-way cross street

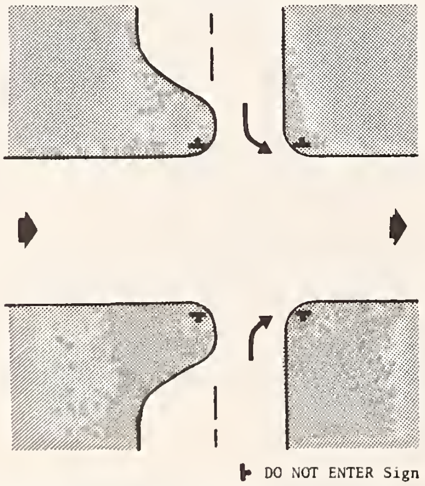


Figure 73. **Typical channelization for residential intersections with opposing one-way movements**

the need to use one-way streets as an overall neighborhood, rather than a single location, treatment.

Effect on Traffic Speeds. The studies evaluating use of the maze technique have not evaluated speed. Speeds have traditionally been higher on through one-way streets. In residential traffic management applications, this tendency can be counteracted by limiting the number of blocks with one-way continuity. And as with other devices which attempt to limit traffic volume and through traffic, use of one-way streets in patterns to achieve that objective may exclude a driver population which formerly used the streets as speedy through routes. Hence, speed reductions may be realized.

Effect on Noise, Air Quality and Energy Consumption. While there is again no documentation, the effects on air quality and energy consumption can be deduced to be marginal. Noise reductions can be expected parallel to traffic volume reductions.

Effect on Traffic Safety. No documentation is available on the effects on safety of one-way streets as employed for traffic restraint purposes in residential areas. But for rather obvious safety reasons, careful treatment is essential at intersections where opposite direction one-way blocks meet and where a two-way block meets an opposed one-way.

Uniform Standards and Warrants. One-way streets are a traditional traffic engineering measure and signs and markings related to one-way operation are included in the MUTCD.

Desirable Design Features

- System discontinuity
- Maintenance of reasonable access routes for local residents and visitors
- Minimizing of the length of one-way continuity to reduce speeding
- Use of "No Thru Traffic" signs to prevent inadvertent entry of through traffic
- Limited channelization (paint or paint and bars) at the point where opposing one-way streets meet (See Figure 73)

Other passive controls

Traffic Signals

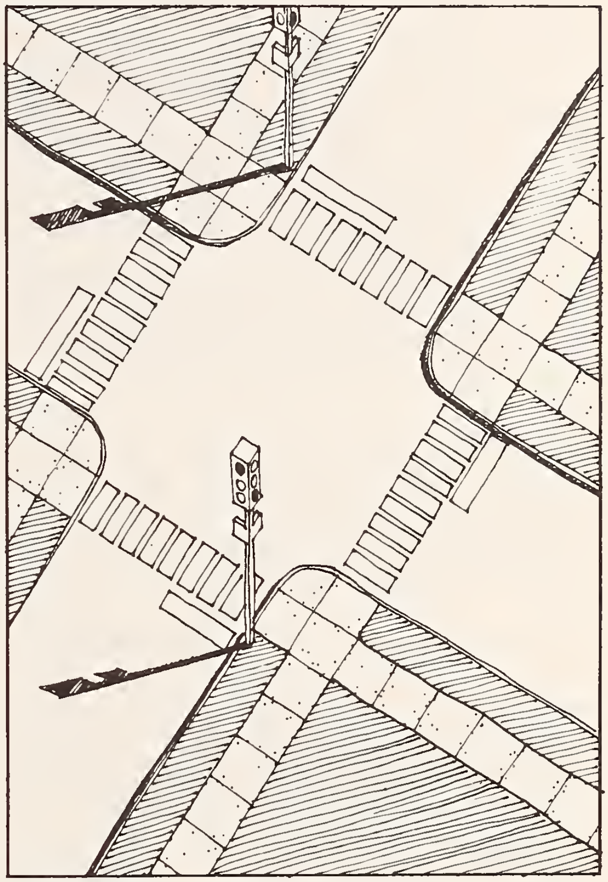
Traffic signals are an obvious but expensive control device that can affect neighborhoods in many ways. Delays at arterial signals are a prime reason for shortcutting and an efficiently run signal system can do much to reduce through traffic's use of neighborhood streets.

Signals can also be used to improve control of access to neighborhoods as well as to add delays, at a high capital cost, to local streets; it is uncommon though that local streets would often satisfy standard warrants for signal installation. In Sacramento, California closely spaced signals with slow progression speeds have been proposed as a deterrent to through traffic on local streets in a neighborhood located between the freeway ring and the central business district.

A novel use of signals to reduce speeding at a Los Angeles, California intersection could have application to the neighborhood situation.[15] An actuated signal is designed with loops to sense speed. If the cross street is clear, autos traveling at the proper speed are given a green light while speeding autos are stopped. As with stop signs, the device is effective primarily near the intersection, in this case within 300-600 feet.

Yield Signs

Much of the evaluation of yield signs was performed in the 1950's when the signs were first introduced. No studies have been uncovered that have evaluated yield signs as a neighborhood protection device. However, two studies have evaluated stop signs, yield signs and no control in terms of their efficiency at low volume intersections.[6,32] Both studies, conducted in Indiana, suggest that at volumes below 200 vph on the controlled legs of an intersection, no signs are an acceptable control in terms of accidents, operating cost, and efficiency. From 200 to 800 vph, yield signs are as effective as stop signs in terms of accidents, and are superior in terms of energy and delay costs. Above 800 vph, stop signs are more effective. In all of these cases. stop signs are desirable if sight distance is unacceptable according to the present standards.



Traffic Signals

School Zones

"School" signs and flashing beacons are frequent and standard throughout the country to warn drivers of the presence of school children in the area. Flashing yellow beacons were studied at several locations in Kentucky and shown to be effective in reducing average speeds by 3-4 mph (5-6 kmph).[103] The use of signs and flashers time-coordinated with the presence of children appears to also be important. Whereas signs continuously present are not always effective, a study in Alabama of a rotating "School" sign, visible only during hours before and after school, was effective in reducing speeds about 5 mph — from 25 to 20 mph (40 to 32 kmph).[1]

Slow Signs

While not in the MUTCD, "Slow" signs are a frequently used warning sign at locations thought to have some hazard. A study in Indiana on a tangent section of highway with no obvious need for slow signs showed that they had no effect.[41] A study on a steep curvilinear street in Millbrae, California showed that speeds increased after the signs were installed.[51] These limited samples are not large enough to make a positive statement about the effectiveness of "Slow" signs, but they do not suggest that they would have great value on residential streets.

Access Regulation Signs

"Do Not Enter," "Not a Thru Street," "Dead End," "Local Access Only," and "Thru Vehicles Prohibited" signs have all been used as regulatory or warning signs in various traffic situations and have potential use for neighborhood protection. Normally used to indicate the prohibited travel direction on one-way streets, and at the surface street end of freeway exit ramps, "Do Not Enter" signs have occasionally been used on residential streets in lieu of but with the same purpose as semi-diverters. "Not A Thru Street" and "Local Access Only" signs in the regulatory black on white format could conceivably be effective in reducing traffic volume on residential streets. A local ordinance limiting continuous travel on streets where such signs are posted could provide legal basis for the control. The ordinance would specify that vehicles traveling on a street so posted would have to stop at a destination or turn off the street within a set number of blocks or else be subject to a traffic citation. "Dead End" and "Not A Thru Street" signs in the warning black on yellow format could conceivably be posted on local streets at their intersections with arterials and collectors to discourage traffic from using them even though the streets posted are actually continuous. This deceit is likely to be most effective in a community where enough cul-de-sacs, diverters and semi-diverters have been deployed. Drivers there would be conscious that many streets are blocked and, except in their own immediate neighborhood, uncertain as to which streets really go through and which don't. However, we believe that chicanery of this type would undermine driver confidence in traffic signs and should not be attempted. No documentation of any of these applications has been obtained in the course of this study.

Truck Restrictions

The establishment of truck routes and use of truck route signing is a well established practice used both for neighborhood protection and to keep trucks on streets with sufficient strength to accommodate them. Regulations permitting truck travel on a street for a limited number of blocks and only for pickup and deliveries are also common.

Parking Control

Parking provisions and control can directly affect the volume of traffic on residential streets, particularly where these streets are heavily used for commuter parking. Parking control may be the **only** effective traffic management device in a neighborhood if the problem traffic is comprised predominantly of outsiders who use the streets for parking. And sometimes the parking itself is considered by residents to be a primary problem. There are three basic control approaches to deal with outsider parking in neighborhoods: bans, time limits and resident preferential parking.

Bans may prohibit parking all-day or for that period of the day most effective against outsiders and least disturbing to residents (9 or 10 am to 3 or 4 pm). Outright bans are a feasible approach only when residents are not dependent on curb space for any of their own parking needs. Midday bans may be workable when resident dependence on street parking is only for nighttime storage of vehicles. Parking for residents' visitors is almost always a problem with bans. And usually there is enough resident dependence on curb parking or inconvenience from its unavailability that bans are not a realistic solution.

Time-limit parking in the midday period can be effective against commuters parking on neighborhood streets. This is true so long as the duration limit would force commuters to move their car more than once during the normal working day. And availability of curb spaces, though duration limited, solves most of the problem of parking for residents' visitors. But if the problem parkers are short-term visitors to an adjacent shopping or activity center rather than all-day commuter parkers, time limit parking may not keep them off the neighborhood streets. And unless residents have absolutely no dependence on daytime curb parking, the duration limits will be a nuisance.

Resident preferential parking schemes combine either bans or time limit parking (usually the latter) with an exemption of residents' vehicles from the parking control. Exemptions are indicated by stickers placed on residential vehicles. These are either given or sold to qualified residents of the preferential parking district. The resident preference element eliminates the primary drawback of using parking bans or time limits for controlling outsider parking and parker traffic in neighborhoods. Since a 1977 United States Supreme Court decision upholding such preferential parking measures in Arlington, Virginia, a number of communities have implemented or taken similar schemes under active consideration.[106]

Scant data on the impacts of such schemes is currently available. Obviously, reductions in parking, traffic and the attendant noise and other problems are dependent upon the outsider component of parking initially. However, experience in cities like San Francisco, California; Arlington, Richmond and Charlottesville, Virginia; Milwaukee and Madison, Wisconsin; Baltimore and Montgomery County, Maryland; Minneapolis, Minnesota; New Orleans, Louisiana; Salem, Oregon; Wilmington, Delaware and many others now implementing parking controls will merit future scrutiny.

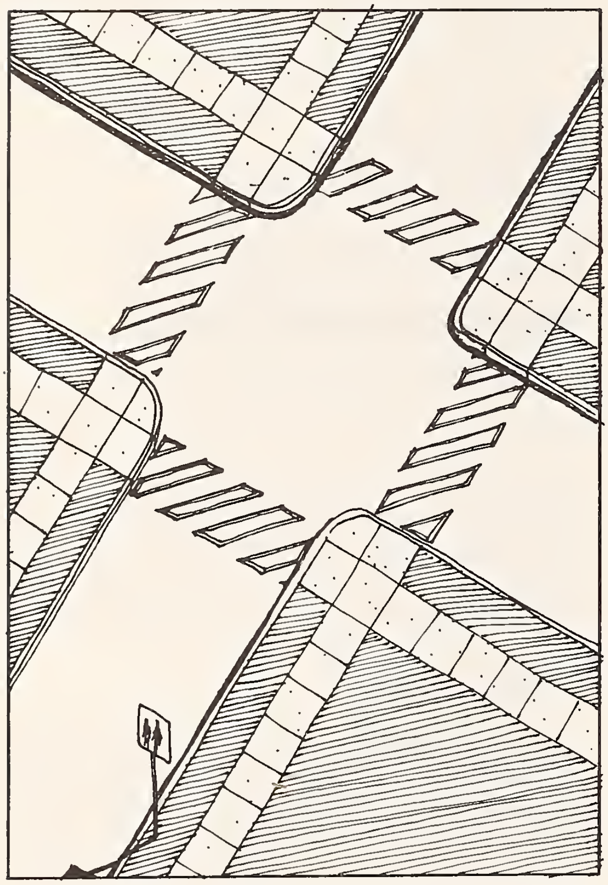
Controls dealing with driver perception and psychology

Control devices in the previous section can be classified as trying to specifically prevent, through physical and legal means, an undesired action by a driver. Another approach to the problem is to try to work on the psyche or attitude of the driver, to encourage him to do the proper thing rather than preventing him from doing the improper thing as the other devices do.

Lateral bars

Experiments with these types of devices have been quite limited, and only two have been discovered which show significant effects. A study in Great Britain evaluated the use of bars painted laterally across a roadway over a length of one-quarter mile (.4 km); the bars were separated by 10 to 20 feet (3 to 6 meters), becoming more closely spaced as the intersection approached.[24] The study showed average speeds 150 feet (45 meters) from the intersection reduced from 35 to 27 mph (56 to 43 kmph) as a result of the device; accidents were reduced from 14 to 2 in a one-year period before and after installation. An installation in Long Beach, California shown in Figure 74, reduced the 85th percentile speed from 40.5 to 38.5 mph (65 to 62 kmph); the percentage of drivers exceeding the 35 mph (56 kmph) speed limit was reduced from 60 to 35 percent.[5] However, a similar installation in Saratoga, California showed a negligible effect.[69] Another study in Great Britain showed that the effect of the pattern on the driver's speed is dependent on the interaction between topography and the pattern, and is improved if a driver has had a previous encounter with the pattern.[12]

Crosswalks



Numerous studies have been made on the effectiveness of marked pedestrian crosswalks in regard to safety and impact on pedestrians' and drivers' perception. A thorough study was made of 400 unsignalized intersections in San Diego, California, each with one marked and one unmarked crosswalk.[36] While the marked crosswalks in a sample of 40 of these intersections attracted 75 percent of the pedestrians crossing the street, the entire sample showed that 85 percent of the accidents occurred in the marked crosswalk. The study concluded that pedestrians show less caution in using marked crosswalks than shown at unmarked locations. In terms of attractiveness, the study showed that where travel distance is the same, pedestrians with a choice between the marked and unmarked crossing chose the marked crosswalk 80 percent of the time; if the marked crosswalk required extra distance, it did not effectively attract users.

Limited sample studies at the University of California showed that the painting of a crosswalk did increase the percentage of drivers who would yield to a pedestrian; however, the majority of drivers still failed to yield.[40,88]

Evaluation has also been made of the zebra-type crosswalk in comparison with unmarked crossings. The San Diego study showed that this design was 94 percent effective in attracting pedestrians at five locations. However, the accident rate was essentially the same for the zebra crossing as for the unmarked crossing at the eleven intersections studied. Other studies in Great Britain showed that zebra crossings had little effect either on driver behavior or on the accident rate at an intersection.[42,99] In these studies, the zebra crosswalks were effective in attracting pedestrians to them. One Great Britain study concluded that the risk to pedestrians was less at a zebra crosswalk than at other points within 50 yards (45 meters) of the crossing.[48] In summary, the studies indicate that crosswalks of the common and zebra design both are effective in attracting pedestrians, but the driver reaction and accident rates are not usually beneficial.

Safety board

In an attempt to deal with safety problems in a neighborhood, the city of Concord, California installed a neighborhood traffic safety bulletin board.[14] The concept on which the bulletin board was based is that the perceived problems are not caused by "outsiders." Rather they are believed to be caused for the most part by the neighborhood residents while they themselves drive and by the residents of nearby neighborhoods. The bulletin boards were an attempt to get residents to connect their concerns about neighborhood traffic with their own behavior as drivers. This, it was hoped, would motivate residents to drive slowly and conscientiously on the streets of their own and nearby neighborhoods. The concept was not wholly successful due to vandalism and lack of continuing interest.

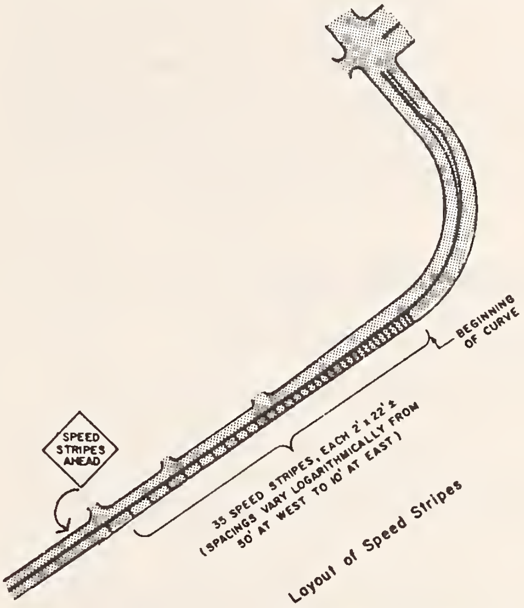
Odd speed limit signs

The city of Saratoga[69] also attempted to attract the driver's attention with unusual speed limit signs, as shown in Figures 75 and 76. The signs had no noticeable effect, and were frequent targets for souvenir hunting vandals. They are also in violation of the MUTCD, which requires speed limits and advisories to be multiples of 5 mph (8 kmph).[86]

Other signs

Many cities have attempted to attract the driver's attention through the use of unique and unusual signs such as those shown in Figures 77-79. Other examples include some of the following messages:[13]

- Slow — Pheasant crossing — Drive Carefully — Thank You
- No signal ahead
- We are not fooling — 30 mph (48 kmph)
- Somewhere Ahead — Radar
- STOP
- Dear Crossing
- Slow-Children at Play
- 35 Children Live On This Block — Drive Carefully



Source: Reference 5

Figure 74. **Typical lateral striping to give impression of increasing speed**

Figure 75. **Odd speed limit sign — Saratoga, CA.**

Figure 76. **Odd speed warning sign — Saratoga, CA.**

All of these attempts, and many others have had a questionable effect. They have usually been installed as final attempt after everything else has failed. Little evaluation has been done. In general, this entire area, if it can be at all successful, will require additional research and a higher level of quantified evaluation.

Speed actuated flashing warning or limit signs

A possible psychological control which might be attempted involves coupling speed detection technology, flashing beacons and standard or possibly unique signs. In operation, if a vehicle were traveling above the desired limit, speed detection gear would trigger a flashing beacon sign installation, calling attention to the sign message and singling out the driver traveling too fast. Signs associated with the beacon could be standard ones — speed limit or SLOW signs for instance — or special messages might be considered.

Figure 77. **Attention getting sign — Concord, CA.**

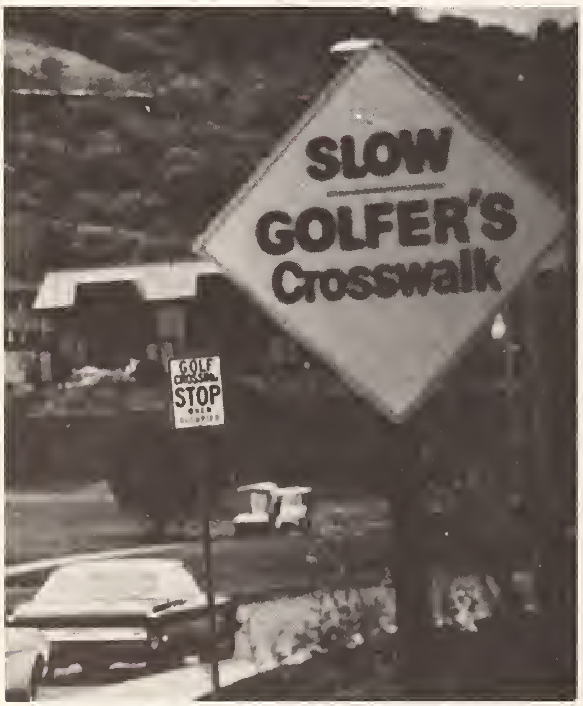


Figure 78. **Attention getting sign — Walnut Creek, CA.**

Figure 79. **Yield sign with supplemental message — Skokie, IL.**

System considerations

Most neighborhood traffic problems are area problems rather than conditions peculiar to a single limited site. Many of the devices used to treat neighborhood problems have impacts which extend well beyond the immediate area of their deployment. Some devices must be deployed in a series of installations to be effective neighborhood traffic management tools. And even if they are not dependent on the presence of other devices for inherent effectiveness, combinations of devices can have synergistic effects. For these reasons, the pattern or systematic way in which devices are deployed can be a significant determinant as to how effective the devices are in managing neighborhood traffic, in how drivers react to them, and the extent to which the devices pose inherent inconveniences to residents of the protected neighborhoods themselves. The various strategies pose trade-offs between the degree of protection from through traffic and compromises to resident access, internal neighborhood circulation and emergency and service access. This trade-off and the specific nature of the individual neighborhood's problems are primary considerations in choosing a control system strategy. Over and above the complex and interactive nature of problems, the fundamental concept of the residential neighborhood as a discrete area and entity to be treated in a holistic way underlies the organized approach to traffic management. The "neighborhood unit" in American planning, Buchanan's "environmental areas," "woonerven" in the Netherlands and "traffic cells" used in Japan and other countries all define discrete residential districts where traffic behavior is to be controlled on internal streets and through traffic confined to peripheral streets.

Basic strategic neighborhood traffic management systems include: peripheral barriers, internal systems of four types — return loops, anti-through systems, mazes and internal obstruction schemes.

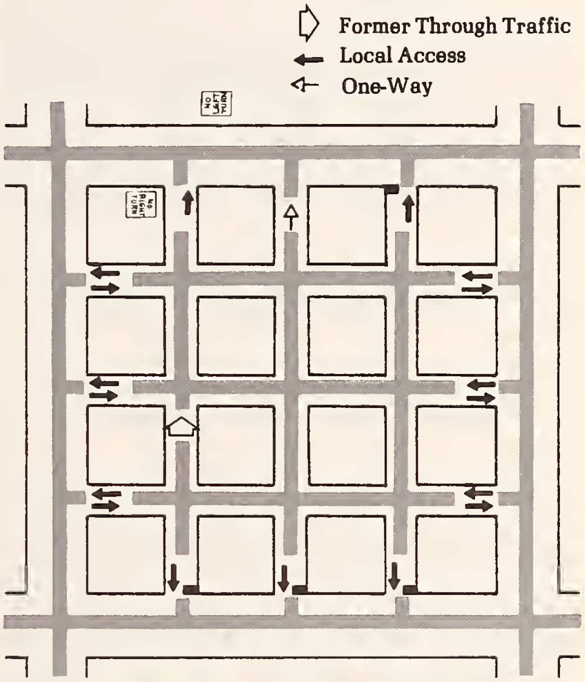


Figure 80. **Peripheral barrier — dominant direction**

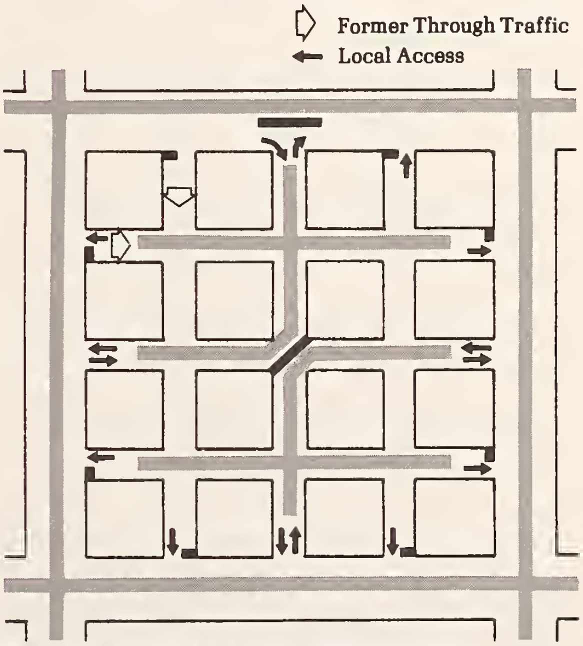


Figure 81. **Peripheral barrier — multi direction**

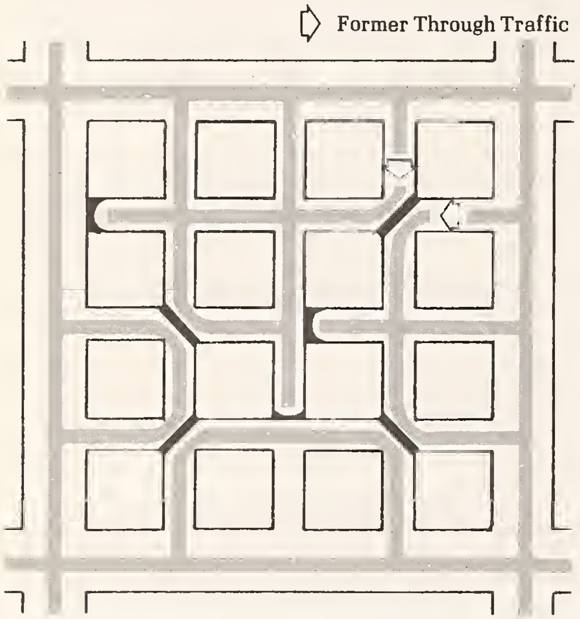


Figure 82. **Return loops — Motorists forced to return to the same boundary street from which they entered the neighborhood.**

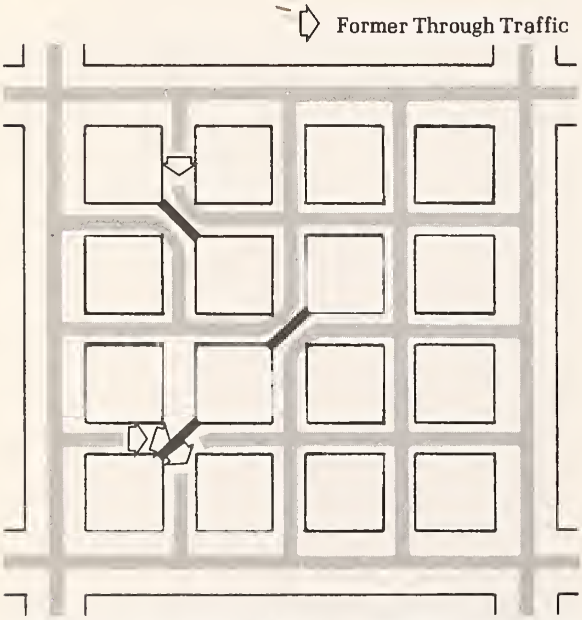


Figure 83. **Anti-through system — Motorists can't travel completely across neighborhood to opposite side from entry although not necessarily forced to return to boundary of entry.**

Peripheral barriers

Peripheral barrier treatments are ones which prevent traffic from entering the neighborhood by means of controls placed at neighborhood street intersections with bounding arterials and collectors. This form of boundary control can be achieved using physical devices such as cul-de-sacs, semi-diverters and median barriers or passive devices such as turn prohibition signs and one-way streets. A primary advantage of the peripheral barrier system is that the potential intrusive traffic encounters the protective barriers while it is still on the bounding streets and still has a clear option to use these routes to its destination with little out-of-direction travel or delay. By contrast, with internal systems drivers are first led into the neighborhood before being blocked and perhaps disoriented, trapped, certainly frustrated and possibly enraged. Another advantage of peripheral systems is that motorists are less likely to violate them along the busier streets where the perceived likelihood of enforcement is greater. Peripheral barrier treatments work best when the problematic through traffic is on a single axis of the street grid as shown in Figure 80. The treatment shown allows streets at right angles to the problem flow to be left open so that local trips can enter from the sides; entries are blocked in problem directions.

If through traffic incursions are problems on two axis of the street grid, the peripheral barrier scheme does not work quite so well because gaps must be left in the protective cordon to provide opportunities to allow neighborhood residents to return home. If this is done, the streets left open will suffer from a concentration of through and local traffic. One solution to the two axis problem is to supplement peripheral devices with internal devices to prevent the open streets from becoming through routes as shown on Figure 81. Even if this is done, the peripheral barrier scheme tends to be less effective in responding to biaxial through traffic problems than in the single axis situation.

Another advantage of the peripheral barrier scheme is that inconvenience to residents as drivers is relatively limited. Traffic flows internal to the neighborhood are unobstructed, residents have freedom of egress in any direction and reasonably convenient access in returning to the neighborhood.

Guidelines for peripheral barriers

If the through traffic enters and exits neighborhood streets with left turns to and from the bounding roadways, left turn prohibition signs can be effective. This is particularly true if the problem occurs at peak periods only. Supplementary "time in effect" signs can be added to place the control in force during periods when it is needed but leaving free access to all travelers at other times of the day. If the problem traffic is comprised of traffic crossing the bounding streets from adjacent neighborhoods plus some left turning traffic to and from the bounding streets, median barriers may be appropriate. If the problem traffic originates from several directions, or is heavily comprised of right turning traffic, semi-diverters are appropriate. Full cul-de-sacs may be substituted for semi-diverters if other conditions make restriction of egress also desirable. Where semi-diverters are desirable but conditions such as emergency vehicle access considerations preclude their use, one-way streets in the outbound direction may be substituted.

Internal barrier systems

Internal systems are preferred over peripheral ones in cases where problem traffic is biaxial, where boundary street oriented office-commercial uses extend partially into the neighborhood along local streets, where traffic conditions preclude a peripheral scheme or where a large traffic generator which requires good access, such as a hospital, is located within the neighborhood. Internal barrier systems are of three types: return loops, anti-through and maze.

As shown in Figure 82, return loops force traffic entering from any one of the streets bounding the protected neighborhood to return to the same boundary street from which it entered.

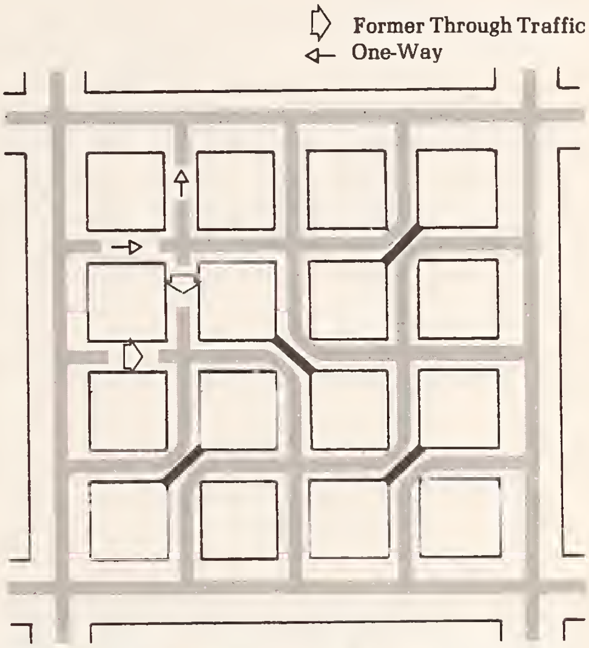


Figure 84a. Maze — **Motorist has no direct path across neighborhood but through travel is possible.**

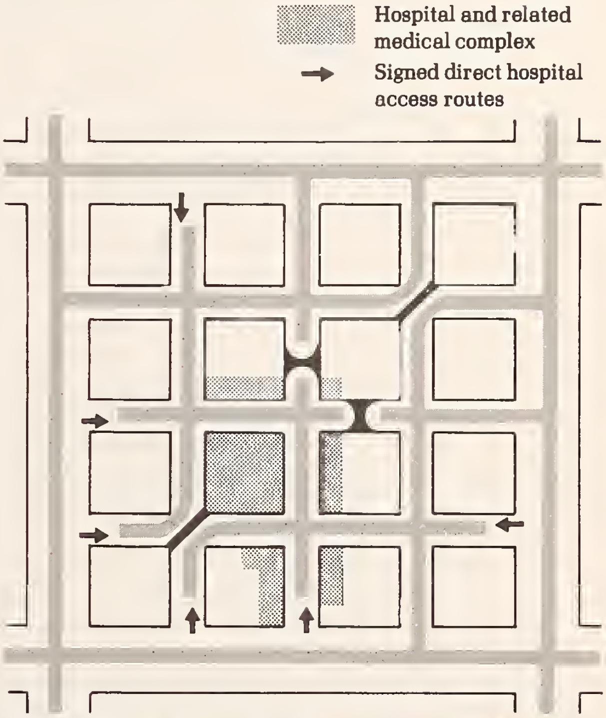


Figure 84b. **Maze system with internal special generator (Hospital)**

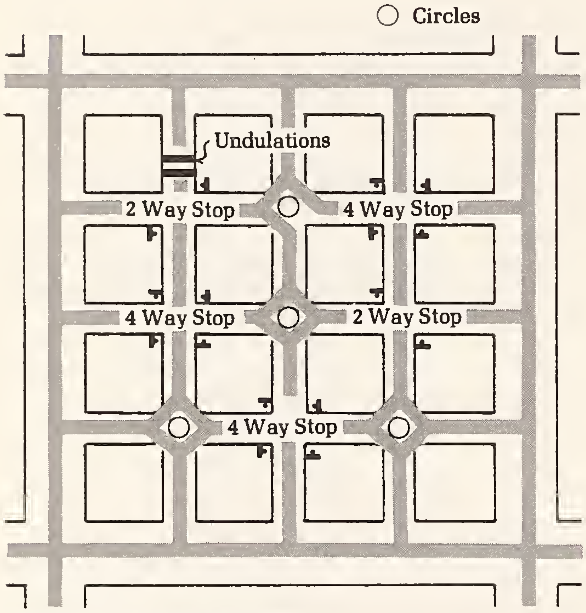


Figure 85. **Internal obstruction**

While return loops are extremely effective in limiting through traffic in the neighborhood, they are also extremely restrictive on resident travel, since each residence has access to only one boundary of the neighborhood. Internal vehicular travel in the neighborhood is virtually impossible and the system poses considerable barriers to emergency and service travel.

Figure 83 shows a typical anti-through system. It prevents traffic from traveling completely across a neighborhood to the opposite side although the motorist is not necessarily forced to return to the same boundary street from which entry was made. In anti-through systems, most residences have accessibility to two of the neighborhood boundaries although internal neighborhood travel by automobile is still problematic. Barriers to emergency and service vehicle travel are still formidable though less so than in the case of return loop system. Return loop and anti-through systems work well to combat through traffic incursions on both axes of the residential grid. However, more limited systems of either type can be devised to respond to problems on a single axis while leaving the remainder of the neighborhood street network relatively unobstructed.

Maze systems use physical barriers or other controls in a less intensely restrictive way. In these schemes the object is to leave no street as a continuous through path across the neighborhood. As shown in Figure 84, through penetration is possible, but only by following a circuitous path dodging around diverters and cul-de-sacs and other barrier devices. The theory behind the maze is that it will be sufficiently confusing to non-local travelers that they will not continue to attempt passage. For drivers familiar enough with the system to know how to get through, the out-of-direction travel and turning will make the route through the neighborhood unsatisfying as a short cut.

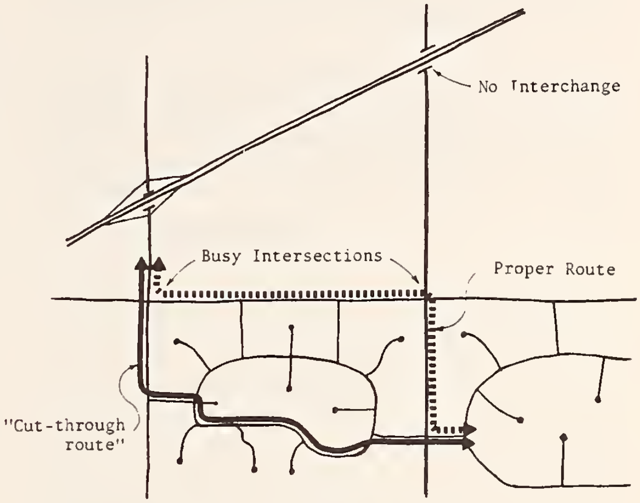
Of all the internal barrier systems, mazes entail the least inconvenience for residents as most residents have access to all of the bounding streets; usually only one or two blocks of out-of-direction travel is required and a fair degree of internal vehicular circulation within the neighborhood is preserved. However, this increase in resident access convenience is secured by having a system which is less positively effective against through traffic.

Figures 82, 83 and 84 all show return loop anti-through and maze systems designed to combat biaxial traffic incursions. However, all three can be designed to affect problem traffic on a single dominant axis if necessary. As noted above, internal systems are particularly effective when a special traffic generator requiring good access is located within the neighborhood, complicating the problem of combating thru traffic. Figure 84b shows a typical example of a hospital and related medical offices (hatched areas) located within a neighborhood and a maze system designed to discourage thru traffic. Note that the medical complex is directly accessible from all four of the bounding arterials.

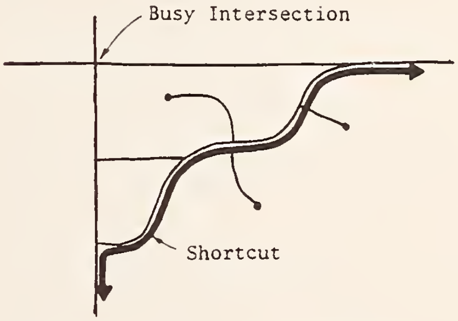
Principal devices in return loop, anti-through and maze systems are diverters, semi-diverters, cul-de-sacs, median barriers and one-way streets.

The three types of systems described above are intended primarily to reduce traffic volumes. Figure 85 illustrates a scheme intended to reduce neighborhood speeds. A series of obstructions within the neighborhood are intended to reduce speed while not necessarily reducing through traffic, though this may in fact occur a system is needed to prevent traffic from transferring to another local street and avoiding the obstruction. These devices have the least impact on service and emergency vehicles and also allow unimpeded access to residents.

The foregoing has focused upon applications in grid pattern situations. In some suburban situations, problems are analogous to those on a grid and the peripheral or internal barrier strategies may apply as shown below on Figure 86. In other situations, subdivision street patterns produce problems unique to modern suburban development. A residential collector street is pressed up the valley with a few cul-de-sacs branching from it. Traffic is not a problem. Later the collector is extended and more branches are added. Now all the residents living on or close to the collector trunk feel they are exposed to too much, too fast traffic. In such situations none of the barrier strategies are applicable since the problem is the only way in and out of the area. Here reliance on speed control devices, whether



Position of the freeway interchange and congestion at busy arterial intersections leads traffic from one neighborhood to cut through another even on a non-grid system.



In certain circumstances, shortcutting can be as much a problem on non-grid systems as on the grids.

Figure 86. **Non-grid system problems**

physical, passive or psychological, is the only traffic control recourse. Residential **protection** or **amelioration** schemes can be considered as alternatives to traffic control in this situation.*

---

*This example has been cited to demonstrate a residential street traffic problem in the context of a modern suburban environment. Virtually any arterial or collector street fronted by residential development whether in a grid or non-grid system, whether urban or suburban, is in somewhat the same situation and has the same limited set of countermeasure options.

4

Planning for neighborhood traffic management

Introduction

An effective, well-organized planning process is the single most important element in the creation of a successful neighborhood traffic management program. It seems overemphasizing the point to say the planning process is more important than selection of the "right" device; more important than design; or more important than implementation technique. Yet experiences reported in cities contacted in this State-of-the-Art search feature some successful efforts and numerous failures. In virtually every case, the failure of a program can be traced directly to either a breakdown in the planning process or the failure to have a structured process at all.

For this reason, this chapter has been designed to illustrate the more effective technical, political and social techniques for achieving a successful program. The chapter begins with an illustration of specific problems which have been observed in the unsuccessful efforts. It then concentrates on technical evaluation and community involvement techniques which have been used in the more successful program. The planner should be aware, however, that each local situation is unique. His main task in using this chapter will therefore be to select those techniques, from the many presented, that are most applicable to his problem.

Some Problems with Previous Neighborhood Traffic Management Programs

The contacts with local jurisdictions across North American cities uncovered a number of basic reasons why neighborhood traffic management (NYM) programs were unsuccessful. These reasons are summarized here to alert professionals to possible pitfalls to be avoided. They include:

- **Total lack of action.** Cases where no action whatever was taken can be traced to lack of procedures for receiving and recording citizen complaints, lack of perception by staff of the true nature of the problem or complaint, available data failing to confirm a stated problem, or lack of resources (staff, time and/or money) to deal with the problem.
- **Leaping to "obvious solutions".** Seemingly obvious solutions usually had hidden impacts not discovered until after implementation; the true need were not completely known, or better solutions were passed over either in haste or ignorance. Eliminating the needs assessment and alternative evaluation steps usually caused difficulties which could have been avoided with more time, care and a step-by-step analysis.
- **Too limited focus.** Neighborhood traffic problems are frequently more complex and extensive than the complaint initially brought to the professional's attention. If professionals react to the initial complaint or complaint site alone, they may overlook the systematic nature of neighborhood traffic problems and the potential systemic impacts of site-oriented solutions. As a result, the problem is not solved but simply pushed elsewhere. The problem identification and assessment stage must be broad-searching in initial examinations.
- **Lack of community involvement.** If the affected neighborhood is not involved in the planning process at an early stage, problems have developed because: (1) critical details which only community input can provide were not taken into account; (2) concern for the problem was limited to the original complainants who comprised a small segment of the community affected by the solution; (3) the solution involved secondary impacts unacceptable to the majority of those affected, or (4) those affected simply reacted adversely to a change to which they had no input and which took them by surprise. The planning process should include a well-orchestrated program for community information and involvement at all stages.
- **Discontinuity.** Gathering data, assessing the problems and conceiving solutions takes time. From the community's perspective, this appears as brief flurries of activity interspersed among lengthy periods of delay and no action. During these periods the community's support for the planning effort can melt away, or the community may in frustration and anger use the political process to institute inadequate solutions. The community involvement process must be organized to give a sense of continuous progress in planning activities during periods when technical progress cannot keep pace with public expectations. Newsletters, experiments and "early action" implementations are good ways of maintaining a sense of momentum while technical studies are ongoing.
- **Setbacks — Abandonment or Salvage?** When "solutions" didn't work out, some communities simply abandoned the effort. Others were able to salvage the attempt by testing proposals temporarily, by modifying devices based on field experience or by recycling the study process to produce a better solution. A formal procedure for evaluation after implementation — including the possibility of test applications and plan modification — should be a feature of the planning process as should the possibility of repeating the entire planning effort.
- **No final resolution.** In a few communities, discussion of issues and modification processes have carried on for years without satisfactory resolution. This can ultimately have a deleterious effect on the community's ability to carry out essential planning and engineering functions. The process should have limits so that, after a reasonable period for adjustments and reappraisals, any further appeals must move outside the planning process to decision-making bodies such as a city council or the courts.

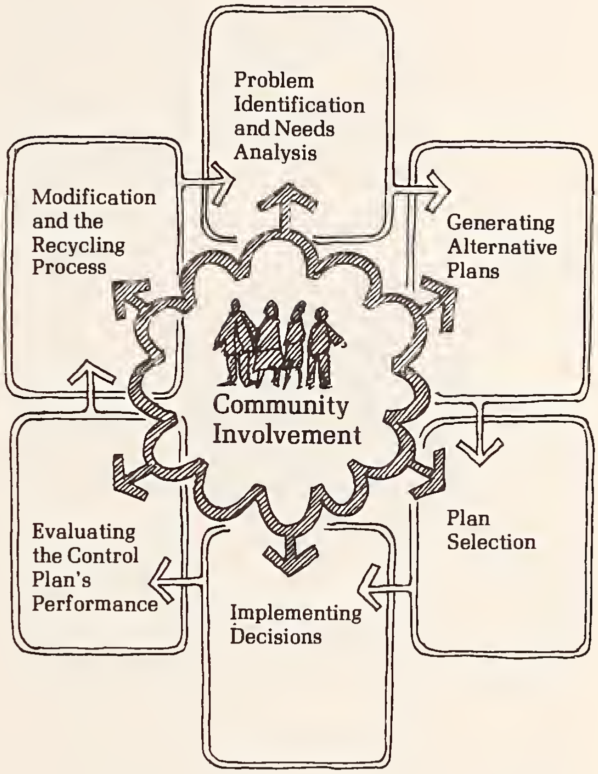
Structuring an Effective Planning Process

Planning for neighborhood traffic management is normally done in cognizance of but independent from the ongoing formalized city and regional planning process structure.

An effective planning process for a neighborhood consists of the following steps:

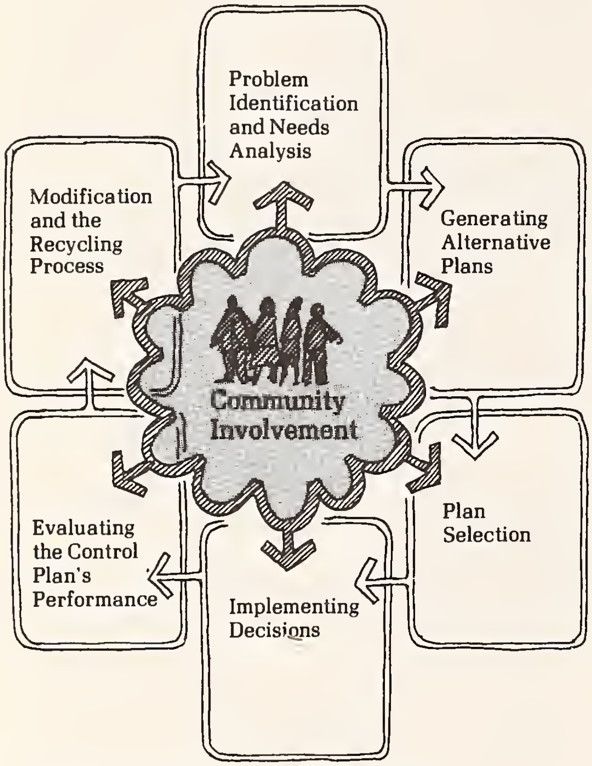
- Assessment of Problems and Needs
- Development of Alternative Plans
- Evaluation of Alternative Plans and Plan Selection
- Implementation of Selected Plan
- Evaluation of Selected Plan
- Modification of Plan and Recycling the Process

Each of these steps involves technical effort by the professional and involvement of the community. The sections which follow delineate the components of each of these steps, noting necessary technical and community involvement techniques. All of the techniques have been used to some extent by State-of-the-Art cities observed, though none followed the process exactly or completely. Thus what follows is an "ideal" planning process synthesized by the research team from current successful practice. The planner is again left with the task of choosing those techniques which best fit the local situation.



Why Community Involvement Is Necessary

Cities observed in this State-of-the Art review provide examples where well-intentioned efforts have failed because community involvement was inadequate or non-existent. The need for an effective community participation process is evidenced not only from a technical, but also a political or social standpoint. Engineers and planners may propose a technically correct solution relative to the data they have, but the solution may not solve the real problem because it does not address the unrecorded incidents observed by and of concern to the community. Or the community, distrustful of the professionals, may use political muscle to gain implementation



- Why Community Involvement Is Necessary
- Reliable Techniques and References for the Community Involvement Process

of a scheme which has overwhelming technical weaknesses. Community involvement allows the professionals to learn of residents' perceptions of problems, their depth of feeling about their needs, their ideas about what ought to be done and data items which only people as close to the situation as residents can observe, while professionals let residents know the physical, legal, financial and technical constraints on what can be done.

Local traffic schemes arouse powerful emotions and have widespread impact. Politically, neighborhood traffic management is controversial because inevitably some people gain and some lose. The public participation process permits assessment and exposure of potential trade-offs before implementation. Communication with potential opposition raises the possibility of working out compromises during the planning stage. And if adverse effects are not "advertised" in advance, the fact that they do occur might be used to discredit the planning process — it will be alleged that the process and the plan were defective because of these "unplanned" and "unforeseen" adverse impacts. People are also far more likely to accept a plan or take responsibility for making it successful if they have been part of the planning or design process.

The following section provides an assessment of reliable techniques and references for the community involvement proces, highlighted by documented experience in some of the case study cities. Specific guidance for community involvement is also presented within each section describing the individual steps in the planning process.

Techniques For Community Involvement

A diverse array of community involvement techniques developed for other types of planning activities is potentially adaptable to neighborhood traffic management. Community involvement usually operates at two levels:

- **participatory programs** involve community "leaders" and "active citizens"
- **outreach programs** to communicate with the "silent citizens," normally the vast majority of residents.

Table 7

Community involvement purpose by program stage

Program Stage	Community Involvement Purpose
Needs Assessment	Notify community that process is ongoing Receive community complaints Determine problems and assets Gauge level of concern and points of conflict Familiarize community with constraints and issues Focus data gathering activities
Generating Alternatives	Obtain citizen ideas and suggestions for solutions Sound out professionals' solution ideas with citizens Test strengths and weaknesses of solutions Draw out points of conflict
Plan Selection	Advise public of likely effects of each alternative Obtain public's weighing of tradeoffs involved in each alternative Test support for each alternative Work out compromises to potential conflicts Build a consensus and commitment for a single alternative Inform public of plan chosen
Implementation	Ease acceptance of the plan Identify problems early and make responsive adjustments
Evaluation and Modification	Inform the public of measured effects of the plan Learn of unforeseen problems or unexpected severity of foreseen ones Conceive and assess potential modifications

Committees, commissions, councils, discussion groups and other small meetings are the principal form in which leaders participate. Larger meetings, public hearings, design-ins and workshops are the primary means by which public officials can relate with larger numbers of active citizens. The main instrument used to learn about silent citizens' problems is the survey. Outreach techniques to inform them include use of media announcements and articles (newspapers, radio and TV), posters at prominent locations and leaflets mailed out or distributed by hand. Table 7 shows the functions of community involvement at each stage of the neighborhood traffic planning process. Naturally, different types of involvement techniques are needed to meet the disparate objectives at each stage. Figure 87 presents a range of involvement techniques and indicates which ones may be useful at each planning step. Descriptions of these techniques are provided on Figure 88.* Many of the techniques shown may be more sophisticated, costly or time consuming than is appropriate in the context of the particular community and problem under consideration. The following are major factors to consider in selecting techniques most applicable to the particular situation and community.[87]

- The intensity and pervasiveness of the community's **interest** in the traffic problem. Where strong interest is limited to a few residents, outreach approaches are indicated. Where interest is broad based, direct participatory techniques can predominate.
- The community's **attitude**, positive, negative, or neutral, toward the traffic problem. When a community has already developed an attitude, more sophisticated techniques may be required to assure fair consideration of all alternatives.
- The community's **cohesion** which greatly determines the ease with which consensus can be reached on a proper course of action.
- The community's **expectations of its role** in the planning process, which can determine what techniques they will accept and consider legitimate.
- The community's **past experience with citizen participation** and particular techniques.
- The community's **median education level** which can influence success of techniques heavily relying on certain skills, such as reading and writing.

---

*Figures 87 and 88 are adapted from **Effective Participation In Transportation Planning**, a comprehensive survey of techniques used in overall transportation planning programs.[87] Appendix A, drawn from the same source, summarizes resources required in using these techniques. Appendix B provides a listing of seven other comprehensive reference documents on community participation techniques and processes, with particular emphasis on transportation planning. Detailed discussion of techniques highlighted in this section may be found in these references. Further discussion and application of the community participation process to cities observed in this State-of-the-Art review is presented in other sections of this chapter.

In general, esoteric techniques should be avoided and the simplest techniques which seem likely to produce satisfactory results should be tried.

Planning Steps	Public Information Programs	Drop-in Centers	Hotlines	Meetings — Open Information	Ombudsman	Surveys	Focused Group Discussion	Delphi	Public Hearings	Meetings — Community Sponsored	Advocacy Planning	Charrettes	Community Planning Centers	Computer-Based Techniques	Design-in and Color Mapping
Needs Assessment	●			●		●	●			●					
Generating Alternatives	●	●	●	●	●	●	●	●		●	●	●	●	●	●
Plan Selection	●	●	●	●	●	●	●		●	●	●	●	●		●
Implementation	●		●												
Evaluation and Modification	●		●		●	●	●		●	●					

Planning Steps	Plural Planning	Task Force	Workshops	Citizens Advisory Committees	Citizen Representatives	Fishbowl Planning	Interactive Cable TV Participation	Meetings — Neighborhood	Neighborhood Planning Councils	Policy Capturing	Value Analysis	Arbitrative and Mediative Planning	Citizen Referendum	Citizen Review Board	Media-Based Issue Balloting
Needs Assessment				●	●			●	●					●	●
Generating Alternatives	●	●	●	●	●	●	●	●	●	●	●				●
Plan Selection	●	●	●	●	●	●	●	●	●			●	●	●	●
Implementation		●												●	
Evaluation and Modification		●		●	●			●	●					●	

● Indicates a technique that may be useful at that step.

Adapted from: U.S. Federal Highway Administration, Socio-Economic Studies Division. **Effective Citizen Participation in Transportation Planning, Volume I**; Community Involvement Processes, Washington, D.C. Government Printing Office, 1976 (p. 25).

Figure 87. **Citizen participation in the transportation planning process**

PARTICIPATION TECHNIQUES

Public Information Program: The provision to the public of information on a particular plan or proposal usually over a long period of time.

Drop-In Centers: Manned information distribution points where a citizen can stop in to ask questions, review literature, or look at displays concerning a project effecting the area in which the center is located.

Hot Lines: Any publicized telephone answering service connected with a planning process and used to answer citizens directly, to record questions to be answered with a later return call, or to provide citizens a recorded message.

Meetings-Open Information: Assemblies held voluntarily by the agency to present detailed information on a particular plan or project at any time during the process to all interested parties.

Surveys: Structured questioning of a probability sample of citizens who statistically represent the whole population.

Focused Group Discussion: Small meetings (8-10) guided by a trained moderator using a prepared outline and based on the assumption that the group collectively has more information and insight than the individual members (synergy).

Delphi: A method for systematically developing and expressing the views of a panel of individuals on a particular subject. Initiated with the solicitation of written views on a subject, successive rounds present the arguments and counterarguments from the preceding round for panelists to respond to as they work toward a consensus of opinion or clearly established positions and supporting arguments.

Meetings — Community-Sponsored: Assemblies organized by a community group, these meetings focus upon a particular plan or project with the objective to provide a forum for discussion of various interest group perspectives.

Public Hearings: A method usually required by law when some major governmental program is about to be implemented or prior to passage of legislation; characterized by procedural formalities, an official transcript or record of the meeting, and its being open to participation by an individual or representative of a group to present views for the official record.

Ombudsman: An independent, impartial official who serves as a mediator between citizen and government to seek redress for complaints, to further understanding of each other's position, or to expedite requests.

Advocacy Planning: A process whereby affected groups employ professional assistance directly with private funds and consequently have a cliet-professional relationship.

Charretts: A process which convenes interest groups (governmental and non-governmental) in intensive interactive meetings lasting from several days to several weeks.

Community Planning Centers: Ongoing local bodies which independently plan for their community using technical assistance employed by and responsible to a community-based citizens group.

Computer-Based Techniques: A generic term describing a variety of experimental techniques which utilize computer technology to enhance citizen participation.

Design-In and Color Mapping: A variety of planning methods in which citizens work with maps, scale representations, and photographs to provide a better idea of the effect on their community of proposed plans and projects.

Plural Planning: A method whereby each interest group has its own planner (or group of planners) with which to develop a proposed plan based on the group's goals and objectives.

Task Force: An ad hoc citizen committee sponsored by an agency in which the parties are involved in a clearly-defined task in the planning process. Typical characteristics are small size (8-20), vigorous interaction between task force and agency, weak accountability to the general public, and specific time for accomplishment of its tasks.

Workshops: Working sessions which provide a structure for parties to discuss thoroughly a specific technical issue or idea and try to reach an understanding concerning its role, nature, and/or importance in the planning process.

Citizens' Advisory Committees: A panel of citizens called together by the agency to represent the ideas and attitudes of their groups and/or communities.

Citizen Representatives on Policy-Making Boards: The participation by citizens as either appointed or elected members of public policy-making boards.

Fishbowl Planning: A process involving citizens in restructuring a proposed plan before adoption. Fishbowl planning uses public meetings, public brochures, workshops, and a citizens' committee; the brochures provide continuity between successive public meetings.

Interactive Cable TV-Based Participation: An experimental tool utilizing two-way coaxial cable TV to solicit immediate citizen reaction; this technique is only now in the initial stages of experimentation on a community level.

Meetings — Neighborhood: Meetings held for residents of a specific neighborhood that has been, or will be, affected by a project or plan. Usually they are held either very early in the planning process or when plans have been developed and response is needed.

Neighborhood Planning Councils: A structure for obtaining participation on issues which affect a specific geographic area; the council serves as an advisory body to the public agency in identifying neighborhood problems, formulating goals and priorities, and evaluating and reacting to the agency's proposed plans.

Policy Capturing: A highly sophisticated, experimental method involving mathematical models of policy positions of parties-at-interest. It attempts to make explicit the weighing and trading-off patterns of an individual or group.

Value Analysis: A process which involves various interest groups in the process of subjectively ranking consequences of proposals and alternatives to articulate community goals against which alternative plans can be evaluated and consensus for one alternative be developed.

Arbitrative and Mediative Planning: The utilization of labor-management mediation and arbitration techniques to settle disputes between interest groups in the planning process.

Citizen Referendum: The choice by citizens between proposed measures via balloting, may be an official, statutory technique or unofficial.

Citizen Review Board: A structure whereby decisionmaking authority is delegated to citizen representatives who are either elected or appointed to sit on a board with the authority to review alternative plans and decide which plan should be implemented.

Media-Based Issue Balloting: A tool whereby citizens are informed through public media such as newspapers or TV of the existence and scope of a public problem, alternatives are described, and then citizen are asked to indicate their views and opinions in a ballot to be returned for counting.

Figure 88. **Description of participation techniques**

PARTICIPATION PROCESS SUPPORT

Citizen Employment: The direct employment of client representatives; results in continuous input of clients' values and interests to the policy and planning process.

Citizen Honoraria: Payments originally used as an incentive for participation of low-income citizens; honoraria differs from reimbursement for expenses in that it dignifies the status of the citizen and places a value on his/her participation.

Citizen Training: Instruction in technical issues, planning, or leadership for participants.

Community Technical Assistance: The provision of professional staff and/or technical information and explanations to interest groups so they may develop alternative plans or articulate objections to plans and policies proposed by the agency.

Coordinators or Coordinator/Catalysts: An individual who has responsibility for providing a focal point for citizen participation in a project, being in contact with all parties, and channeling feedback from citizens into the planning process.

Game Simulations: Experimentation by citizens in a risk-free setting with various alternatives (policies, programs, plans) to determine their impacts in a simulated, competitive environment where there is no actual capital investment and no real consequences at stake.

Group Dynamics: A generic term referring to either interpersonal techniques and exercises to facilitate group interaction or problem-solving techniques designed to highlight substantive issues.

Figure 88. **Description of participation techniques (continued)**

Source: **FHWA, Selecting Effective Citizen Participation Techniques, 1979. (pp. 4-5).**

Community Involvement And The Professional's Role

Community involvement has been heavily emphasized herein because of shortcomings observed in programs to date. However, planners and traffic engineers cannot rely on community involvement alone to produce successful traffic management programs. Professionals have a vital role to play in assembling and interpreting technical information, in defining the full range of alternative solutions, in identifying technical constraints, in estimating the effects of alternative schemes, in acting as an intermediary between conflicting groups and in advocating schemes which appear most effective, beneficial and equitable. A program devoid of true professional analysis is as likely to fail is one in which the community has little or no voice.

Problem identification and needs analysis

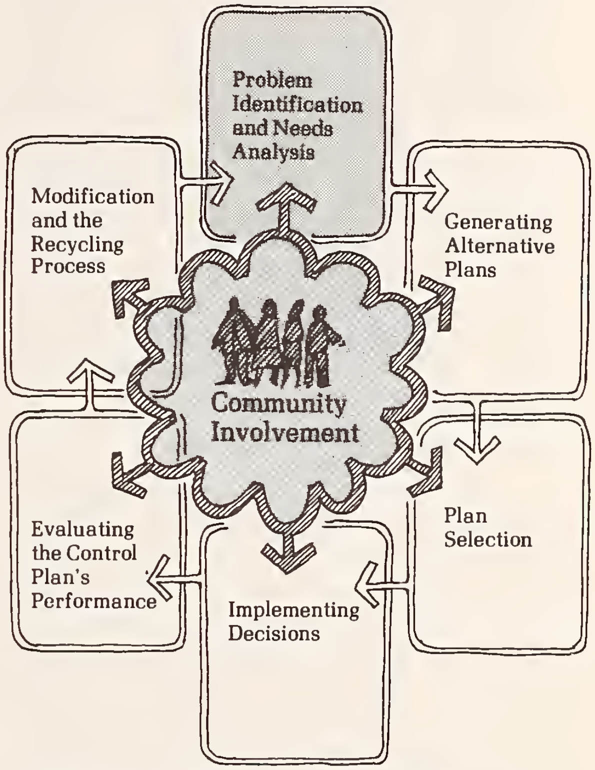
Elements of a Community Needs Assessment

The planning process usually begins with citizen requests for action or with the professional's perception that a problem exists. In either case, the planner must gain a thorough understanding of the problem both in technical terms and from the community's point of view. With this background, a technical evaluation of need can be made to compare perceived problems with objective data that may or may not confirm the problem. Effective analysis at this stage of the planning process requires:

- **Searching for all possible points of view.** Attempts should be made to involve merchants, residents and commuters who may not actively participate in public hearings but who will be affected by any plan.
- **Outreach to silent citizens.** Although outgoing and active citizens easily become involved, the vast majority of people, even though they have strong feelings on an issue, do not write letters to editor, petition city councils or attend public meetings. If the community involvement process is to be effective and truly representative, it must reach out to these **silent citizens**. Early use of mass media, publicity and opinion surveys are good ways of gaining silent citizens' inputs at the

start of the planning process.

- **Efficient utilization of citizen involvement or input.** Early involvement is vital to assure that the process is directed to citizen needs rather than following preconceived notions of officials. Citizen involvement must be sufficiently focused to provide useful input. Surveys which ask citizens to prioritize their concerns on a general level about neighborhood issues such as traffic, beautification, maintenance of housing stock, etc., do not address the problems which traffic management can solve. Usually more direction is required; any survey should seek reactions to specific issues such as: "heavy traffic on my street affects my walking pattern . . ." or "the noise of truck traffic keeps me awake at night . . ."
- **Proper weighing of viewpoints.** Recognition of different viewpoints and needs in the neighborhood should be acknowledged, as should determination of whether a vocal majority or minority is representing interested parties at public hearings/neighborhood meetings.
- **Sensitivity to special resident groups.** Residents most vulnerable to changes in traffic patterns include the elderly, handicapped and children. These groups are usually less vocal, less organized participants in the public or political process and their needs and concerns are different than those of other residents. Similarly, recognition should be given to different residential preference or lifestyle groups, e.g., those who spend a majority of their time at home versus those working during the day and often seeking relaxation and enjoyment outside their home.
- **Sensitivity to perceived as well as measurable problems.** The nature of traffic engineering as it is practiced on arterial and higher order facilities is usually to rely heavily on evaluation of objective and quantifiable data. On local neighborhood streets, a different approach is needed. Driver actions which citizens on local streets perceive as problems often "measure" to be quite normal when they are evaluated by arterial standards. The key to successful assessment of neighborhood traffic problems is to understand the residents' perception of the neighborhood, and to use measures which respond to the residents' perceptions and expectations rather than the drivers'.



- Elements of a Community Needs Assessment
- Citizen's Direct Input — Community Involvement in Needs Assessment
- Environmental and Resident Activity Observations
- Synthesizing Community Input and Technical Measurements

- **Organized analysis program and relevant observations.** Resources can easily be wasted collecting large amounts of irrelevant data or conversely critical data items may be overlooked. Once the issues and individuals involved become clear, an organized approach to the needs assessment is essential.
- **Proper staff and resource support.** In the cities observed, traffic engineers often assumed responsibility for performing a needs assessment. While their technical input was complete and reliable, their handling of community participation was often ineffective or virtually non-existent. Planning departments can usually offer guidance in community participation techniques such as surveys, interviews, presentations and meetings.

Initiating The Needs Assessment

When should a formal needs assessment be undertaken? If the objective traffic statistics available or casual direct observation present direct evidence of a problem, there is clear indication that some sort of analysis should begin. However, the absence of such direct objective evidence in an initial screening is **not** a sufficient basis for concluding that no problem exists and therefore no assessment is needed. As is discussed at length subsequently, data customarily collected by traffic and planning professionals or the way they customarily analyze and interpret that data may not be relevant to the actual concerns of residents and other street users.

If a sizeable minority of residents or users of a block, street or area complain about some condition, or if a majority of people in a particularly vulnerable or sensitive group (i.e., the elderly, parents with young children) complain, then there indeed is some kind of problem, even if not reflected in normal traffic data.

Techniques and Measures for Problem Identification and Needs Analysis

Community needs analysis has two points of focus, resident conditions and traffic service conditions. Resident analysis assesses the needs, problems and impacts of traffic on residents, and other institutions sensitive to it. Traffic and services analysis assesses the needs and problems of all those who wish to have access to or through the area.

The traffic analysis and resident analysis act as mutual checks, ensuring that there are gounds for community concerns, that solutions will be relevant to residents' concerns and that basic transportation needs will be met. Taken together they generate a "before" data base upon which performance of the "solution" eventually implemented can be evaluated.

Techniques used for **resident analysis** and **traffic service analysis** fall into five main categories: citizens direct inputs, traffic/service observations, environmental observations, observations of resident activities, and records. Table 8 presents a range of measures in each of these categories. The large number of measures reflects the diversity of traffic impacts and the limitations of individual measures. No single measure or small group of them is sufficiently comprehensive to reasonably relate to all of the issues of possible concern. And even where measures are relevant, reliability of the measure can be a problem.* Direct inputs of citizens are usually relevant but not necessarily reliable. Direct observations and records are usually reliable but not always directly relevant. For this reason Table 8 arrays measures by resident and traffic conditions each purports to assess, and rate each for relevance and reliability. The table also demonstrates why traffic counts are the most predominant measure in current use — volume counts are a highly reliable and at least somewhat relevant indicator on virtually every needs issue.

The needs assessment should not become an immense data-bound project. Table 8 provides a basis for organizing an analysis plan so that only those measure relevant to the specific problem at hand are used. Because neighborhood traffic concerns often involved microsale issues and impacts, data should generally be aggregated at the block level. Data should be assembled not just for the apparent problem site but for the full area likely to be impacted by the problem or by its solution.

---

*A measure is said to be reliable if different people independently evaluating a condition or event consistently coincide in rating it.

Table 8

TECHNIQUES AND MEASURES OF ASSESSMENT AND EVALUATION

TECHNIQUES	MEASURES	QUALITIES MEASURED												
		RESIDENT NEEDS										TRAFFIC/SERVICE NEEDS		
		Safety	Children's Play	Walking, Cycling, Handicapped	Parking	Noise	Air Pollution	Appearance & Maintenance	Neighboring	Social Stability	Crime	Vehicular Access	Emergency Services	Other Services
CITIZEN INPUTS	resident needs/values	◑	◑	◑	◑	◑	◑	◑	◑	◑	◑	◑		
	satisfaction/disturbance	◑	◑	◑	◑	◑	◑	◑	◑	◑	◑	◑		
	suggested improvements	○	○	○	○	○		○	○	○	○	○		
	traffic needs/values											○	◦	◦
TRAFFIC/SERVICE OBSERVATIONS	traffic volume	•	•	•		●		•	•			●	•	•
	speed	•	•	•		●		•	•			●	•	•
	parking	•	•	•	●			•				●		●
	composition	•	•	•		●		•				•		
	safety, conflicts	•	•	•								•		
	obedience	•	•	•								•		
	access											●	●	●
ENVIRONMENTAL OBSERVATIONS	traffic noise					●								
	traffic safety conditions	●												
	street access										●	●	●	●
	walking, cycling & handicapped conditions	●	●	●										
	space analysis	●	●	•								•		
	visual quality							●						
RESIDENT OBSERVATIONS	street activities	●	●	●					●					
	walking, cycling & handicapped behavior	●		●										
	parking activities				●									
RECORDS	accidents	●	●	●										
	crime statistics										●			
	existing traffic counts	•	•	•		●		•	•			●	•	•
	census data									◦				
	land use data									◦				
	assessed values									◦				
	station and route inventories												●	●

● highly relevant and reliable
○ highly relevant, somewhat reliable
• highly reliable, somewhat relevant
◦ somewhat relevant and reliable
◑ highly relevant, reliability varies

Citizens' Direct Input — Community Involvement in Needs Assessment

The techniques used at this stage include receipt of initial compaints, direct interpersonal communication, and outreach to the larger community. Neighborhood traffic management programs usually start with the receipt of individual compaints or petitions for action. This is a normal aspect of many governmental processes; the key element is that an efficient method of logging and analyzing the requests should occur, so that each complaint is fairly dealt with and so that repeated requests from a single area can be seen as a more positive indication that a problem exists.

When an agency decides to undertake a program in an area, interpersonal communication between the agency and the citizens is imperative. Contacts with the most concerned individuals can help focus on the greatest needs, and community meetings can produce more detailed viewpoints from a larger segment of the community. However, those who complain to an agency and those who attend public meetings often form only a small percentage of the neighborhood population.

To determine the needs of the silent citizens, and to alert them at an early stage that actions are being considered, outreach techniques — including formal surveys, informational brochures and similar techniques — should be initiated. At this point no formal solutions which may appear as a threatened action should be put forth. However, the agency should have something concrete for the citizens to react to in order to stimulate reactions and new thinking. Lists of specific problems (e.g., noise, safety, visual quality) related to the citizens' own neighborhood and generic illustrations of possible solutions are most effective.

Figures 89 and 90 show two graphical techniques intended to stimulate reaction; Figure 91 is a typical questionnaire used in Seattle as part of an outreach program to determine neighborhood feeling. This questionnaire is especially good at searching for people's perception of problems as well as producing a preliminary indication of problems and inconveniences which the various control measures might produce.

Traffic/Service Observations

This section summarizes the most important measures, including specific details on why certain data is needed and how to interpret it. These measurements are those primarily used in evaluation of alternatives and follow-up evaluation of implemented plans; thus a thorough initial data collection is vital to eventual "before and after" evaluation. The material which follows is pertinent to how the data is used in the needs assessment process. Additional details relating to what to collect is contained in Appendix C.

Total Traffic. Most jurisdictions today have a functional classification system which designates the general purpose a street should serve. Few have specified upper limits to the volume for each classification and used them as threshold levels above which a street can be considered a candidate for management. Daily volumes of 1000 to 2000 or peak hour volumes of 100 to 200 vph have been used for local residential streets, but no national consensus exists.* Table 9 presents one attempt at this type of classification with desirable maximum volumes for each class.[89]

Table 9
Street classification

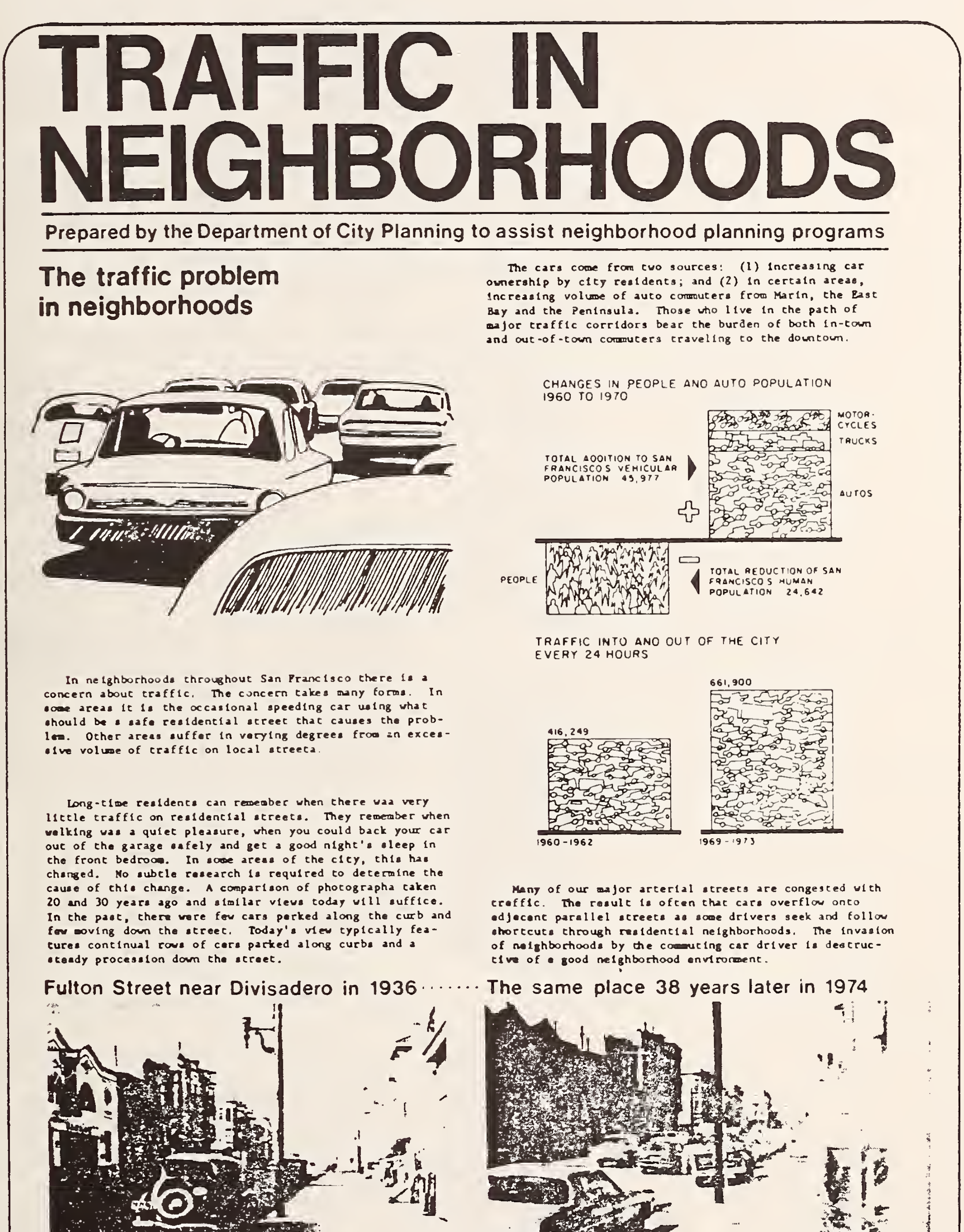
Classification	Usual ADT Range
Place	0 - 100
Lane	75 - 350
Local	200 - 1000
Collector	800 - 3000
Arterial (or higher)	Over 3000

Source: **Reference 89**

Resident demands for changes in neighborhood traffic conditions do not seem in any way linearly related to the actual traffic volume. Rather, it appears that complaints about traffic occur whenever the actual conditions on the street differ from resident's expectations as to what

---

*Traffic volume ranges in this section do not relate to capacity in the traditional traffic engineering sense. Most streets are physically capable of carrying much more traffic than the levels indicated on Table 9. Also note that volume ranges are expressed in vehicles per day (vpd) rather than average daily traffic (ADT) because when dealing with low volume streets most professional simply use the raw ground counts rather than factoring them to produce an ADT.



TRAFFIC IN NEIGHBORHOODS

Prepared by the Department of City Planning to assist neighborhood planning programs

The traffic problem in neighborhoods

In neighborhoods throughout San Francisco there is a concern about traffic. The concern takes many forms. In some areas it is the occasional speeding car using what should be a safe residential street that causes the problem. Other areas suffer in varying degrees from an excessive volume of traffic on local streets.

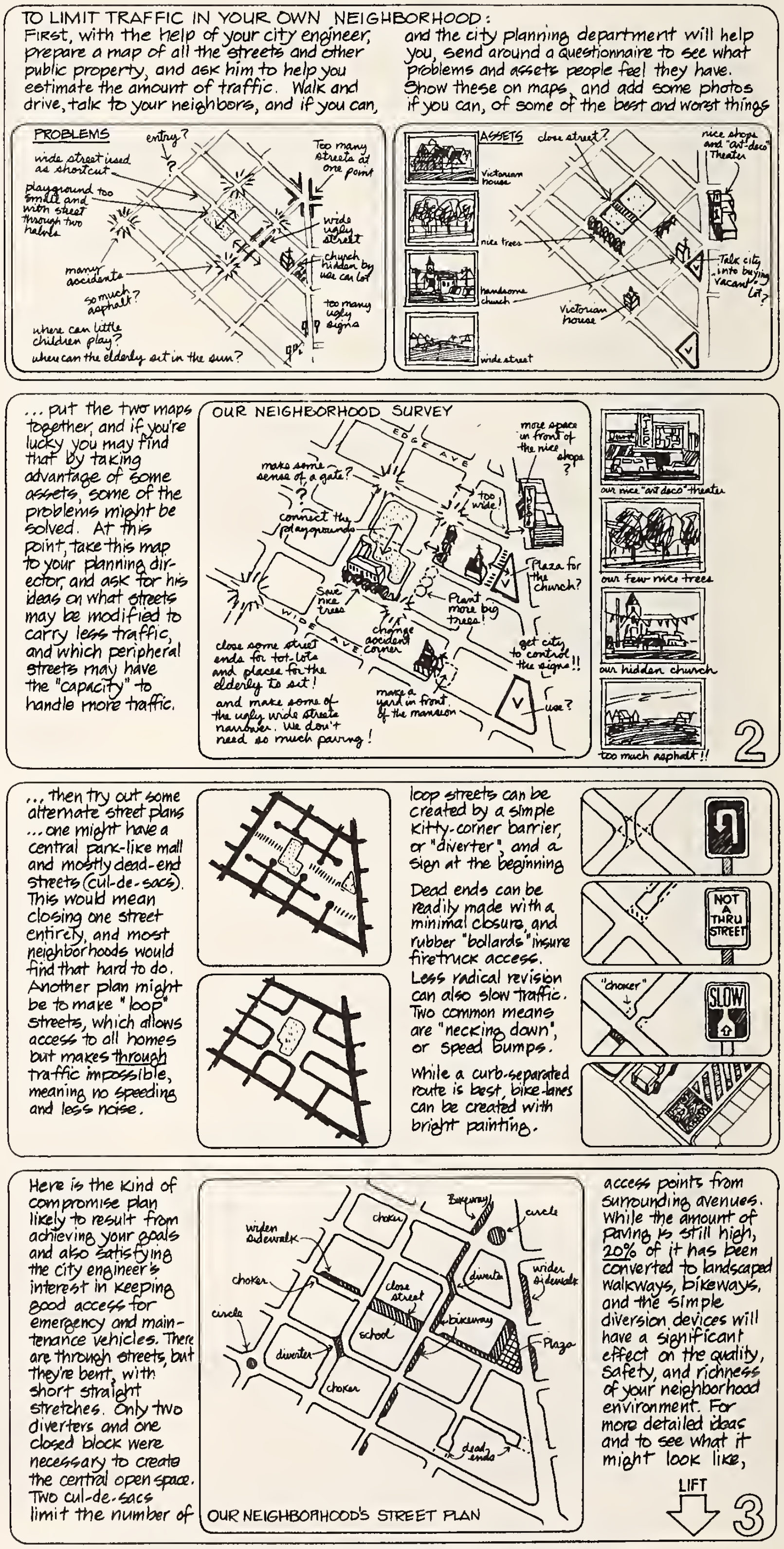
Long-time residents can remember when there was very little traffic on residential streets. They remember when walking was a quiet pleasure, when you could back your car out of the garage safely and get a good night's sleep in the front bedroom. In some areas of the city, this has changed. No subtle research is required to determine the cause of this change. A comparison of photographs taken 20 and 30 years ago and similar views today will suffice. In the past, there were few cars parked along the curb and few moving down the street. Today's view typically features continual rows of cars parked along curbs and a steady procession down the street.

The cars come from two sources: (1) increasing car ownership by city residents; and (2) in certain areas, increasing volume of auto commuters from Marin, the East Bay and the Peninsula. Those who live in the path of major traffic corridors bear the burden of both in-town and out-of-town commuters traveling to the downtown.

Many of our major arterial streets are congested with traffic. The result is often that cars overflow onto adjacent parallel streets as some drivers seek and follow shortcuts through residential neighborhoods. The invasion of neighborhoods by the commuting car driver is destructive of a good neighborhood environment.

Fulton Street near Divisadero in 1936 ······ The same place 38 years later in 1974

Figure 89. San Francisco. A Newssheet, "Traffic in the Neighborhoods."



TO LIMIT TRAFFIC IN YOUR OWN NEIGHBORHOOD:

First, with the help of your city engineer, prepare a map of all the streets and other public property, and ask him to help you estimate the amount of traffic. Walk and drive, talk to your neighbors, and if you can, and the city planning department will help you, send around a questionnaire to see what problems and assets people feel they have. Show these on maps, and add some photos if you can, of some of the best and worst things

... put the two maps together, and if you're lucky you may find that by taking advantage of some assets, some of the problems might be solved. At this point, take this map to your planning director, and ask for his ideas on what streets may be modified to carry less traffic, and which peripheral streets may have the "capacity" to handle more traffic.

..., then try out some alternate street plans ... one might have a central park-like mall and mostly dead-end streets (cul-de-sacs). This would mean closing one street entirely, and most neighborhoods would find that hard to do. Another plan might be to make "loop" streets, which allows access to all homes but makes through traffic impossible, meaning no speeding and less noise.

loop streets can be created by a simple kitty-corner barrier, or "diverter", and a sign at the beginning

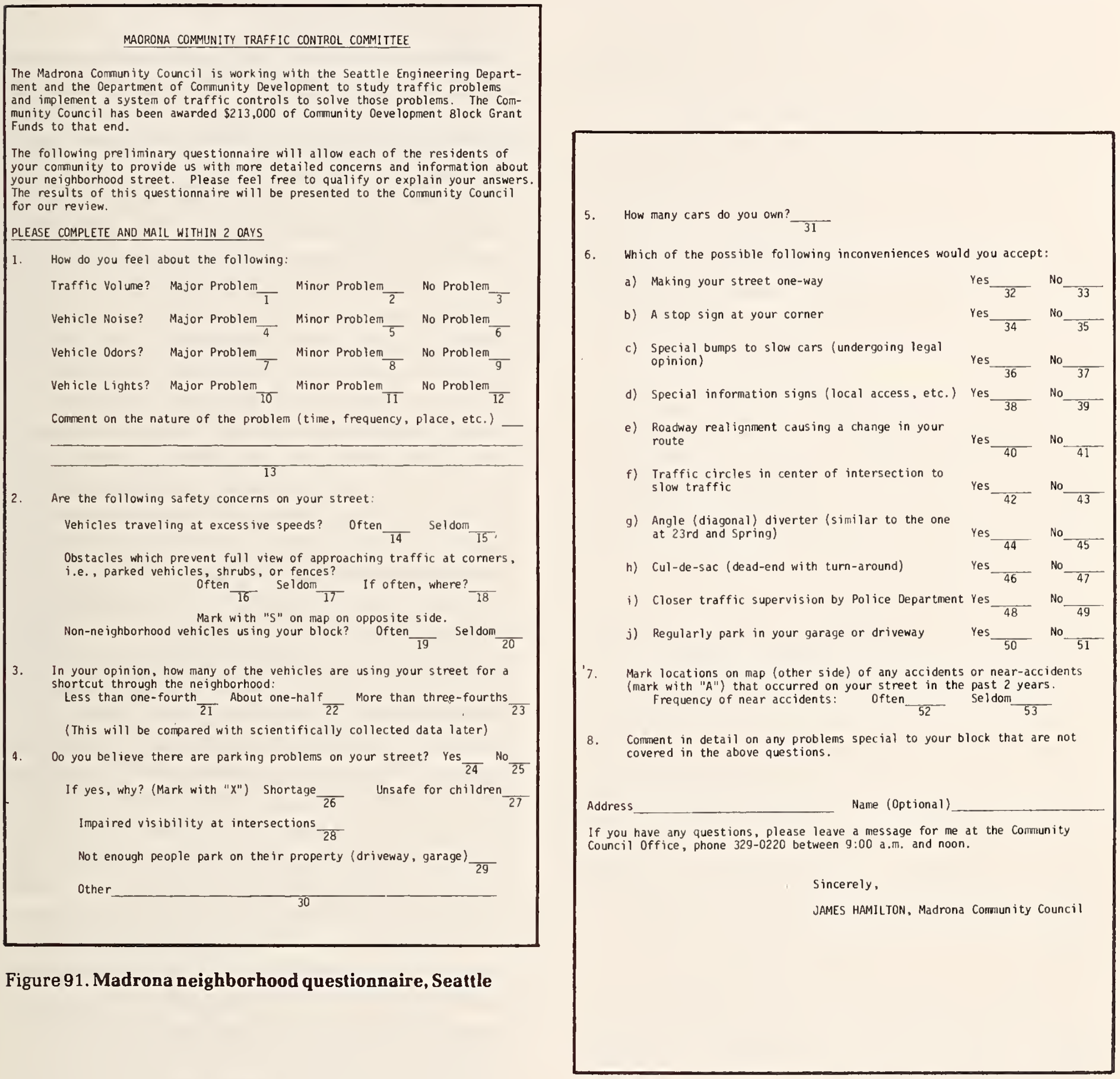
Dead ends can be readily made with a minimal closure, and rubber "bollards" insure firetruck access.

Less radical revision can also slow traffic. Two common means are "necking down", or speed bumps.

While a curb-separated route is best, bike-lanes can be created with bright painting.

Here is the kind of compromise plan likely to result from achieving your goals and also satisfying the city engineer's interest in keeping good access for emergency and maintenance vehicles. There are through streets, but they're bent, with short straight stretches. Only two diverters and one closed block were necessary to create the central open space. Two cul-de-sacs limit the number of access points from surrounding avenues. While the amount of paving is still high, 20% of it has been converted to landscaped walkways, bikeways, and the simple diversion devices will have a significant effect on the quality, safety, and richness of your neighborhood environment. For more detailed ideas and to see what it might look like,

Figure 90. **An innovative approach to soliciting community input**
Source: **Jack Sidener, "Recycling Streets," November 1975**



MADRONA COMMUNITY TRAFFIC CONTROL COMMITTEE

The Madrona Community Council is working with the Seattle Engineering Department and the Department of Community Development to study traffic problems and implement a system of traffic controls to solve those problems. The Community Council has been awarded $213,000 of Community Development Block Grant Funds to that end.

The following preliminary questionnaire will allow each of the residents of your community to provide us with more detailed concerns and information about your neighborhood street. Please feel free to qualify or explain your answers. The results of this questionnaire will be presented to the Community Council for our review.

PLEASE COMPLETE AND MAIL WITHIN 2 DAYS

1. How do you feel about the following:

Traffic Volume? Major Problem___ 1 Minor Problem___ 2 No Problem___ 3

Vehicle Noise? Major Problem___ 4 Minor Problem___ 5 No Problem___ 6

Vehicle Odors? Major Problem___ 7 Minor Problem___ 8 No Problem___ 9

Vehicle Lights? Major Problem___ 10 Minor Problem___ 11 No Problem___ 12

Comment on the nature of the problem (time, frequency, place, etc.) ___ 13

2. Are the following safety concerns on your street:

Vehicles traveling at excessive speeds? Often___ 14 Seldom___ 15

Obstacles which prevent full view of approaching traffic at corners, i.e., parked vehicles, shrubs, or fences?
Often___ 16 Seldom___ 17 If often, where?___ 18

Mark with "S" on map on opposite side.
Non-neighborhood vehicles using your block? Often___ 19 Seldom___ 20

3. In your opinion, how many of the vehicles are using your street for a shortcut through the neighborhood:
Less than one-fourth___ 21 About one-half___ 22 More than three-fourths___ 23

(This will be compared with scientifically collected data later)

4. Do you believe there are parking problems on your street? Yes___ 24 No___ 25

If yes, why? (Mark with "X") Shortage___ 26 Unsafe for children___ 27

Impaired visibility at intersections___ 28

Not enough people park on their property (driveway, garage)___ 29

Other___ 30

5. How many cars do you own?___ 31

6. Which of the possible following inconveniences would you accept:

a) Making your street one-way Yes___ 32 No___ 33

b) A stop sign at your corner Yes___ 34 No___ 35

c) Special bumps to slow cars (undergoing legal opinion) Yes___ 36 No___ 37

d) Special information signs (local access, etc.) Yes___ 38 No___ 39

e) Roadway realignment causing a change in your route Yes___ 40 No___ 41

f) Traffic circles in center of intersection to slow traffic Yes___ 42 No___ 43

g) Angle (diagonal) diverter (similar to the one at 23rd and Spring) Yes___ 44 No___ 45

h) Cul-de-sac (dead-end with turn-around) Yes___ 46 No___ 47

i) Closer traffic supervision by Police Department Yes___ 48 No___ 49

j) Regularly park in your garage or driveway Yes___ 50 No___ 51

7. Mark locations on map (other side) of any accidents or near-accidents (mark with "A") that occurred on your street in the past 2 years.
Frequency of near accidents: Often___ 52 Seldom___ 53

8. Comment in detail on any problems special to your block that are not covered in the above questions.

Address___ Name (Optional)___

If you have any questions, please leave a message for me at the Community Council Office, phone 329-0220 between 9:00 a.m. and noon.

Sincerely,

JAMES HAMILTON, Madrona Community Council

Figure 91. **Madrona neighborhood questionnaire, Seattle**

conditions on that particular street should be. This lends some support to the concept of using comparisons of actual traffic volume to desired range by functional classification as an indicator of need for traffic management action.

While there is not a linear relationship between compaints and traffic volume, there is a critical volume range in which resident expectations seem most likely to differ from actual conditions. This occurs on moderately traveled streets — streets serving from slightly under a thousand to roughly three thousand vehicles per day, particulary streets classified as "local" streets.

Below 800 vpd, conditions normally meet expectations though complaints sometimes occur when a large percentage of the volume is comprised of through trips. Complaints on lightly traveled streets most often focus on other concerns like occasional speeders or a site-specific hazardous condition.

In the 800-3000 vpd range, residents have the image and expectation of their street as a quiet, lightly traveled one. But this range appears to be a threshold at which residents generally become conscious of traffic as an irritant. They become aware of traffic noise, of occasional conflicts while entering or leaving their driveways, of the need to always be wary when crossing streets and increasingly concerned for the safety of children playing in or along the streets. Hence, in this threshold range conditions do not match expectations, and residents demand changes — in specific less traffic. And their demands for action tend to be most persistent and vocal.

At volumes above this "critical" range, more* residents are concerned about traffic than on lightly traveled streets. But residents of these moderately traveled streets (above 3000 vpd) seem to perceive their street as an active rather than lightly traveled one. Hence, while more may be disturbed, residents' expectations are for measures to control traffic's most extreme impacts (i.e., eliminate speeders, provide safer crossings for children) rather than for large-scale traffic reductions.

Above 10,000 ADT, the numbers of people disturbed by traffic seems to stabilize (does not increase with increased traffic volume) and actually complaints about traffic tend to be fewer and less intense than on the light and moderately traveled streets. A number of factors may account for these observations. The 10,000 ADT level seems to be an upper threshold in the sense that if a resident is at all susceptible by traffic-related environmental conditions, the individual's irritation level is likely to be reached before traffic reaches 10,000 ADT. Residents on streets above 10,000 ADT may concede that theirs is a truly busy street and traffic reasonably "belongs there." Hence, they tend to complain only in the wake of major incidents (i.e., a child-pedestrian fatality). Also residents who are somehow insensitive to traffic impacts (the hard-of-hearing elderly person undisturbed by traffic noise or the single young-adult usually home only late at night when there is no traffic) or who accept not-particularly-desired traffic impacts as a trade-off for other considerations (the limited income family living on a busy street because of lower rent there) tend to comprise an unusually large portion of those living on a heavily traveled street. In general, while large numbers of people on busy streets may not like traffic conditions there, in most cases they do not expect or strive for improvements in those conditions through traffic restraints. In fact, busy street residents may not even perceive any changes in environmental conditions as a result of traffic volume changes which would cause large perceptible differences in conditions on the light and moderately traveled streets.

The conclusion that measures to reduce traffic volume should be concentrated on streets in the "critical" and moderately traveled ranges is a valid generalization. This strategy focuses on the volume range of greatest resident sensitivity and complaint. Potential productivity in terms of increasing resident satisfaction is high since relatively small reductions can put traffic below the threshold at which residents normally become irritated. And the size of reduction needed to cross the threshold is usually small enough that there is a fair prospect of achieving

---

*Actual numbers concerned about traffic on a street of any given volume tends to be a function of numerous variables — traffic speed, dwelling type and setback from the street, presence of children, and numerous resident demographic factors.

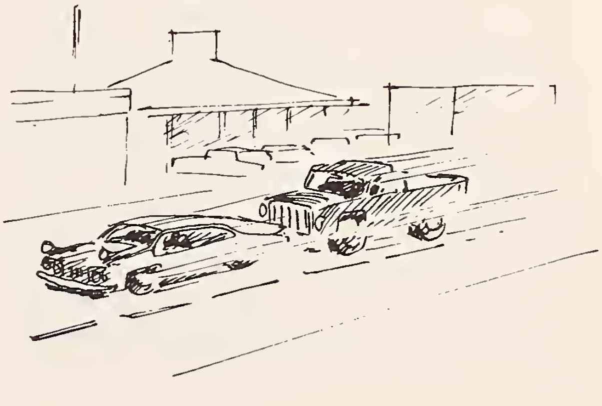
it without incurring major adverse impacts elsewhere. By contrast, a busy street's traffic could be reduced from say 18,000 ADT to 14,000 ADT without any meaningful change in the residents' perceptions of conditions. Meanwhile, the amount of traffic diverted in this latter case is substantial enough that adverse impacts elsewhere seem likely.

Focusing traffic reduction measures on "critical volume range" streets should not be regarded as an absolute principle. Unwarranted through vehicles may comprise most of the traffic on a street still in the low volume range. Or a local street may be loaded not just into the "critical" range but well into the moderate or even busy range by overflow from a congested major street or overloaded intersection. Both these types of conditions may well warrant traffic reduction measures.

Through Traffic. The nature of some street patterns may be such that even though the "critical" volume range is reached on a street designated as local, the traffic is still composed of local residents accessing their homes. Or even on a relatively lightly traveled local street, the total volume of traffic may seem far more than what should be using the street for local access. Surveys or estimates of through traffic can help to determine if neighborhood intrusion really exists, and if so, how great a reduction can be anticipated by a management program.

Traffic Speed. The problem of traffic speed is as much a problem of perception as it is a problem of reality. The key point in measuring speed on residential streets is that the standard technique of determining the 85th percentile speed has little meaning. It is the speed of the highest 15%, or even less, that often arouses the fears, anger, and frustration of residents. It is the fear of the infrequent speeder, the possibility that a child might not be expecting a speeding car, and the insult that the speeding motorist represents to a homeowner enjoying a peaceful quiet afternoon, that causes much of the problem. This aspect should receive as much attention as those cases where the speed of all cars is a demonstrable problem. Perceptions of speed may also result from accelerating and braking actions.

Another key point is that traffic need not be "speeding" to be considered "too fast" for resi-



dential areas. European planning practice is aiming for speed ranges on local residential streets well below the 25-30 mph limit common in the U.S.

Traffic Composition. This measurement is needed only to confirm the presence of trucks, buses, and/or motorcycles when complaints are possibly caused by these particular types of vehicles are received.

Capacity Studies. The ability of designated arterial and collector streets to accept traffic diverted from local streets by traffic management measures is a fundamental constraint to be considered in the assessment. Consideration of major street capacity constraints as a causal factor in local street problems is also important.

Traffic Safety. Because of the low volumes involved, accidents on local streets are a statistically rare event. A neighborhood unit is rarely large enough to allow statistically significant measurements of accident rates. In this case, the evaluation must be a qualitative judgement of whether incidents, rather than accidents, are occurring; whether the potential for accidents (i.e., presence of children near speeding cars) exists; and whether resident perceptions of safety problems are valid or imagined. Figure 92 is an illustration of a real case in San Francisco where incidents rather than accidents define the perception of the problem. This is clearly a volatile issue in which resident opinion and porfessional opinion may diverge with little formal data on either side. Use of city wide accident data may be useful, but comparison with small local areas will still rarely be statistically valid. Other **hard** data measures are possible. In Berkeley, observations of obedience to traffic controls in residential street situations were used as an indicator of potential hazard. In Britain and Holland, counts of vehicle/pedestrian "conflicts" are used as indicators. Field observations of such conditions as sight lines at intersections, visibility of traffic, control signs and markings or absence of needed signs and markings, streetlighting, presence or absence of sidewalks, bikeways and handicapped ramps and similar considerations should be included in the safety assessment. Some cities have included a map on resident questionnaire surveys, requesting residents to locate and describe accidents and hazardous incidents in which they were involved or witnessed.

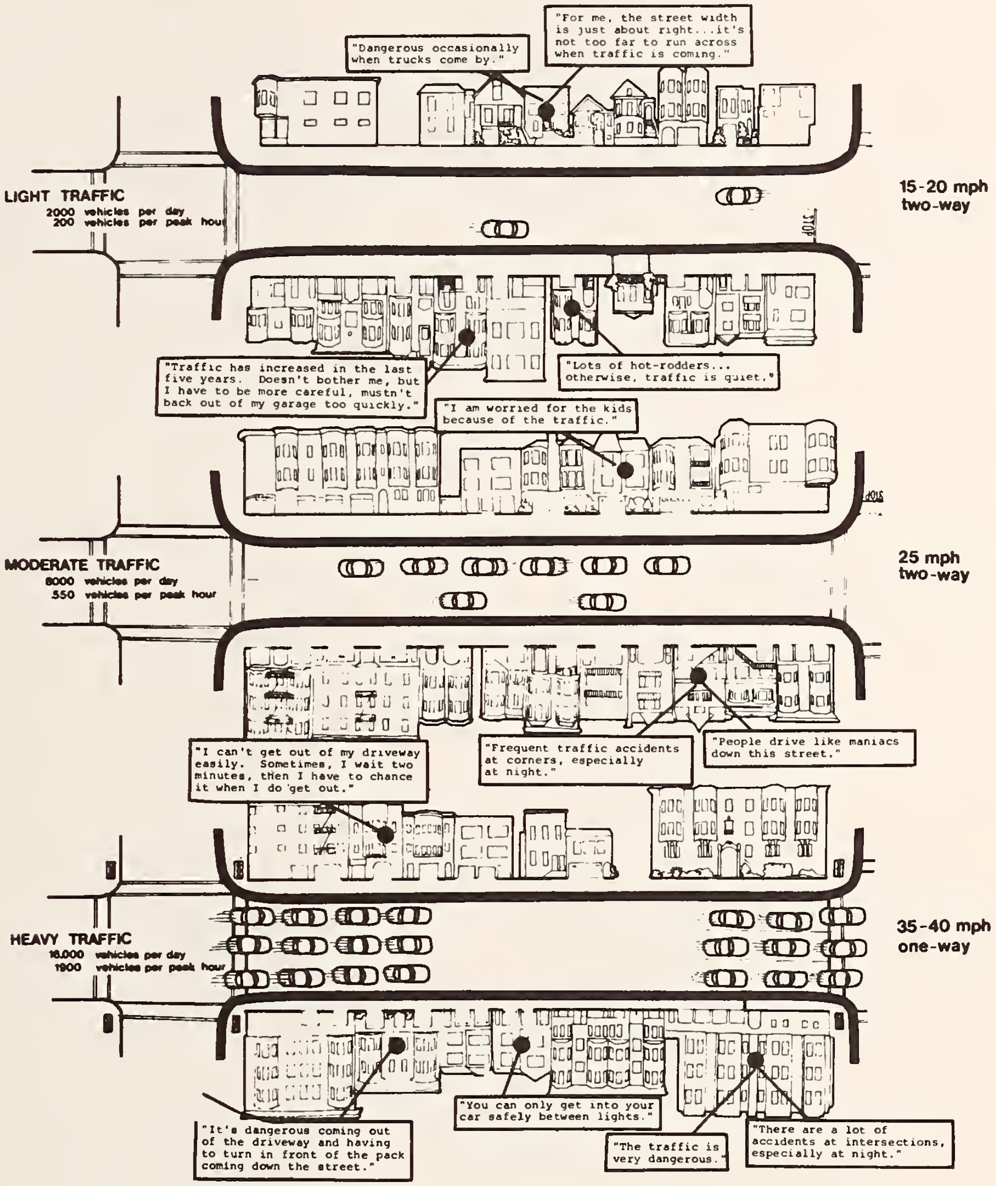
Service Access. Major routes used by regularly routed services and emergency vehicles are essential data to be considered in needs assessment. An inventory of key routes (i.e., main egresses from fire, police and ambulance stations, public transit and school transit routes) and locations critical to operations should be compiled during needs assessment. Further details on this issue are presented in Chapter 5.

Resident Access. Travel time measures from residences to the arterials and collectors bordering a neighborhood and to key points in the community (the freeway entrance, downtown, the shopping center) comprise not so much a needs assessment measure as an essential "before" measure against which eventual conditions must be evaluated.

Environmental Observations

Measures of noise, air pollution, space occupancy, play, walking, cycling and parking conditions, visibility or visual quality or defenses against intrusion can be assessed by field observations and used as needs indicators. Some, such as noise levels, have been quantified more thoroughly than others; but it is important that those like visual quality be, assessed at least qualitatively.

Traffic Noise. Except in unusual cases, traffic noise measurements are rarely needed. The techniques in NCHRP Report #174 are usually sufficient to estimate noise from traffic volume, composition, and distance from the roadway.[84] The more difficult issue is the level of acceptable noise. The Environmental Protection Agency has set an L_{dn} level of 65 db as their criterion for acceptable exterior noise in a residential area; FHWA uses an L_{10} level of 70 db in the peak hour. These are roughly equivalent to the sound of a vacuum cleaner. There is considerable question as to whether these levels are acceptable to residents, and experience suggests that the acceptable level is in part a matter of personal experience and expectation. Figure 93 illustrates another part of the San Francisco perception of the problem. Additional research is needed to determine, in actual application, threshold levels of traffic noise in residential areas that are acceptable to residents.



"Dangerous occasionally when trucks come by."

"For me, the street width is just about right...it's not too far to run across when traffic is coming."

"Traffic has increased in the last five years. Doesn't bother me, but I have to be more careful, mustn't back out of my garage too quickly."

"Lots of hot-rodders... otherwise, traffic is quiet."

"I am worried for the kids because of the traffic."

"I can't get out of my driveway easily. Sometimes, I wait two minutes, then I have to chance it when I do get out."

"Frequent traffic accidents at corners, especially at night."

"People drive like maniacs down this street."

"It's dangerous coming out of the driveway and having to turn in front of the pack coming down the street."

"You can only get into your car safely between lights."

"The traffic is very dangerous."

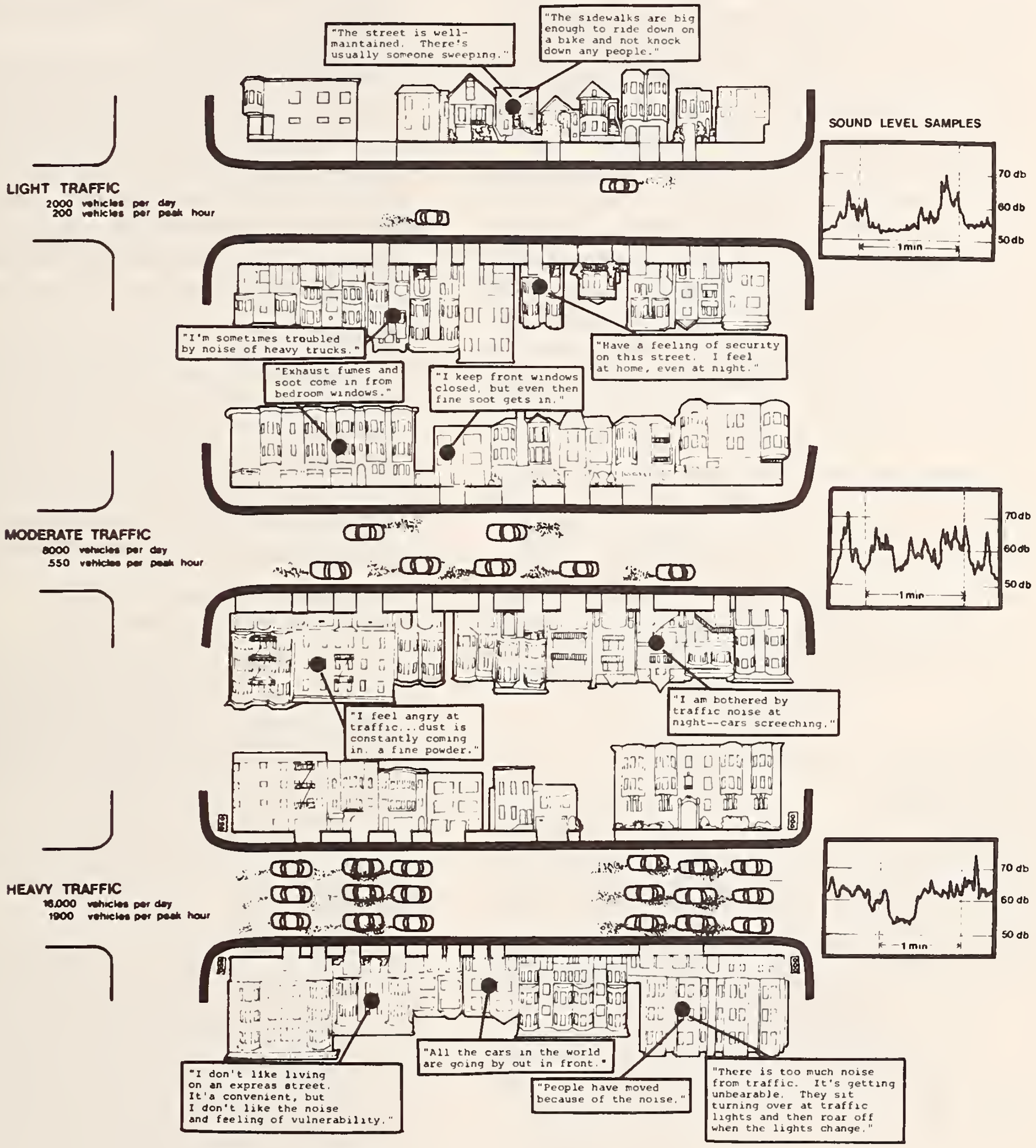
"There are a lot of accidents at intersections, especially at night."

TRAFFIC HAZARD

Figure 92. **Resident defined traffic hazard on three streets, San Francisco**
Source: **Donald Appleyard, LIVABLE URBAN STREETS, 1976, (p. 14)**

Air Quality. Residents express strong concerns about air quality. But in most residential areas, air quality problems stem from total regional traffic and other sources rather than from the presence of neighborhood traffic. While this is a problem for traffic and automobiles in general, a neighborhood traffic management plan will have little effect. Hence, a task for professionals involved in residential street projects lies not in measuring air quality conditions but in dispelling resident misconceptions about what effect neighborhood traffic management might have in improving air quality. Sometimes residents' complaints about air quality relate to fumes from individual vehicles — a phenomena also difficult to measure or affect by neighborhood traffic controls.

Visual Quality and Space Analysis. Neighborhood traffic management devices may achieve changes beyond the immediate objectives of controlling traffic. Traffic control measures offer inherent possibilities of beautifying the neighborhood through landscaping and other amentiy features (i.e., miniparks, benches). These landscape and amenity features may become as important a motivation for implementing the device as is the desire to control traffic. To establish a rationale for such broad purpose actions, inventories of visual quality, dwelling maintenance and the amount of area in the neighborhood allocated to various uses are helpful. The analyst may attempt to assess visual quality and maintenance (Are gutters, sidewalks and lawns clean and tended? What are the characteristics of vegetation and landscape along the street? Is paint peeling off siding, windows broken or boarded up? Are derelict cars a feature of driveways and curbsides?) by simple rankings or by making a more sophisticated attempt (as in the Bath, U.K. work[117]) using a specific checklist or grading matrix. Quantitative or qualitative analyses of outdoor space utilization (i.e., relative areas devoted to traffic, parking, sidewalks, yards and gardens, parks and play space) can help identify neighborhoods where space available for certain uses is deficient and point to traffic management controls most responsive to the deficiency. For instance, in a neighborhood short of private yards, parks and play space, cul-de-sacs might not only solve a

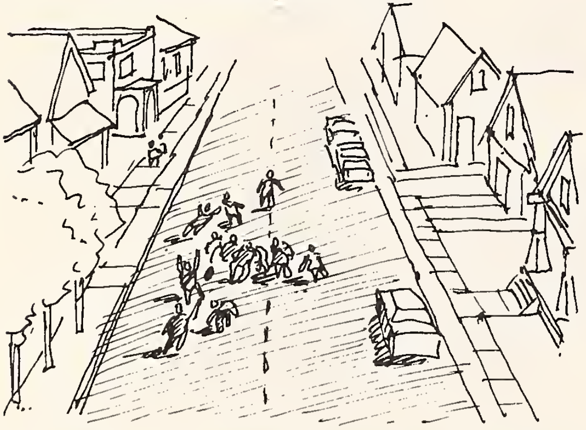


NOISE, STRESS AND POLLUTION

Source: **Donald Appleyard, LIVEABLE URBAN STREETS, 1976, (p. 15)** traffic problem but also supply the needed play space by making the streets safe and useful for this purpose. On streets with parking deficiencies, chokers sheltering angle parking bays might increase the parking supply as well as serving a neighborhood traffic control function.

Pedestrians, Bicyclists and the Handicapped. Basic measures considering pedestrians, involve inventories noting presence or absence of sidewalks and sidewalk continuity, sight distance at crosswalk areas. Counts of pedestrians are normally warranted only at high activity locations where signalization or grade separation might be considered. Notation of delays or conflicts in crossing streets at key points (i.e., a route to school) is a key measure. For bicyclists, notation of key routes and destinations, points of conflict with traffic, inadequate widths, sight distances and site-specific hazards are basic considerations. For the handicapped, notation of locations (or absence) of ramps, sight distance (wheelchair height) at crossings and points where traffic poses particular conflicts for persons with impaired mobility are basic inventory items.

Observations of Resident Activity.



Observing **resident behavior**, walking, cycling, parking, or other street activities such as street play is perhaps the only accurate way to assess the impacts of traffic on street life, especially that of children. For this reason, behavioral observation is an increasingly common technique for assessing environmental conditions especially where there are significant numbers of people involved. Techniques are straight-forward. For instance, simple notations of where street play takes place and where traffic appears to regularly conflict with street play is all that is required.

Parking Conditions. Simple parking use observations can quantify resident dependence on street parking and its use by outside commuters. This is classified as a resident observation rather than a traffic observation because in neighborhood situations, unlike most parking studies, the issue is not **how much** parking space is used, but **who** uses it, residents or outsiders.

Records.

Existing data files on traffic accidents, socioeconomic conditions and concentrations of particularly vulnerable population groups (from the census) land use surveys, crime and assessed values can be used where available. Analysts are cautioned that such data may be outdated or too coarse grained (i.e., not at block level).

Synthesizing Community Input and Technical Measurements

Given these community input and technical measurements, the professional or the community must decide if a problem exists, how large an area the problem covers, where the most severe problems are and whether neighborhood traffic management is applicable. While this is a highly judgemental process, the following questions may provide useful guidance:

- Does the technical data confirm the community perception? If not, is the community perception more important than technical data or vice versa? Even if there is no confirmed "problem," is there a reasonable opportunity to improve on existing conditions?
- Is the problem site-specific, or does it cover an entire neighborhood? If it is site-specific, will the solution cure the problem or merely shift it to another location? If the latter is true, would a site-specific solution do any real harm elsewhere or is a systemic solution advised?
- Does the problem exist throughout the day or at specific periods?
- Will a solution in one neighborhood cause resentment in another one? Will it stimulate

requests for similar action in other neighborhoods?

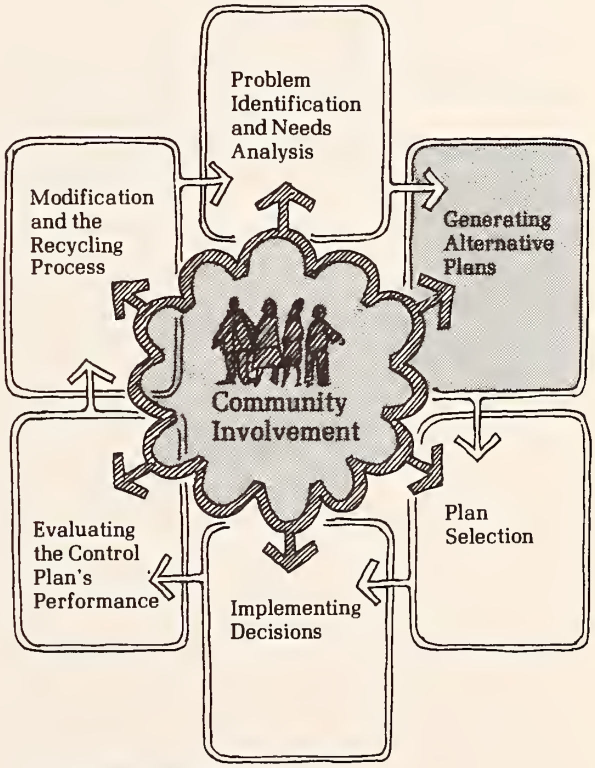
- Which neighborhoods should receive priority attention?
- Are complaints of traffic problems symptomatic of other problems such as crime, dirty streets, no place to play, etc.? Can neighborhood traffic management help to solve these problems, or is it irrelevant?
- Is the community united in its viewpoint of the problem, or are there internal conflicts? Are all views known well enough to define the problem?

These questions are illustrative of key considerations for the planner in needs assessment. Clearly, the more that is known about the community's perception of the problem, the more likely the planner will assess the area's needs accurately.

Generating alternative plans

The reasoned approach to neighborhood traffic issues recognizes the potential for more than one adequate solution. It also allows for orderly assessment of a variety of inputs, e.g., neighborhood groups, businessmen, traffic engineers/planners, and public officials.

In current practice, consideration of a full range of possible solutions may be the exception rather than the rule; i.e., needs assessment, definition of a solution, and implementation often are compressed to a single line of action. A neighborhood group may petition to City Hall that diverters be installed to discourage through traffic, and a resolution may be voted on and action mandated to the traffic engineering department — all within the course of one or two public hearings or city council sessions. Whether such a course of action, undertaken with little or no citizen input or technical analysis, will succeed or fail depends on good luck and good intuition. Cities studied in the State-of-the-Art review exhibited mixed results under such circumstances. For instance, **Lake Oswego, Oregon's** implementation of traffic diverters failed while **Joliet, Illinois**



- Plan Development Strategies
- Managing and Arraying Available Data
- Developing The Alternative Control Plans
- Community Involvement in Plan Generation

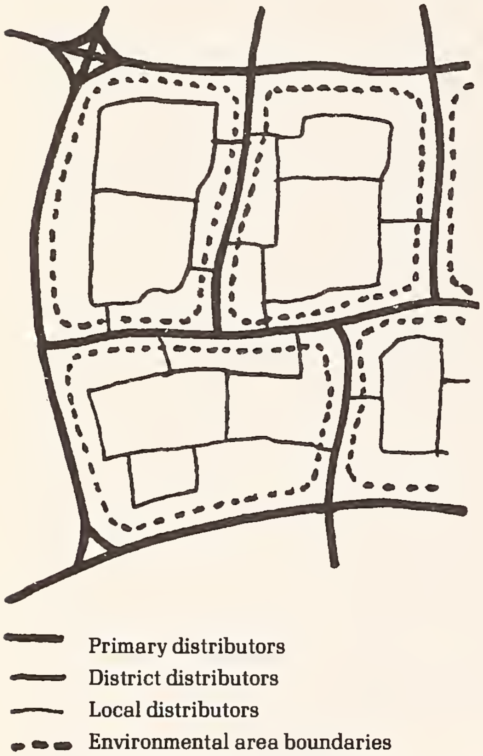


Figure 94. **Area oriented or "top-down" planning strategy**

Source: **The "environmental area" concept from the Buchanan Report, 1963**

succeeded in closure of one street at a large intersection.

The more conventional approach for analysis of alternative traffic control plans recognizes the need to accommodate a variety of inputs through a formal, and sometimes lengthy, evaluation process. Key elements of the alternative development process are:

- Plan development strategies
- Managing and arraying available data
- Developing the alternative plans
- Community involvement in plan development

Each procedure is addressed below.

Plan Development Strategies

Generating alternatives involves incorporating a number of objectives and wide range of information into responsive plan options. There are two basic strategies for achieving this — area-oriented and problem-oriented methods.

The area-oriented method involves definition of an easily recognizable planning unit, such as a neighborhood unit or "environmental area" (see Figure 94). Site-specific problems may initiate the planning process, but treatment is sought for the entire unit. In essence the strategy works from the "top down," from an end state vision for the entire area to a specific plan to achieve that state — e.g., a series of devices to "wall-off" a particular defined neighborhood. While conditions which spurred action are not specifically considered, the plans produced will hopefully resolve site-specific problems initially recognized. This method is the basic approach set forth by Buchanan, and is typically utilized in European "traffic replanning" efforts and in U.S. urban renewal schemes.

Application of this fairly simple concept may result in a clearly understandable scheme which generates community support and operates well in practice. The approach also eliminates need for extensive data on the specific nature of problems. However it suffers from these drawbacks:

- There may be difficulty in defining homogeneous environmental precincts or neighborhood units. Quite often there are isolated divergent land uses within neighborhoods such as corner stores, hospitals and schools within the unit which require special consideration. Frequently too, neighborhoods do not have sharply defined boundaries; the transition in land use character and neighborhood identity may be rather amorphous.

- In working from a broad scale vision, this approach may fail to satisfy micro-scale needs within planning unit, e.g., the one or two households near the device severely impacted by one device or location but not by another.
- The approach is one primarily directed to diversion of non-neighborhood traffic. It does not respond well when diversion is infeasible or when the residents themselves cause the problem — e.g., speeding on other blocks of their own neighborhood.

The problem-oriented method develops a traffic management scheme from analysis of an array of conditions in an area. The focus is at a micro-scale level, a "bottom-up" approach in which attempts are made to solve identified problems individually, while still considering the systemic effects and interrelations of separate problem sites, until a set of solutions is developed for an entire area (see Figure 95). This method requires a substantial array of data on the specific nature of problems to determine feasible and effective alternatives. This method is common to U.S. efforts at neighborhood traffic management. The Berkeley Neighborhood Traffic Plan is perhaps the most extensive example of this assessment strategy. A chief advantage of this approach is that it works well in dealing with problem situations internal to a neighborhood such as those created by a divergent land use or by the behavior of the residents themselves.

Potential drawbacks ot the problem-oriented approach become evident when large areas are being treated. They relate to difficulties in gathering and effectively using large amounts of data and a tendency toward lack of cohesion among the solutions at sites which impact one another. These potential problems can be overcome by effective data management systems (see subsequent sections) and by subdividing the total study area into manageable sized units or neighborhoods for which data can be effectively organized and solutions to problems can be considered both in a site context and in a cohesive neighborhood context. Then alternatives for the individual neighborhoods can be matched with one another to develop cohesive plan alternatives

Figure 95. **Problem oriented or "bottom-up" planning strategy**
Source: **Grafton Hill (Dayton, Ohio) Neighborhood Identity Demonstration Program**

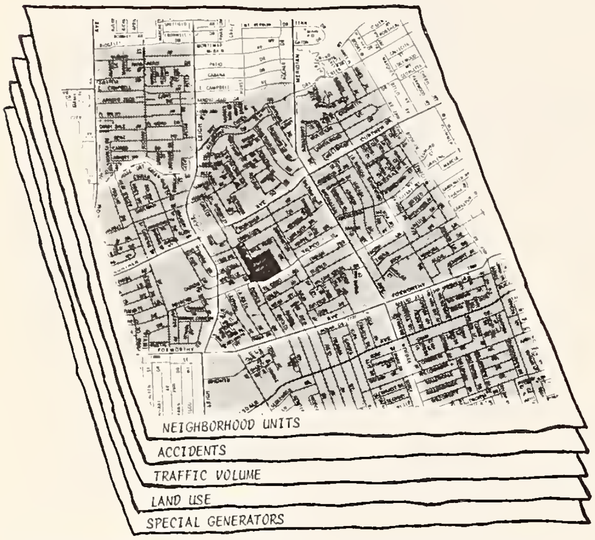


Figure 96. **Example of arraying planning data in overlays**

for the entire planning area.

This discussion of strategic planning methods is emphasized out of concern for the tendency in current practice to overlook the systemic nature of most neighborhood traffic conditions and control plans. However, it is also possible to err by being "over-comprehensive." When traffic issues in a community are few and site specific, they can be successfully addressed on an ad hoc basis. Furthermore, the broad-focused approaches above can take considerable time and resources which in many cases may not be available. In such circumstance, consideration on an individual site basis of conditions or solutions recognized to be systemic in nature can be a responsible professional approach provided no serious and irreversible damage seems likely to result. At times, treading the fine line between over comprehensiveness on the one hand and too limited focus on the other may demand more clairvoyance than professional judgement. But it is as important to pursue ad hoc solutions when "half a loaf is better than nothing" as to resist incomplete schemes when well-thought out systemic approaches are indicated. Once an overall assessment strategy has been developed, the basic approach to traffic control must be determined. Control strategies are summarized in Chapter 2 and discussed in detail in the systems section of Chapter 3.

Managing and Arraying Available Data

Most communities observed in this State-of-the-Art review had no organized method for arraying and utilizing data. Yet this is critical in the problem-oriented approach which depends upon consideration of extensive micro-scale information for success. In Berkeley, probably the most extensive problem-oriented process undertaken to date, a system of overlay plots was used to array and assess information. Information plotted included citizen complaints, accidents, traffic volumes, speed studies, citations, public transit routes, truck routes, congestion points, neighborhood boundaries, site inspection field notes, community analysis, land use, and activity generators (see Figure 96). This process of recording and analyzing such information using this technique is outlined in detail in Appendix D. Locations where information from surveys, petitions, logs of letters or telephone complaints and suggestions of neighborhood residents is available can also be overlay encoded for retrieval.

Developing the Alternative Control Plans

The overlay technique permits organized consideration of large amounts of highly detailed information. But solution schemes do not spring miraculously from a stack of data overlays. Developing solutions responsive to an array of problem conditions, and constraints of any complexity demands exercise of judgement and creativity by the planner (though the word implies a single professional, the planner could be a single person or a small group and include residents). While the control strategies discussed in Chapters 2 and 3 provide general guidance and Appendix D provides further procedural guidance, each alternative must be tailored to the peculiarities of the specific study area. It is inevitable that conflict of values and needs with each other and with constraints will occur. The responsible planner must define a set of alternatives which reflect the full range of technical possibilities and trade-off choices between benefits and undesired impacts, roughly estimating what the gains and drawbacks will be as each alternative is evolved through trial and error. Once a set of alternatives is reasonably developed, a more formalized projection of each alternative's potential effects and trade-offs is prepared as input to selection of one for action.

Community Involvement in Plan Generation

The purpose of community involvement at this stage is to guide development of schemes which seem to respond to resident perception of needs and constraints and assure that residents' schemes are somehow addressed in the analysis. Community involvement at this stage can range from residents taking full responsibility for developing their own alternatives to simply reacting to proposals developed by professionals. Either participatory process requires immediate clarification of the relationships and roles of professionals and different kinds and groups of public participants.

Communities observed in the State-of-the-Art review exhibited the full range of citizen involvement in generation of alternative plans from almost nil to full responsibility.

In some cases, once citizen input on needs had been received, the professionals took sole responsibility for producing alternative plans responding to them. In Palo Alto, California and Rocky Mount, North Carolina, staff-generated schemes responding to community inputs on problems have proven highly successful upon implementation. In this type of program where technicians lead and carry out the process while the public acts as a sounding board, the process for review and reaction may take the form of citizen's advisory committees, citizen representatives on public policy-making bodies, public meetings and neighborhood planning councils. Surveys may be useful to collect supplementary information or to receive initial feedback on proposed alternatives. A public information program organized by the technical staff should inform the general public of the alternatives being considered.

In other cases, citizens provided general guidance on the strategic approach to the control preferred (i.e., indicating preference for physical barriers over STOP controls and increased enforcement; or for a limited peripheral barrier plan over an intensive internal one), leaving the professionals responsible for determining the specific details of devices and locations in each alternative plan. For instance, in Davis, California, a Citizens Safety Advisory Commission (SAC) meets once month to discuss problems and recommendations which are then passed on to the Department of Public Works.

In yet other cases, residents themselves developed specific plans which were taken under consideration together with those developed independently by staff. This was general procedure in Berkeley where most neighborhood groups were able to propose one or more plan alternatives responding to their needs. These were supplemented by staff-generated proposals. Other communities relied on a joint citizen-staff working group which collaborated in preparation of plan alternatives. Such is the case with Oakville, Ontario (Canada) where a Traffic Advisory Committee composed of citizens and technical advisors responds to complaints with staff-supplied traffic data.

Finally, in a few communities, citizens took full responsibility for designing solutions to their problems which were then forwarded to decision-making bodies for acceptance or rejection. In Wichita, Kansas, a neighborhood association was told to develop their own design solutions to their traffic problems which was then presented to the Transportation and Planning Commission for approval. Rarely is this degree of responsibility assigned to community participants since few residents ordinarily have the technical skills required; and when staff are assigned to provide training and technical assistance, they tend to take on a dominant role. Also, because neighborhood traffic management involves conflicts among deeply felt personal interests, city official are reluctant to give real power to individuals who stand to personally gain or lose. However, the technique worked quite effectively as early as 1960 in Richmond, California. The technician's or professional's role is to provide guidance in application of technical procedures and to act as "legmen" in gathering data. Initiative planning is usually conducted through public workshops or some other form of structured public sessions. Design-ins, color mapping techniques or model kits may be applied. These use maps, pictures or other visual tools to allow citizens to develop "sketch plans" of alternatives.

While there is a definite hierarchy in the level of citizen involvement at the alternatives generation stage — and strengths and weaknesses in each approach — the State-of-the-Art review appears to indicate that community involvement at the needs assessment and plan selection stages has far more impact than community input to the alternatives generation process. Nonetheless, involvement of a broad range of actors at those stages appears a key to success.

Plan selection

In neighborhood traffic issues, selection of one of several alternative plans for implementation is inevitably both a technical and a social/political process. Technical analyses help clear the potential impacts each alternative might have. However, the process of placing value on these impacts and weighing trade-offs is predominantly a social and political one. It involves individual citizens, neighborhood organizations and/or public officials. How these people perceive benefits and drawbacks of the alternatives ultimately has a large effect on what plan is selected. If the selection process is not carefully structured and technical information is not convincingly presented to the public, there is a good possibility that technical considerations which should not be compromised will be cast aside.

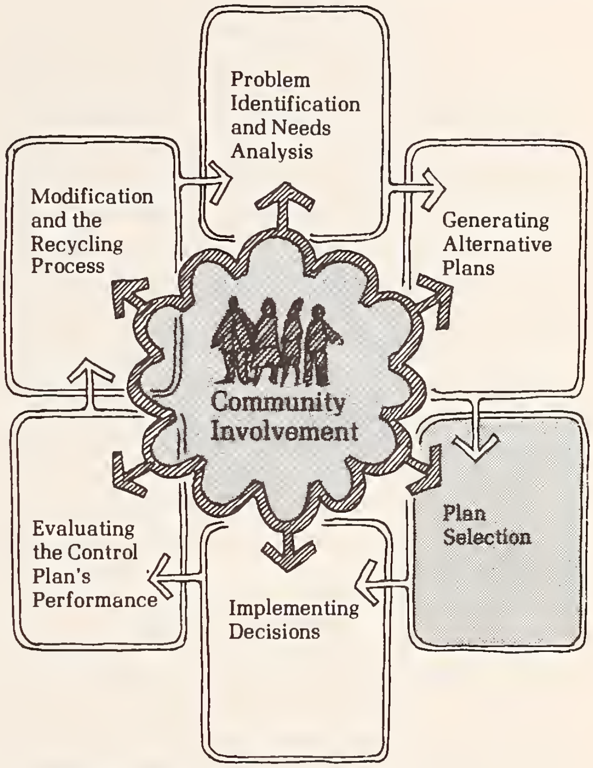
This section first presents guidance on technical information which should be available at the evaluation stage. It then presents, through illustrations from actual application, the various types of social/political selection processes which are possible. Individual planners must determine which techniques are applicable to their local resident and political situation.

Technical Inputs

The technical inputs needed to choose a neighborhood traffic management plan are primarily estimates of what changes are likely to happen relative to those qualities used originally to determine the needs of the neighborhood. In this sense, the selection process is a formal method of determining to what degree the needs will be met. But the technical inputs to plan selection must also attempt to estimate what other possible impacts (positive or negative) each alternative might have beyond its direct objectives. The technician's role at this stage of the process is to present for each alternative the best quantified or qualitative estimates for the measures listed previously in Table 8. Pertinent aspects in plan selection include:

- **Traffic volume.** What reductions occur on the protected streets? Is this enough to solve the problem? Where does traffic go? What are the specific increases on the streets gaining more traffic? Does this cause new problems? Do route changes cause particular hardships for the drivers involved?

- **Traffic speed.** Any meaningful change? If so, will this cause traffic diversion? If yes, see traffic volume considerations above.
- **Traffic composition.** Are problem type vehicles shifted off the streets in question? If so, where do they go? Does this cause a new problem on that street? Does it cause undue hardship for the drivers involved?
- **Safety.** What safety gains are expected in the protected area? Any safety compromises? What gains or compromises can be expected in the surrounding areas (i.e. to which the traffic is diverted)? What is the likely net safety impact?
- **Noise.** Using the techniques in NCHRP report 174,[84] the impacts of noise in relation to volume and speed should be estimated for all streets for which changes in traffic volume or speed are projected.
- **Visual Quality and Condition.** What areas are likely to improve? What areas suffer?
- **Neighborhood Accessibility.** A block by block evaluation should be made of the degree of constraint each alternative poses relative to the existing situation. Possible measures of residential accessibility include the number of arterial/collector streets bordering the neighborhood which can be accessed using neighborhood streets only and the number of blocks out of direction travel necessary to access each border street.
- **Emergency Vehicle Accessibility.** As further detailed in Chapter 5, evaluation of emergency vehicle accessibility should consider accessibility to each block from the emergency vehicles' most logical point(s) of origin.
- **System-Wide Measurements.** Calculation of expected volume and capacity of adjacent arterial intersections should be made to determine the degree to which the alternatives might create or increase levels of congestion.
- **Parking.** How does the scheme affect the availability of curb parking for residents? For outsiders?



- Technical Inputs
- Community Involvement in Plan Selection

- **Level of Expected Violation.** If comparisons are made between physical and passive devices, the expected level of violations should be projected, as noted in Chapters 3 and 5.
- **Impact on Bicyclists.** If any formal bikeway or heavily traveled bicycle route is affected, what modifications are needed to preserve continuity and improve bicyclist conditions? Is street space for cyclists limited below recommended minimums or is continuous and/or specific locational encroachment by motorists upon the cyclists path caused? Can devices which might obstruct cyclists passage be modified to serve the cyclist while maintaining desired effects on the motorist? Can this be done in a safe, formalized way or does it simply involve tacit acceptance of barrier violations by cyclists? Does any device cause any specific safety problems for the cyclist such as obstructing sight distance or affecting balance (as with a speed bump) or causing the cyclist to take a path deviating from normal operating expectations?

- **Impact on Pedestrians.** Do neighborhood traffic controls help meet any specialized pedestrian needs (i.e., site adjacent to an elementary school). Does the plan reduce the pedestrian/vehicle conflict, or does it merely transfer it to another location? If the latter is true, are the traffic controls at the new location an improvement over the previous condition? What effect does each device have on the pedestrian's visibility and on his view of traffic? Does any device encourage unsafe pedestrian practices, particularly by the young? Does each increase or decrease safe play space for children? Does any pose any demands for quick reactions by pedestrians? Does any device form a barrier to the pedestrian or can it be designed to enhance pedestrian accessibility?
- **Impact on the Handicapped.** Does any device interfere with people using aids (canes, walkers)? Does any require difficult maneuvers by the wheelchair-bound or pose the potential for causing them to lose control? Does any device demand quick reactions by any of the above types or by elderly people who simply can't react too quickly? Does any device cause any

form of disorientation to the blind? Does any device create any visibility problems for people in wheelchairs? Are there specific needs of handicapped persons in the planning area to which neighborhood traffic control devices can be designed to respond?

- **Construction Costs.** See Chapter 3.
- **Maintenance Costs.** Consider both maintenance of the control device and possible cost implications due to impacts on current maintenance operations.
- **Visual Quality.** What areas are likely to be improved? Are there any adverse appearances associated with the devices?
- **Space Utilization.** Does the device help remedy any existing deficiencies in allocation of outdoor space to various uses? Does it leave the situation unchanged? Or does it exacerbate existing weaknesses?
- **Costs of Added Driving Time, Fuel Consumption, etc..**
- **Number and Type of People Affected.** It is important to identify, by block, those people who will benefit by an alternative and those who will not relative to all of the other criteria noted above. An aggregate evaluation should be made to determine if the number benefiting are greater or fewer than those who are disbenefited. A scaled evaluation is normally desirable to determine if the level of impact is significant. Impacts might be rated strongly positive, somewhat positive, unnoticeable, somewhat negative and strongly negative. For example, if 500 cars can be diverted from a local street carrying 800 cars to an arterial carrying 5,000, the effect on people living on the local street will be strongly positive, whereas the effect on the arterial may be unnoticeable, even if the arterial has a residential population.

The measures listed above are quite comprehensive and may not be needed in all applications. They are presented mainly as a checklist for the planner to use in determining those issues which he believes will be important in his specific case. In large part, the importance of issues will depend on site circumstances and the concerns of those who are involved in the selection process, and at what point in the process they are involved, as illustrated below.

Community Involvement in Plan Selection

At this stage, community involvement must serve several purposes: to draw out citizens who won't participate until confronted with specific plans, eliminating the chance for "no one told me" arguments; to provide opportunity for all needs and constraints to be taken into account, to let the citizens decide the social trade-offs between alternatives, and to select a plan which has reasonable consensus or community support while meeting technical conditions and constraints. Normally, plan selection is a two phase process. In the **preparatory** phase the community develops a consensus. In the **decision** phase, officials confirm (or reject) the community's choice.

Preparatory Phase to Decision Making. Citizen participation may vary in form from **citizen review boards**, where a small number of participants represent the whole neighborhood or community, to, in rare cases a **citizen referendum** where the affected electorate formally votes on a plan. The key issue is the degree to which the agency, the community, and elected officials agree to be bound by the results.

Citizen Review Boards. Representative panels are usually most effective in reaching decisions. The small group composition of the decision-making body makes it easier for its members to come to grips with all the issues and trade-offs involved and to effectuate compromises where the interests of segments of the community they represent come into conflict. But for representative panel decision-making to be successful, these elements are critical:

- Due representation must be provided to all significant interest groups and allowance made for interjection of an individual's interest when group representation is not possible.
- The representatives should be leader types to make reasonable decisions and compromises and to "sell" the selected plan to their constituencies, particularly where it involves compromises. The most concerned citizen gadfly from a neighborhood is usually not the best member of a decision panel.

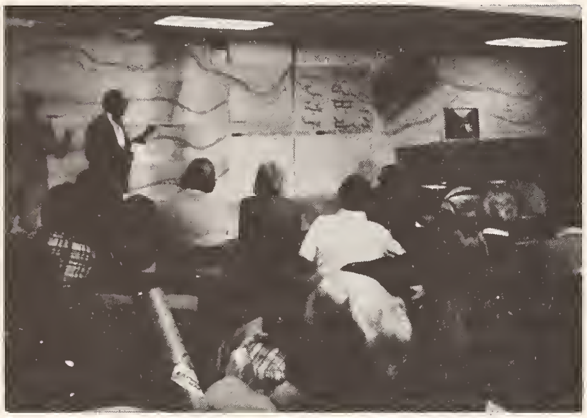
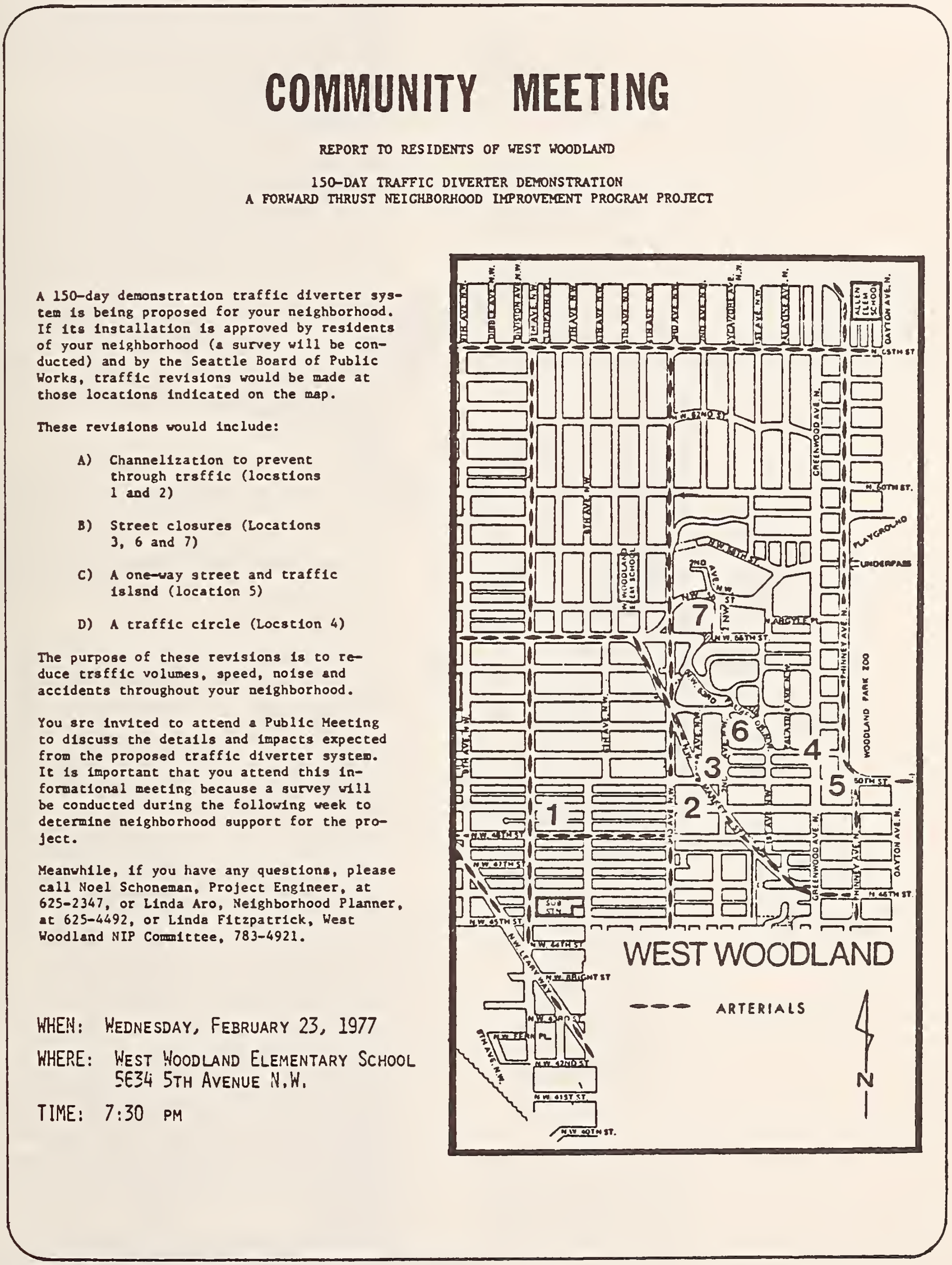


Figure 97. Typical community meeting for plan selection

Community Hearings or Meetings. Decision-making mechanisms relying upon community hearings or less formal meetings provide a more open forum for individuals to voice concerns or have their specific questions answered. They also provide a final opportunity for educating the active public to technical considerations, conflict issues and other constraints (see Figure 97). If the meeting is small, professionals and the community can work together to develop compromises and consensus. Large group meetings rarely offer this opportunity. Important considerations in making such meetings work are these:

- In public meeting situations, citizens tend to state their own positions rather than to listen to others and work toward compromises. Productive meetings take a coordinated and disciplined effort by professionals and hopefully community leadership elements. This implies a working relationship of trust between the professionals and the community leadership, further implying a separate process to develop such a relationship.
- Since this is the last chance for "silent citizens" to affect decisions, substantial effort must be devoted to **drawing the public** to the meeting. At the problem identification stage, it was important that specific solutions not be put forward as a threatened action. Now, at the decision stage, announcements should convey the sense that something specific really is going to happen, that individuals have vital interest at stake, and this is their last chance to affect what will be done. Figure 98 is an excellent example of an announcement of this type from Seattle, Washington.
- If the planning area is sizeable, consideration of all the details of all the alternatives at an open meeting can be extremely cumbersome. One way of coping with this is to combine meeting announcements with an informational newsletter which presents information on each of the alternatives and what each is likely to achieve.

Surveys. Surveys can be an efficient way of reaching large numbers of people and can provide the definitive type of response which gives elected officials confidence. However, beyond



COMMUNITY MEETING

REPORT TO RESIDENTS OF WEST WOODLAND

150-DAY TRAFFIC DIVERTER DEMONSTRATION
A FORWARD THRUST NEIGHBORHOOD IMPROVEMENT PROGRAM PROJECT

A 150-day demonstration traffic diverter system is being proposed for your neighborhood. If its installation is approved by residents of your neighborhood (a survey will be conducted) and by the Seattle Board of Public Works, traffic revisions would be made at those locations indicated on the map.

These revisions would include:

A) Channelization to prevent through traffic (locations 1 and 2)

B) Street closures (Locations 3, 6 and 7)

C) A one-way street and traffic island (location 5)

D) A traffic circle (Location 4)

The purpose of these revisions is to reduce traffic volumes, speed, noise and accidents throughout your neighborhood.

You are invited to attend a Public Meeting to discuss the details and impacts expected from the proposed traffic diverter system. It is important that you attend this informational meeting because a survey will be conducted during the following week to determine neighborhood support for the project.

Meanwhile, if you have any questions, please call Noel Schoneman, Project Engineer, at 625-2347, or Linda Aro, Neighborhood Planner, at 625-4492, or Linda Fitzpatrick, West Woodland NIP Committee, 783-4921.

WHEN: Wednesday, February 23, 1977

WHERE: West Woodland Elementary School
5634 5th Avenue N.W.

TIME: 7:30 PM

Figure 98. Effective announcement form for community meeting — Seattle, WA.

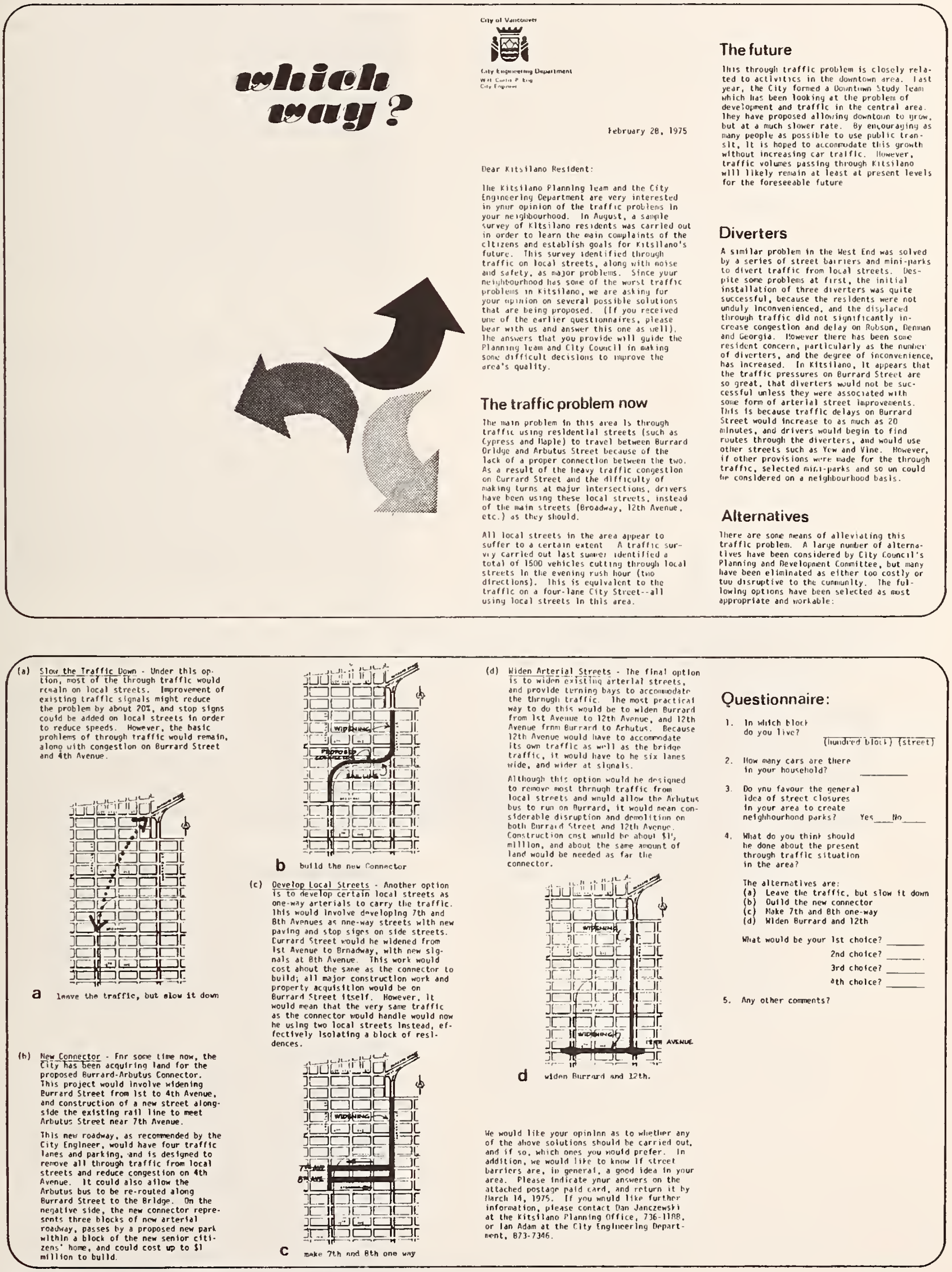
the common survey problems of sampling, language and reading comprehension, the points specific to their application in choosing among neighborhood traffic alternatives should be taken into consideration:

- Generally, surveys should be used to measure public preferences only after the range of alternatives has been narrowed to just a few by other processes. Otherwise, unless very sophisticated attitude-preference measurement techniques are used, the solution indicated as favored **may not** be the best one. The best solution usually is the one acceptable to the largest number of people or absolutely unacceptable to the least number, not necessarily the one the largest number of people ranked as their "first choice."
- The survey instrument does not include allowances for compromises. Any needed compromises must be developed within each alternative prior to the survey. Schemes which would impose intolerable impacts on small numbers of people must be eliminated or modified before the survey.
- Considerable information on the alternatives and their effects must have been previously disseminated or accompany the survey. Respondents have no opportunity to ask clarifying questions which might affect their response unless an information phone is set up.

Figure 99 shows an example of a survey to test resident reactions to various alternatives.

Referenda. Plebiscites are normally effective only when the range of choice has been already narrowed to that between two options (doing nothing possibly being one of them). They offer no opportunity for compromises or rankings. They usually invite a larger group than those truly affected by the scheme to vote on it, and they give uninvolved citizens equal voice with those deeply affected. They sometimes exclude persons who have an important stake in what the community does to traffic but who are not voters from the decision-making — people such as non-resident businessmen and commuters to the area.

Informing Citizens of Plan Details. A problem common to this stage of the planning process is



which way?

City of Vancouver
City Engineering Department
W.H. Curtis P. Eng
City Engineer

February 28, 1975

Dear Kitsilano Resident:

The Kitsilano Planning Team and the City Engineering Department are very interested in your opinion of the traffic problems in your neighbourhood. In August, a sample survey of Kitsilano residents was carried out in order to learn the main complaints of the citizens and establish goals for Kitsilano's future. This survey identified through traffic on local streets, along with noise and safety, as major problems. Since your neighbourhood has some of the worst traffic problems in Kitsilano, we are asking for your opinion on several possible solutions that are being proposed. (If you received one of the earlier questionnaires, please bear with us and answer this one as well). The answers that you provide will guide the Planning Team and City Council in making some difficult decisions to improve the area's quality.

The traffic problem now

The main problem in this area is through traffic using residential streets (such as Cypress and Maple) to travel between Burrard Bridge and Arbutus Street because of the lack of a proper connection between the two. As a result of the heavy traffic congestion on Burrard Street and the difficulty of making turns at major intersections, drivers have been using these local streets, instead of the main streets (Broadway, 12th Avenue, etc.) as they should.

All local streets in the area appear to suffer to a certain extent A traffic survey carried out last summer identified a total of 1500 vehicles cutting through local streets in the evening rush hour (two directions). This is equivalent to the traffic on a four-lane City Street--all using local streets in this area.

The future

This through traffic problem is closely related to activities in the downtown area. Last year, the City formed a Downtown Study Team which has been looking at the problem of development and traffic in the central area. They have proposed allowing downtown to grow, but at a much slower rate. By encouraging as many people as possible to use public transit, it is hoped to accommodate this growth without increasing car traffic. However, traffic volumes passing through Kitsilano will likely remain at least at present levels for the foreseeable future

Diverters

A similar problem in the West End was solved by a series of street barriers and mini-parks to divert traffic from local streets. Despite some problems at first, the initial installation of three diverters was quite successful, because the residents were not unduly inconvenienced, and the displaced through traffic did not significantly increase congestion and delay on Robson, Denman and Georgia. However there has been some resident concern, particularly as the number of diverters, and the degree of inconvenience, has increased. In Kitsilano, it appears that the traffic pressures on Burrard Street are so great, that diverters would not be successful unless they were associated with some form of arterial street improvements. This is because traffic delays on Burrard Street would increase to as much as 20 minutes, and drivers would begin to find routes through the diverters, and would use other streets such as Yew and Vine. However, if other provisions were made for the through traffic, selected mini-parks and so on could be considered on a neighbourhood basis.

Alternatives

There are some means of alleviating this traffic problem. A large number of alternatives have been considered by City Council's Planning and Development Committee, but many have been eliminated as either too costly or too disruptive to the community. The following options have been selected as most appropriate and workable:

(a) Slow the Traffic Down - Under this option, most of the through traffic would remain on local streets. Improvement of existing traffic signals might reduce the problem by about 20%, and stop signs could be added on local streets in order to reduce speeds. However, the basic problems of through traffic would remain, along with congestion on Burrard Street and 4th Avenue.

a leave the traffic, but slow it down

(b) New Connector - For some time now, the City has been acquiring land for the proposed Burrard-Arbutus Connector. This project would involve widening Burrard Street from 1st to 4th Avenue, and construction of a new street alongside the existing rail line to meet Arbutus Street near 7th Avenue.

This new roadway, as recommended by the City Engineer, would have four traffic lanes and parking, and is designed to remove all through traffic from local streets and reduce congestion on 4th Avenue. It could also allow the Arbutus bus to be re-routed along Burrard Street to the Bridge. On the negative side, the new connector represents three blocks of new arterial roadway, passes by a proposed new park within a block of the new senior citizens' home, and could cost up to $1 million to build.

b build the new Connector

(c) Develop Local Streets - Another option is to develop certain local streets as one-way arterials to carry the traffic. This would involve developing 7th and 8th Avenues as one-way streets with new paving and stop signs on side streets. Burrard Street would be widened from 1st Avenue to Broadway, with new signals at 8th Avenue. This work would cost about the same as the connector to build; all major construction work and property acquisition would be on Burrard Street itself. However, it would mean that the very same traffic as the connector would handle would now be using two local streets instead, effectively isolating a block of residences.

c make 7th and 8th one way

(d) Widen Arterial Streets - The final option is to widen existing arterial streets, and provide turning bays to accommodate the through traffic. The most practical way to do this would be to widen Burrard from 1st Avenue to 12th Avenue, and 12th Avenue from Burrard to Arbutus. Because 12th Avenue would have to accommodate its own traffic as well as the bridge traffic, it would have to be six lanes wide, and wider at signals.

Although this option would be designed to remove most through traffic from local streets and would allow the Arbutus bus to run on Burrard, it would mean considerable disruption and demolition on both Burrard Street and 12th Avenue. Construction cost would be about $1½ million, and about the same amount of land would be needed as for the connector.

d widen Burrard and 12th.

We would like your opinion as to whether any of the above solutions should be carried out, and if so, which ones you would prefer. In addition, we would like to know if street barriers are, in general, a good idea in your area. Please indicate your answers on the attached postage paid card, and return it by March 14, 1975. If you would like further information, please contact Dan Janczewski at the Kitsilano Planning Office, 736-1188, or Ian Adam at the City Engineering Department, 873-7346.

Questionnaire:

1. In which block do you live? ________ ________
(hundred block) (street)
2. How many cars are there in your household? ________
3. Do you favour the general idea of street closures in your area to create neighbourhood parks? Yes___ No____
4. What do you think should be done about the present through traffic situation in the area?

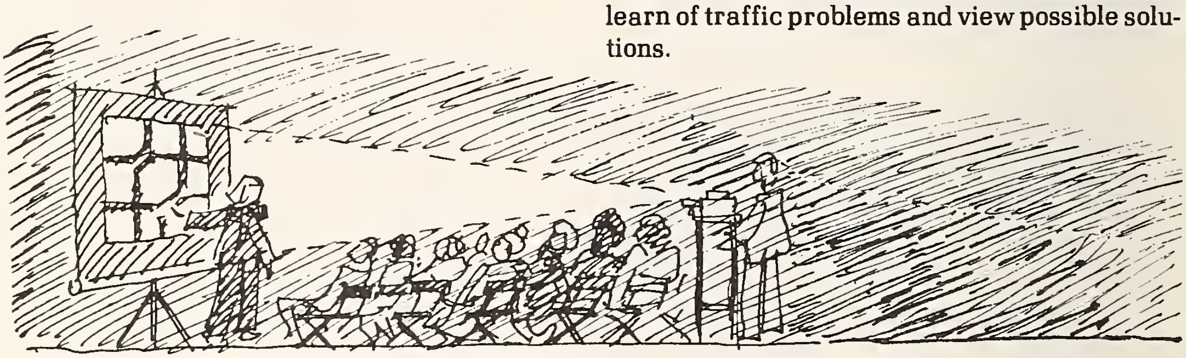
The alternatives are:
(a) Leave the traffic, but slow it down
(b) Build the new connector
(c) Make 7th and 8th one-way
(d) Widen Burrard and 12th

What would be your 1st choice? ______
2nd choice? ______
3rd choice? ______
4th choice? ______

5. Any other comments?

Figure 99. Survey to determine resident preferences among proposed alternatives — Vancouver, B.C.

effective dissemination of details of plan alternatives and their projected impacts. Media announcements and articles (newspapers, radio and TV), posters at prominent locations and leaflets mailed out or distributed by hand can be effective. Several cities contacted in the State-of-the-Art search had produced useful leaflets and broadsheets. San Francisco's **Traffic In Neighborhoods** newssheet explains in a few pages the traffic problems, offers an array of alternative solutions and tells residents how the planning process works. Seattle has produced color broadsheets of neighborhood improvement proposals showing, by plans and drawings over photographs, how proposals will actually look. In other cases, exhibits of proposals in model form or colored drawings have been displayed at public meetings (Melbourne, Stanley, Barnsbury). Videotapes showing community traffic problems and possible solutions have been shown in Detroit (Woodside) and in Berkeley. All these methods allow large audiences to learn of traffic problems and view possible solutions.



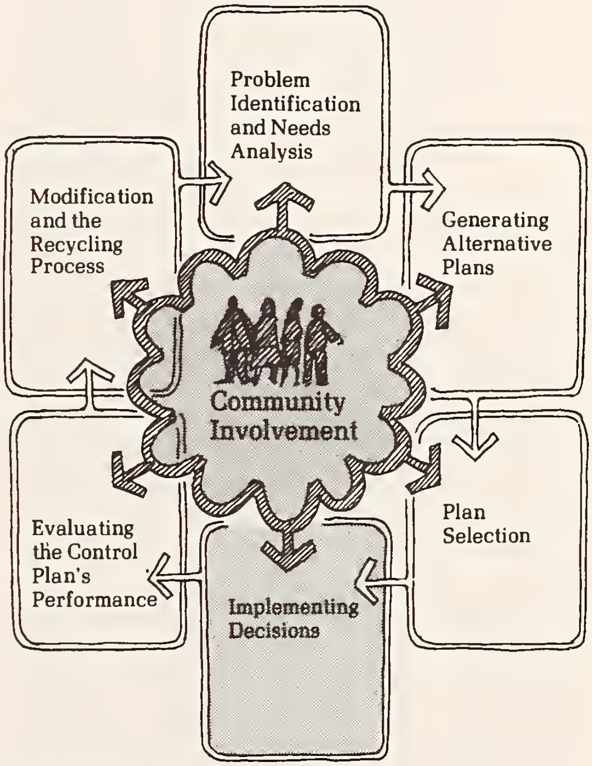
Decision Making. Ultimately, most community decision making is finalized at the city council level (or equivalent elected body). While the council is the ultimate decision-making body, what goes on before usually has strong impact on which alternative is selected and its likely eventual success.

If the decision process is truly initiated only at the council or Planning Commission level, virtually anything can happen. A well-organized interest group with political clout can gain their way, leaving important technical considerations and the legitimate interests of other residents and travelers ignored. Or, as more often happens, public inputs give officials nothing more than a sense of bitter conflict, leading officials to choose to do nothing or to decide issues on the basis of narrow technical findings.

Decision-making by an official board works best when a consensus of citizens and technicians has been reached to support a single alternative prior to consideration by the board. In essence, this depends on an already established process, either formal or informal, which is recognized as having status by the board. The official body's decision-making provides both an affirmation by authority of the prior work and a point of last appeal for those who oppose the recommended alternative.

Implementing decisions

Once the traffic plan has been adopted by an official political body and funded, staff must proceed with the physical act of installing the planned devices. While implementation may seem straightforward — most city public works or traffic departments have the resources, possibly with contractor assistance — implementation actions can have critical effect on the success or failure of the plan. This section reviews some of the significant implementation issues.



- Permanent Versus Temporary Controls
- Criteria for Successful Implementation
- Community Involvement in Implementation

Permanent Versus Temporary Controls

There is widespread disagreement among practitioners as to whether temporary or permanent devices should be used in initial installations of diverters, semi-diverters, cul-de-sacs, circles and any other devices involving substantial construction. In large and complex traffic management schemes, it is inevitable that some modifications will prove necessary after the schemes are implemented. Temporary devices provide flexibility for such modification. Since they normally cost far less than permanent installations, an entire program can be implemented immediately with temporary devices even if funds are short. Individual installation can then be upgraded to permanent facilities after they prove successful and as funds become available. On the negative side, foreknowledge of the ease of modification may lead to incomplete and sloppy planning. And because of the devices' inherent impermanence, issues are never truly settled. The ready possibility of change encourages opponents to continue the controversy and leads others who might prefer limited modifications to join the agitation.

As for immediate permanent installations, the very nature of their permanence seems to command more driver respect; hence better obedience and less vandalism. Residents readily accept permanent landscaped devices as enhancements to the beauty of their neighborhood whereas temporary materials are often regarded as eyesores. Because permanent installations involve sizeable funding commitments, professionals and the public hopefully ensure they have the "right answer" before deciding on a solution.

In the State-of-the-Art search, situations supporting all the arguments on both sides of the issue have been found. In Australia, a fixed experimental test period with temporary devices is mandatory before permanent installation. Palo Alto, California and St. Louis, Missouri, have had successful permanent installations approved after experimental periods with temporary devices. But in Lake Oswego, Oregon, residents displeased with the appearance of temporary traffic barrier devices joined those who totally opposed the concept in having the devices removed. Many cities with small-scale plans have had success with immediate implementation of permanent landscaped facilities. But in San Francisco, residents of the Richmond District who had little input to the plan's design caused immediate "permanent" installation of a large number of traffic management devices to be halted. Though many residents supported some form of traffic management, they saw the "permanence" of the construction as an overwhelming obstacle to ever making the plan more reasonably responsive to their desires and thus stopped the project in mid-construction. Directly across San Francisco Bay, Berkeley's extensive traffic management plan survived two recall ballot measures largely on the strength of arguments that modifications to temporary devices in use there were possible and were being made. Yet controversy over Berkeley's plan continues.

Choice between immediate permanent implementation or initial use of temporary devices should be based on the individual community's situation. In general, temporary installations might be favored in cases where plans are extensive and complex (where the possibility of some planning error is high) and/or where funds are short. Where temporary devices are selected, careful attention to their attractiveness is a must and a future commitment to make permanent those devices which prove themselves should be made clear.

Incremental Versus One-Step Implementation

Devices in an individual neighborhood should be constructed or erected as nearly simultaneously as available resources permit. But if the plan encompasses a large district and involves a significant number of devices, should it be constructed as a single short-term activity? Or is an incremental neighborhood approach more realistic?

The incremental approach allows staff to devote more attention to the details of individual installations and to assure that all necessary construction materials are on hand. In Berkeley, haste to install all devices at one time citywide led to initial problems with materials shortages and design oversights. But in a smaller scale scheme in Shaker Heights, Ohio, careful procurement and installation crew preparation permitted successful implementation of all devices in a single day.

With the incremental approach, lessons learned in early action neighborhoods can be applied citywide and repetition of mistakes avoided. Yet the incremental approach leads to a lengthy period of turmoil as traffic adjusts and readjusts to a continuing series of changes in street conditions. And public reactions to temporary adverse impacts of an early implementation increment can derail a plan at the outset even though a later staged step would have eliminated the impact. On the other hand, massive changes in traffic conditions resulting from several programs implemented at once can unite a large opposition. The planner must carefully review the individual situation to judge whether an incremental or one-step implementation approach is most appropriate.

Timing

Another helpful installation hint is to install devices at a time when the least number of drivers is likely to be around. For instance, in Hampton, Virginia, a beach resort area, devices were installed during the winter "off-season." This permitted year-round residents and motorists to adjust to the change before the summertime crowds arrived and summer residents and visitors were confronted with a fait accompli. Similarly, summer implementation would be appropriate in a campus town or winter resort area. Although not every city has the advantage of "off-seasons," known major activity periods should not be chosen as a time for implementation.

Publicity

Publicity about the adopted plan's features and its construction schedule are important components of implementation. Frequently, residents and motorists are rudely surprised by abrupt changes in their street system. The immediate result can be erratic or illegal behavior such as dangerous driving maneuvers or outright vandalism. In cases of large-scale plans involving barrier devices, maps showing features of the plan and its construction schedule should be distributed to residents, to commuters at their places of employment and to all firms operating routed services and deliveries in the city (see Figure 100). Notices warning of traffic control changes and dates of construction should be prominently posted on the control sites several days before construction takes place. Where barriers are to be constructed on internal neighborhood streets, similar warning notices should also be posted at the neighborhood entry points and left standing for at least a week after construction is complete.

Favorable First Impressions

When the first sign of a scheme is obtrusive and ugly without apparent purpose, people naturally react against it. Efforts to present an attractive appearance even with low budget temporary devices are rewarded. The extra cost of **mature** landscaping may be money well spent. A planter-bollard with tree or shrub may look very nice in the planner's rendering, but in the field it may look like a small twig tied to a large stake stuffed in a fancy trash can if the community scrimps on the landscape budget. Devices initially perceived as ugly may be removed before landscaping matures.

Early Surveillance and Adjustment

Planners and engineers should anticipate the inevitable adverse reactions that accompany the installation of traffic control devices. Almost every city contacted experienced some unfortunate occurrence, ranging from illegal driving maneuvers to out-right vandalism. Professional staff should be on the scene to observe deviant behavior in first-encounter reactions, to note if any design features are its cause and if design modifications can provide a countermeasure to unsafe or purpose-defeating behavior.

Additional police surveillance during the period immediately following installation helps to discourage erratic or illegal driving behavior, such as blatant violation and vandalism of barriers and one-way streets. The period of intense first-encounter reaction usually lasts no more than a week or so. After that time, drivers have adjusted their routes sufficiently to avoid the inconvenience caused by the new system.

Commitment to Specific Evaluation Period

While minor adjustments as a result of early surveillance findings are possible, a commitment to a specific evaluation period before major changes in the scheme are made should be established. This allows time for traffic and residents to adjust patterns, and for tempers to cool and permits evaluation to be based on longer-term performance rather than initial reactions.

Community Involvement in Implementation

Community involvement at this stage is passive, e.g., citizens receiving information on how plans will be implemented. The technical staff assumes the duties of informing the citizens of plans and schedules to minimize surprises. The continuing **public meetings** or **public information program** can serve as techniques to notify the public — particularly those susceptible to change or negative impacts — of the implementation schedule and work-in-progress plans if construction is needed. Negative reaction to any neighborhood traffic management project may be due to residents taken by surprise by actual implementation activities.

A process is also necessary for identifying problems created by work in progress. The process may be informal, e.g., directly addressing

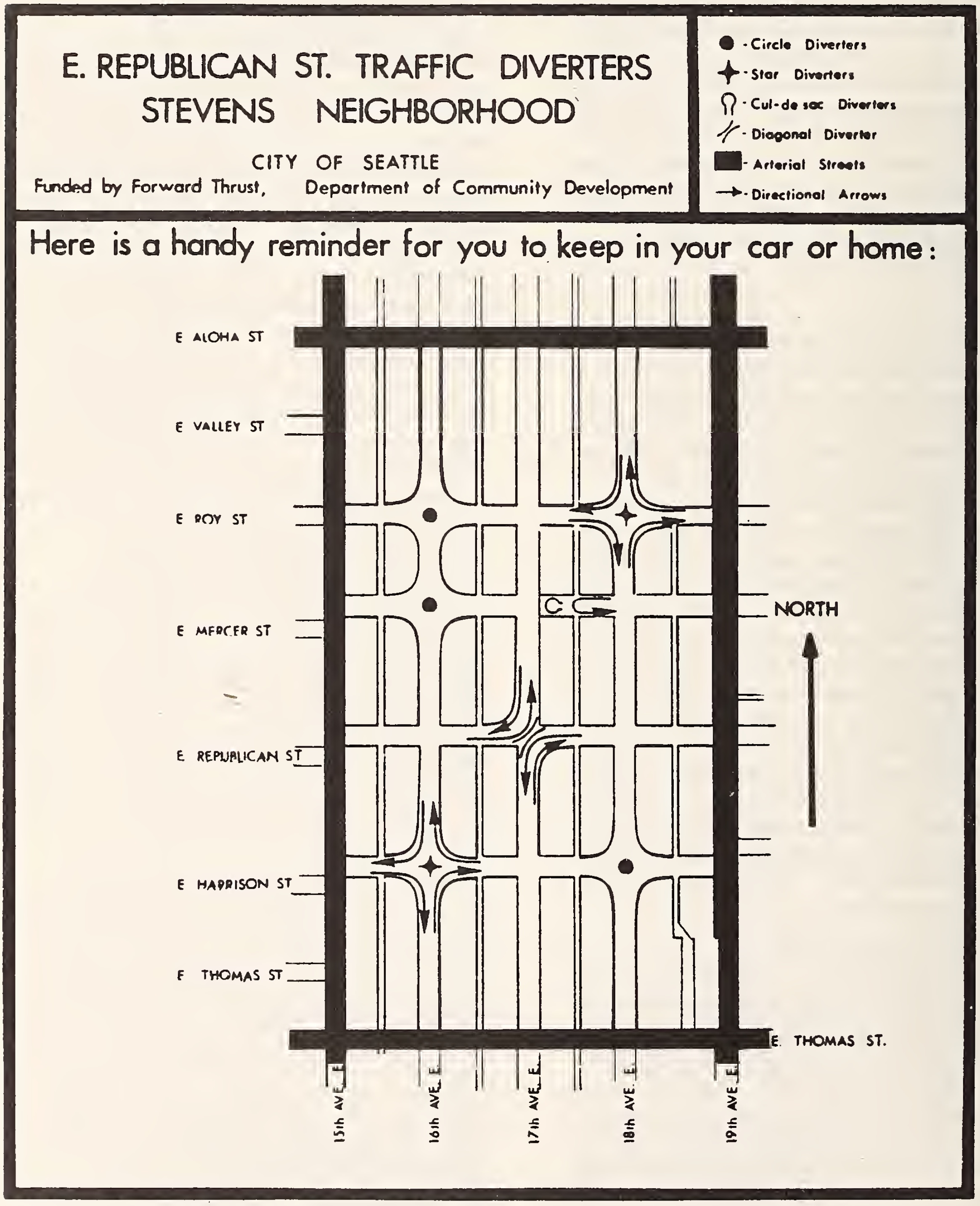


Figure 100. Flyer distributed to businesses and residences in Seattle, Washington

complaints to the technical staff, or continuation of the more formal process of public meetings or workshops.

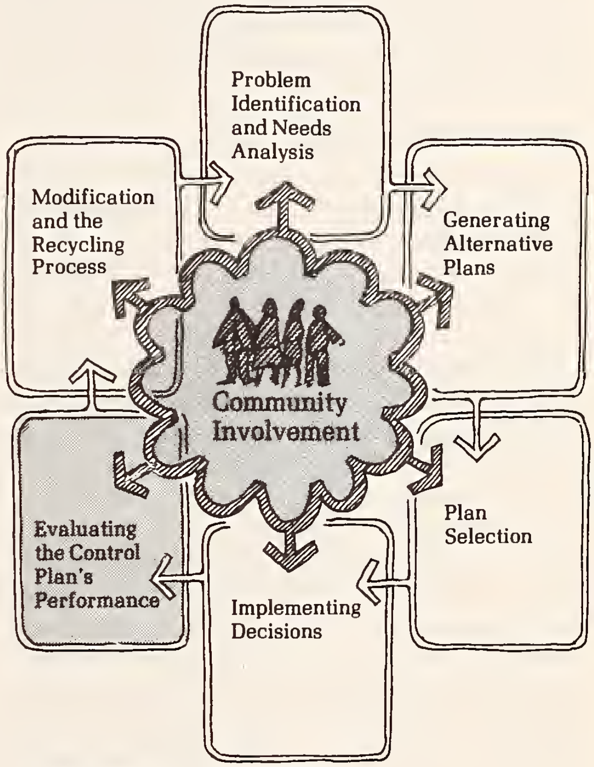
Evaluating the control plan's performance

State-of-the-Art Observations

Thorough evaluations of how neighborhood traffic control measures actually perform in use are the exception rather than the rule in current practice. This accounts in large measure for the paucity of hard data in Chapter 3. In rare cases where cities have deliberately set out to experiment with unusual devices or have undertaken particularly large-scale control programs, there have been some attempts at true performance evaluation. In most cases, if the devices implemented have the effect of silencing the original complainants and no significant opposition surfaces or serious operational problems result, the program is normally judged to be a success. Little hard data other than a few traffic counts is likely to be taken. If the complainants are not satisfied or substantial opposition does arise, no significantly greater efforts are normally made to collect hard data; the scheme is simply judged a failure.

If decisions can be made so simply, why evaluate? For one reason, evaluation of technical performance and community perceptions is needed to provide an unbiased basis for decisions as to whether a plan is kept or abandoned. Actual performance and impacts are often quite different from what opponents may believe or claim. Public reaction is often shaped by first impressions and observation of erratic initial performance characteristics. An evaluation can clarify issues, bring the more stabilized long-term performance characteristics into focus, and spotlight "hidden" gains and losses which may be significant. If traffic management opponents' allegations regarding traffic safety and congestion impacts were not countered by hard evaluation, Berkeley might well have abandoned its neighborhood traffic plan at an early date.

Secondly, evaluation makes modification pos-



- State-of-the-Art Observations
- Evaluation Techniques
- Community Involvement in Evaluation
- Timing

sible. Decisions made without evaluation are typically all-or-nothing — retain the scheme or abandon it. Evaluation can point to opportunities for modifying a scheme to make it perform its intended function better or to lessen adverse impacts. It can also be used to determine if the plan should be expanded both in terms of devices and geographical area. Finally, only when evaluations are conducted will there be true growth in the State-of-the-Art in neighborhood traffic control. So little is known today, not because measures haven't been tried, but because the measures which have been applied have not been evaluated.

Evaluation Techniques

Most of the measures described in connection with Needs Assessment shown in Table 8 and detailed in Appendix C are relevant to evaluation. Basically, measures taken during that planning stage constitute "before" conditions which can be compared to parallel measures of conditions "after" implementation to determine changes resultant from the control scheme. The conduct of the "after" measures and the comparisons comprise the evaluation. In addition, evaluation includes consideration of other data measures not studied in the assessment stage. Some of these measures may be relevant solely on an "after" basis (such as incidents in which traffic controls interfered with emergency vehicle operations); others involve "before" and "after" comparisons of information which was not relevant as an assessment tool but is affected by the plan (e.g., changes in residential property values). In preparing for before and after studies, analysts should take care that all important measures of perishable "before" conditions do get taken, even if some of these are not needed or useful in the initial program planning.

Community Involvement in Evaluation

Public inputs to the evaluation are obtained by continuing an active community involvement process. It is useful to maintain a means of communication between staff and public which is clearly recognized by both parties. The public can be helpful in providing feedback on their perception of how well the plan is working, details of problems, possibilities for improvement and any aspects overlooked in the initial planning process. The technical staff should provide information on technical measurements made to determine the project's effectiveness. The staff should also address citizen complaints and suggestions.

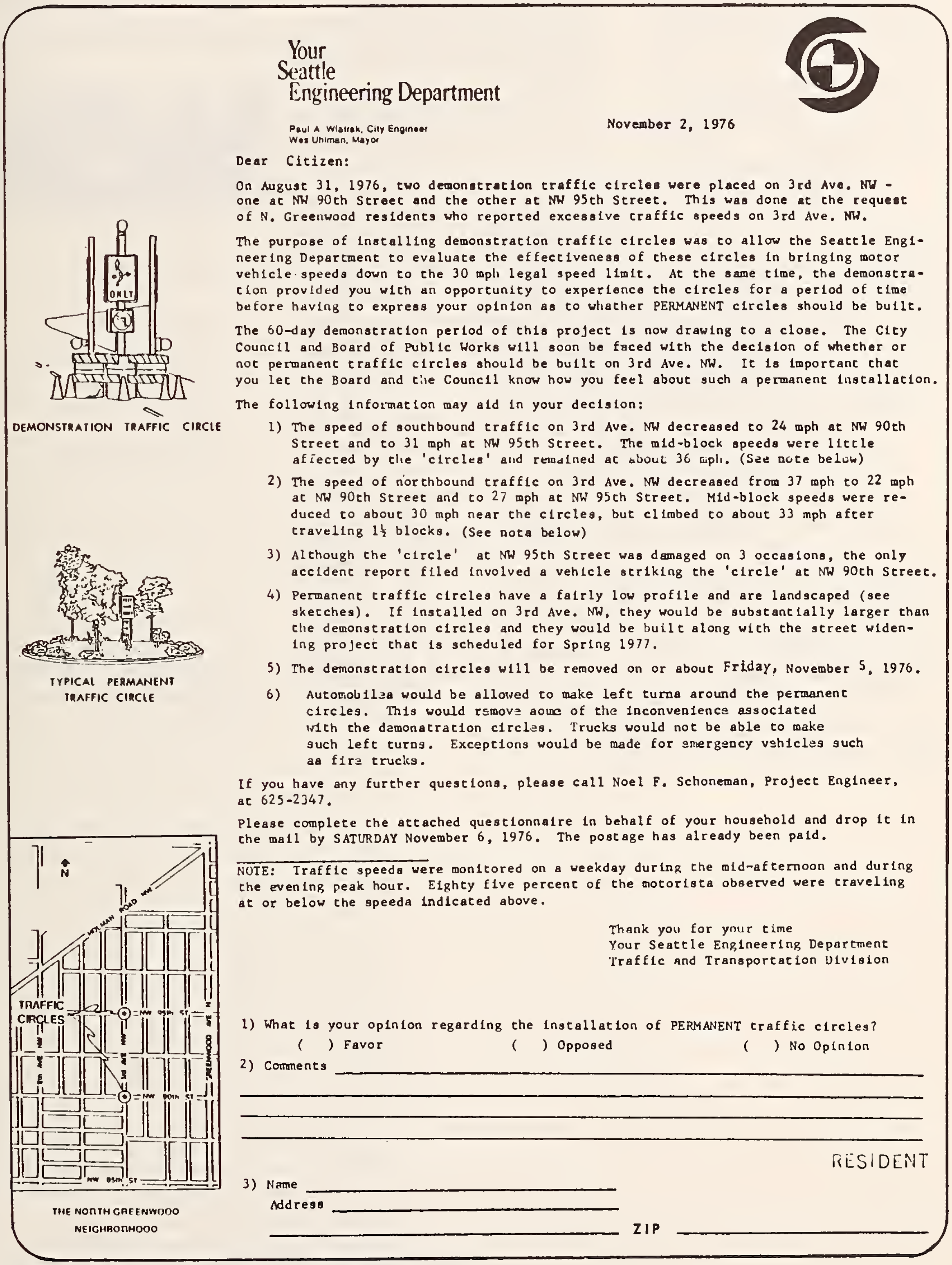
Such communication between the public and technical staff may be accomplished through public hearings set for specific time intervals after implementation of the project or through a more informal means of direct contact with a representative of the technical staff or ombudsman as the need for contact is warranted. To evaluate in detail the acceptability — but positive and negative — of the project usually requires a more structured approach in the form of a survey or special neighborhood meetings where questions and reactions can easily be focused and addressed to all concerned groups and individuals.

Figures 101 and 102 are examples of survey instruments used in follow-up evaluations in Seattle, Washington.

Timing

In conducting the evaluation, three to six months after implementation should be allowed before "after" data measures are taken. This gives residents and motorists time to become familiar with the controls and make adjustments. With this interval, the "after" measures will be of stabilized reactions rather than first-encounter responses. For this same reason, three to six months would appear to be the reasonable period for application of experimental devices. In explicit experiments, a fixed period for application of the devices should be firmly committed in advance (Baltimore uses three months, Melbourne uses six). After the period, temporary materials can be removed while a final decision about the device is made.

This focus of the formal evaluation on stabilized long-term effects is not to suggest that first-encounter responses and early reactions should be ignored. In fact, these should be carefully observed from the start so that countermeasures to any serious safety problem or obvious defect can be quickly implemented.



Your
Seattle
Engineering Department

Paul A. Wiatrak, City Engineer
Wes Uhlman, Mayor

November 2, 1976

Dear Citizen:

On August 31, 1976, two demonstration traffic circles were placed on 3rd Ave. NW - one at NW 90th Street and the other at NW 95th Street. This was done at the request of N. Greenwood residents who reported excessive traffic speeds on 3rd Ave. NW.

The purpose of installing demonstration traffic circles was to allow the Seattle Engineering Department to evaluate the effectiveness of these circles in bringing motor vehicle speeds down to the 30 mph legal speed limit. At the same time, the demonstration provided you with an opportunity to experience the circles for a period of time before having to express your opinion as to whether PERMANENT circles should be built.

The 60-day demonstration period of this project is now drawing to a close. The City Council and Board of Public Works will soon be faced with the decision of whether or not permanent traffic circles should be built on 3rd Ave. NW. It is important that you let the Board and the Council know how you feel about such a permanent installation.

The following information may aid in your decision:

1) The speed of southbound traffic on 3rd Ave. NW decreased to 24 mph at NW 90th Street and to 31 mph at NW 95th Street. The mid-block speeds were little affected by the 'circles' and remained at about 36 mph. (See note below)
2) The speed of northbound traffic on 3rd Ave. NW decreased from 37 mph to 22 mph at NW 90th Street and to 27 mph at NW 95th Street. Mid-block speeds were reduced to about 30 mph near the circles, but climbed to about 33 mph after traveling 1½ blocks. (See note below)
3) Although the 'circle' at NW 95th Street was damaged on 3 occasions, the only accident report filed involved a vehicle striking the 'circle' at NW 90th Street.
4) Permanent traffic circles have a fairly low profile and are landscaped (see sketches). If installed on 3rd Ave. NW, they would be substantially larger than the demonstration circles and they would be built along with the street widening project that is scheduled for Spring 1977.
5) The demonstration circles will be removed on or about Friday, November 5, 1976.
6) Automobiles would be allowed to make left turns around the permanent circles. This would remove some of the inconvenience associated with the demonstration circles. Trucks would not be able to make such left turns. Exceptions would be made for emergency vehicles such as fire trucks.

If you have any further questions, please call Noel F. Schoneman, Project Engineer, at 625-2347.

Please complete the attached questionnaire in behalf of your household and drop it in the mail by SATURDAY November 6, 1976. The postage has already been paid.

NOTE: Traffic speeds were monitored on a weekday during the mid-afternoon and during the evening peak hour. Eighty five percent of the motorists observed were traveling at or below the speeds indicated above.

Thank you for your time
Your Seattle Engineering Department
Traffic and Transportation Division

DEMONSTRATION TRAFFIC CIRCLE

TYPICAL PERMANENT TRAFFIC CIRCLE

THE NORTH GREENWOOD NEIGHBORHOOD

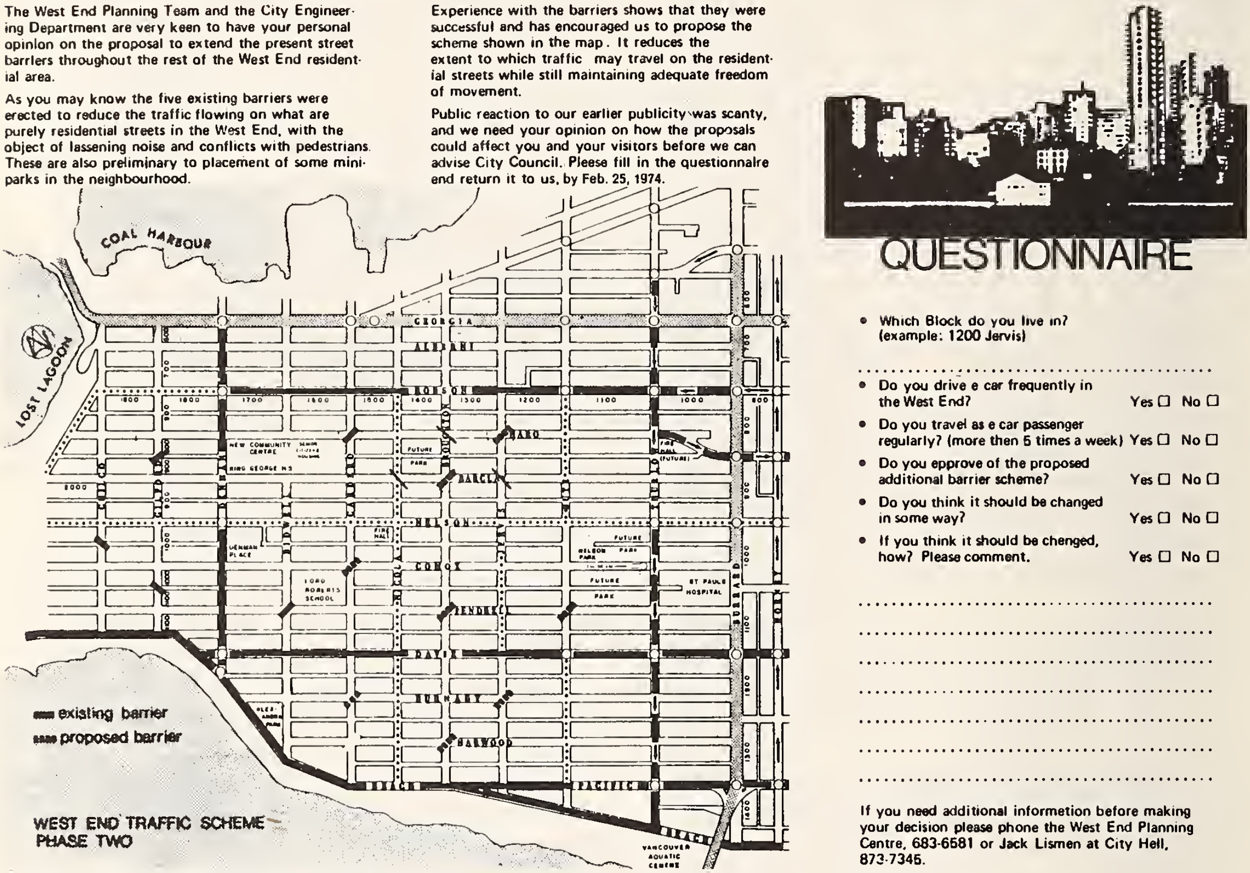
1) What is your opinion regarding the installation of PERMANENT traffic circles?
( ) Favor ( ) Opposed ( ) No Opinion

2) Comments ______________________________

RESIDENT

3) Name ______________________________
Address ______________________________
______________________________ ZIP ______________

Figure 101. Survey to evaluate whether temporary devices should be made permanent, Seattle, WA.



The West End Planning Team and the City Engineering Department are very keen to have your personal opinion on the proposal to extend the present street barriers throughout the rest of the West End residential area.

As you may know the five existing barriers were erected to reduce the traffic flowing on what are purely residential streets in the West End, with the object of lessening noise and conflicts with pedestrians. These are also preliminary to placement of some mini-parks in the neighbourhood.

Experience with the barriers shows that they were successful and has encouraged us to propose the scheme shown in the map. It reduces the extent to which traffic may travel on the residential streets while still maintaining adequate freedom of movement.

Public reaction to our earlier publicity was scanty, and we need your opinion on how the proposals could affect you and your visitors before we can advise City Council. Please fill in the questionnaire and return it to us, by Feb. 25, 1974.

QUESTIONNAIRE

- Which Block do you live in? (example: 1200 Jervis)

....

• Do you drive a car frequently in the West End?	Yes ☐ No ☐
• Do you travel as a car passenger regularly? (more than 5 times a week)	Yes ☐ No ☐
• Do you approve of the proposed additional barrier scheme?	Yes ☐ No ☐
• Do you think it should be changed in some way?	Yes ☐ No ☐
• If you think it should be changed, how? Please comment.	Yes ☐ No ☐

....

....

....

....

....

....

....

If you need additional information before making your decision please phone the West End Planning Centre, 683-6581 or Jack Lismen at City Hall, 873-7346.

Figure 102. Survey to determine resident reaction to expansion of NTM Program, Vancouver, B.C.

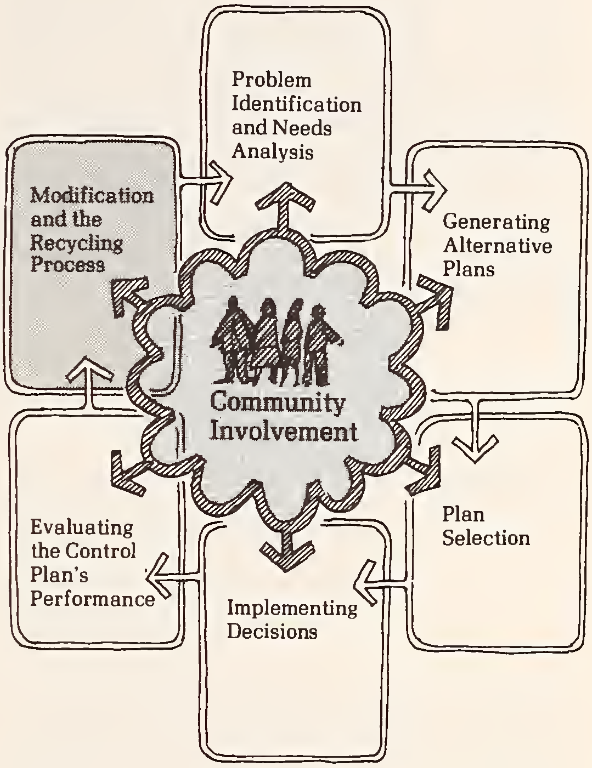
Modification and recycling the process

Minor modification to a neighborhood street's protection plan is a common occurrence. Most modifications are physical changes to individual devices or application of a standard change to all devices of a particular type. Usually such changes are minor measures intended to improve the devices' operation, eliminate some hazardous condition or counter some deviant driver behavior. Addition of reflectors and delineators to barriers or posts to prevent avoidance of them, or repositioning a stop sign for better visibility are examples of this type of modification. Most are undertaken by professionals on the basis of their own observations without any extensive formalized review process.

More important are situations where a plan is successful enough that abandonment is not a consideration, but its performance falls short of its intended objectives or it has some undesired side effects. Here significant modifications may be considered to fine-tune the plan.

The evaluation stage doubles as a needs assessment for such modification. In modifications of this nature which usually relate to a multi-device plan for a sizeable area, on some sites one type device may be substituted for another, some devices may be eliminated entirely or devices may be added, reoriented or shifted from one location to another. Normally, this type of modification involves a mini-version of the analytic and participatory processes used in needs assessment, alternatives development and selection. Because of all that has gone before, the actual activity can be extremely compressed in time and scope, though modification planning should be as thorough and deliberate as the original plan development. Major quick reaction modifications to large-scale schemes can create as much confusion and opposition as they were intended to cure.

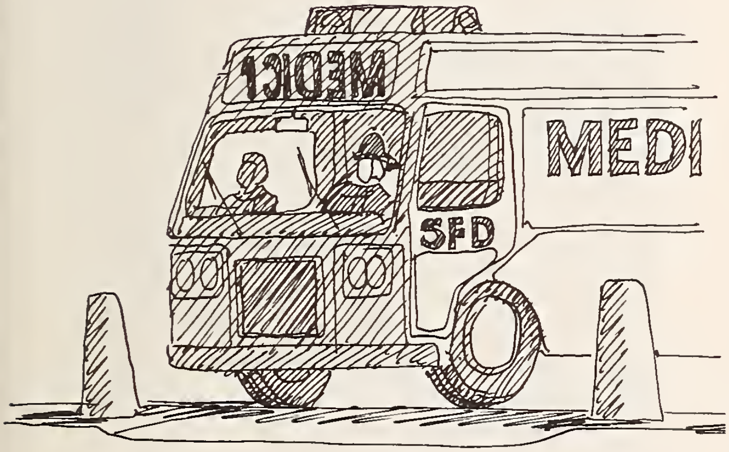
When a plan is deemed to fail irretrievably, "recycling" can occur. In essence, the scheme tried is abandoned and the problem is either returned to the alternatives development stage for a fresh approach or one of the previously dismissed planning alternatives is resurrected for



implementation. In actual practice, when neighborhood traffic control schemes have failed, the process involved so much controversy and acrimony that there has been no energy or enthusiasm for a "recycling" process. Calls for modification and recycling can continue years after initial installation. In Berkeley, three years after implementation, opponents still attempt to eliminate some or all diverters while supporters aim for numerous modifications. In Barnsbury, London the control plan was substantially recycled over a four-year period and two evaluation sequences, with nighttime control signs eventually replacing barriers.

5

Planning and design aspects common to all neighborhood management devices



Effects of physical barrier type devices on emergency service vehicles

Many of the neighborhood traffic control devices detailed in Chapter 3 pose potential problems for emergency and service vehicles by blocking their path or hindering their mobility. Devices of concern include diverters, semi-diverters, cul-de-sacs, circles, forced turn channelization, and median barriers. Primary concerns are for fire, police and ambulance services, and for private vehicles traveling in emergency situations. In addition, routine services such as public transit, school transportation services, delivery vehicles, refuse collection, and street and utilities maintenance operations can be affected. This section examines in detail the effects of traffic management devices on all of these operations. It also examines legal issues in traffic management.

Fire

Concerns for the impact of control devices on firefighting operations center on two elements: dispatching personnel and equipment to the fire (response) and maneuvering equipment at the fire site (extinguishment operations).[63]

Response Times

Response time — the time between the start of a fire and the beginning of extinguishment — bears an extremely significant relationship to accomplishing lifesaving missions, the seriousness of property damage and the difficulty of extinguishment. Response time has three elements: **discovery time, alarm transmission time** and **apparatus travel time.** Very clearly, traffic management plans can affect travel time and travel opportunities of fire apparatus. Neighborhood traffic management plans, particularly ones with barrier devices, may:

- Force apparatus to longer, less direct routings. This can affect insurance ratings as well as increasing response time.
- Confine apparatus to the busier streets, exposing it to increased potential for significant congestion/delay and to increased potential for collisions with other vehicles.
- Lead to an apparatus ending up on the wrong side of a barrier from the fire. This can result from driver error in route choice or from error in initial reporting of the fire location. Significant time is lost in backtracking when this occurs, particularly when an apparatus has already been laying hose.
- Preclude the good practice of routing companies responding from the same station via parallel routes. Multi-route response is normally practiced so that a single traffic incident will not delay all companies responding.
- Lead to an entire area being temporarily inaccessible to fire apparatus. This can occur when barrier devices interrupt several residential streets, one or more episodal incidents (sewer and water hookups, street repair, tree pruning and the like) block other streets normally unimpeded, and traffic from the blocked streets jams the remaining open streets.
- Slow down heavy fire apparatus maneuvering through or around barriers.

Firefighting Operations

At the scene of the fire, barrier devices may:

- Interfere with maneuvering and effective deployment of apparatus and equipment;
- particularly interfere with effective deployment of tillered aerial ladder apparatus;
- interfere with access to water supply points;
- complicate diversion of traffic away from the fire scene.

Counter Measures

It is possible that the potentially adverse effects of traffic barriers on response travel time can be offset by other improvements affecting travel time or discovery and alarm transmission. Some possibilities include:

- **Signal preemption.** Hardware permitting emergency vehicles to preempt traffic signals (thereby clearing the intersection approach of other traffic and quickly stopping cross traffic) is readily available. Its employment at all signalized intersections could cut response time along arterial and collector routes, offsetting increases caused by barriers on other streets.
- **Improved detection.** Reliable, low-cost combustion detection units are now readily available commercially. These are capable of significantly reducing detection time. A community considering a traffic management plan involving barriers could require installation of such detection units in all structures to offset increases in response travel time.
- **Improved alarm transmission.** Telephone and modern electronic signaling and retransmitting devices now in use in most urban areas have generally reduced alarm transmission time to the lowest attainable level. But in areas where the 911 universal emergency number call system is not yet operational, improvements are possible.

While the above possibilities hold some promise, the best approach might be to design a neighborhood traffic management system which would **minimize its adverse impact on response and firefighting operations.** Primary solutions include making barriers **traversable**, planning the neighborhood traffic management barrier system to minimize blockage of primary fire access routes and operations in the vicinity of potential multiple alarm fire sites, and providing **additional fire hydrants** where barriers compromise accessibility to existing fire plugs.

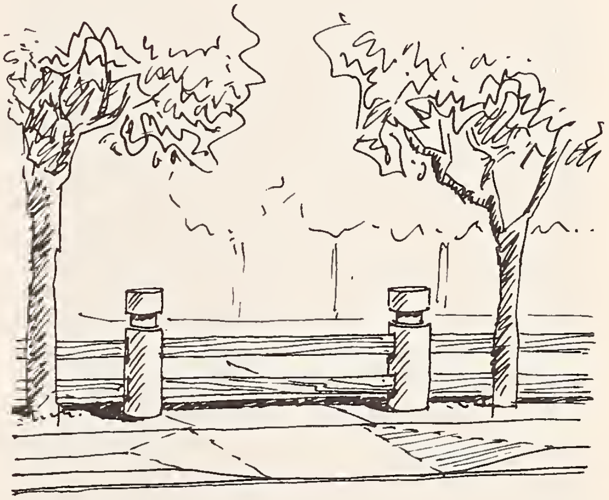
Traversable Barriers

Traversable barriers can be designed in many ways. Methods include open gaps in the barrier, emergency vehicle passageways guarded by mountable curbs, passageways guarded by flexible or breakaway materials, gaps guarded by raised traffic bars or "undercarriage preventer devices" and passageways guarded by automatic or manually operated gate devices.

Each of these measures has inherent problems. Any emergency vehicle gap must be kept free of obstruction. Instances of parked cars blocking emergency vehicle gaps are not infrequent. Unfortunately, with many of the devices located on the interior streets of residential areas, enforcement actions against such parking violations tend to be lax. Any emergency vehicle finding an expected gap blocked may be delayed more than if the barrier were an absolute one and the vehicle were routed around it initially. Vigorous enforcement of parking regulations at emergency vehicle openings is essential.

Barriers with open gaps (restriction of passage to emergency vehicles done by signs and markings only) are obviously subject to violation by other vehicles. This is treated in the following section on violations. But in terms of performance relative to emergency vehicle needs, open gaps rate highly. Seattle observed occasional problems where gaps were located near the curbline as parked cars complicated maneuvering through the space (though not blocking it). Positioning of emergency vehicle passages in the middle of the barrier appears advisable.

As an alternative to simply providing an open gap, some communities have placed mountable curbing across the emergency vehicle passage to discourage or slow motorists. Unfortunately, any curb which poses a somewhat formidable barrier to normal traffic is also a problem for emergency vehicles. If emergency vehicles attempt to take a raised curb at speed, the shock of crossing can lead to problems with wheel alignment, dislodge equipment and pose safety problems for the crew. It seems advisable where an emergency vehicle passageway is provided through a raised barrier device, that smooth ramps be constructed rather than "mountable



curbs."

Protection of emergency vehicle gaps by means of breakaway or flexible materials appears inadvisable. Breakaway barriers are equally permeable by vandals in private vehicles. And, debris from the breakaway material poses a hazard to firefighters riding on the exterior of the apparatus. Flexible plastic bollards have proven unsuccessful in several cities. Normal vehicles find them no deterrent to passage. And, while they do spring back to shape if subject only to infrequent passage, when subject to frequent violation they tend to become permanently deformed or break off. These materials are also an easy target for vandals. Some communities have placed raised traffic bars in the emergency vehicle openings. However, these did not pose much of a deterrent to drivers determined to violate the barrier. And, when the fire apparatus traverses them at speed, they tend to dislodge equipment and hazardously jolt firefighters, particularly those standing on the tailboard of the apparatus.

A few cities, notably Berkeley and Palo Alto, California, have employed an "undercarriage preventer" device in the emergency vehicle passage. As shown in Figure 8, this is a wooden or concrete block, usually about 3 feet (1 meter) wide, 6 inches (.2 meters) thick, raised about 6 inches (.2 meters) above the surface of the emergency vehicle passage. In theory, emergency vehicles are higher slung than most vehicles in normal public use. By measuring the underbody clearance of all emergency vehicles in use in a community, the projection height for the undercarriage preventer device which will allow emergency vehicle passage but discourage or prevent other vehicles can be selected.

In practice there are problems. A projection height which can be cleared adequately on a flat roadway surface can cause the same vehicles to bottom-out when the device is placed on a crowned contour. Because crowns vary substantially and the tolerances of concern are small, projection height must be determined on an individual site basis. Some emergency vehicles, particularly some police and fire chief's cars, differ little in underbody clearance characteristics from the vast majority of automobiles in normal use.* Conversely, virtually any private truck and some common high-slung automobiles can clear almost any undercarriage preventer that fire apparatus can clear. So the undercarriage preventers are not wholly effective. The section on violations presents some data on effectiveness of the undercarriage preventer in deterring normal traffic.

Gates automatically opening for emergency vehicles have proven problematic. In one Berkeley barrier on the immediate egress route of a fire station, a heavy duty parking lot type gate which opened upon radio actuation from all emergency vehicles was employed. Unfortunately, it proved so highly susceptible to vandalism (it needed repair on the average of once to twice per day), that it was removed after a brief period and an undercarriage preventer was substituted. Yet a similar type gate used for a similar purpose on the campus of the University of California at Davis has functioned well for many years. Radio or electronically actuated devices using even heavier duty gates and opening mechanisms — such as an adaptation of railroad grade crossing protection gear — may be more resistant to vandalism, but involve considerably more installation cost than a simple parking lot gate.

Manual devices in which the emergency vehicle operator dismounts to unlock and open a gate or remove a retractable bollard have been in use in vehicle free zones in many areas for numbers of years. Because of their simplicity, they are not particularly subject to mechanical failures and are resistant to vandalism. However, while they work acceptably in a simple situation of providing emergency access to individual blocks, they are less satisfactory in a situation where an emergency vehicle is simply attempting to traverse the block they protect. At each barrier encountered, the vehicle has to come to a full stop while someone dismounts, unlocks and opens the device and reboards. This can be unacceptably time-consuming, particularly if more than one device is encountered on a response route. Such manual "gates" are much more acceptable for

---

*In the long term, replacement purchases of emergency vehicles with suitable undercarriage clearance can alleviate this problem.

purposes of service access than they are for emergency vehicle accessibility.

Planning Considerations

The potential for traffic management plan interference with fire apparatus accessibility and firefighting operations can be minimized through good planning efforts such as:

- Developing traffic management plans which meet neighborhood objectives without placing barrier-type devices on the main egress routes from fire stations.
- Using semi-diverters or one-way street mazes in preference to full barrier treatments where strong traffic control devices are necessary on primary fire station egress routes. So long as the sight distance is good, operation of the fire apparatus the "wrong way" around a semi-diverter or on a one-way street is a generally accepted practice.
- Minimizing the use of full barrier treatments in close proximity to potential multi-alarm fire sites — multi-story apartment buildings, places of public assembly, etc.
- Minimizing problems of accessibility to water supplies by installing new fire plugs on the "dry side" of any barrier device which does not have an emergency vehicle opening. Typical current costs for installation of additional hydrants and laterals is about $2,000 per unit.

Police

Concern for the effects of barrier type devices on police functions centers on four topics: (1) Barriers make it more difficult for police to patrol a given area thereby decreasing police surveillance. As a natural reaction, individual patrol officers may tend to avoid regular patrolling of areas which become relatively isolated by barriers. These factors might be expected to lead to increase in certain types of residential crime. (2) Barriers tend to hamper patrol car pursuit of motorcycles, motorscooters, bicycles, and suspects fleeing on foot. (3) Use of large numbers of barriers in the city as a whole or in one or several adjoining neighborhoods could adversely affect police response to emergency calls. (4) The ability to use streets paralleling arterial and collector routes as an alternate route in cases of blockage due to fires, construction activity or special events traffic is a police concern.

Available information, however, lends minimal support to these concerns. For instance, relative to the patrolling issue, studies in Minneapolis, Minnesota have demonstrated that blocks with lower accessibility (characteristic of situations where diverters and cul-de-sacs are employed) tend to experience less residential crime than blocks with higher accessibility exposed to similar crime-related social variables.[9] In Berkeley, California nearly 70 cul-de-sacs and diagonal diverters have been deployed along with numerous semi-diverters, circles and other neighborhood traffic control devices. Comparison of residential crime statistics before and after plan implementation lends no support to the hypothesis that neighborhood traffic management would lead to greater crime rates due to inhibited police patrolling.[21]

Experience with their neighborhood traffic management barriers gives slight support to the notion that the barriers would pose significant obstacles to "hot pursuit" situations. There have been incidents where a barrier has been a factor in a pursuit situation, but in over two years of experience in Berkeley there is no instance in which Berkeley police attribute traffic barriers as the cause of failure to capture a suspect. Rather than hot pursuit, police feel the most interference is with "block covers" (where a suspect is believed contained within a residential block), particularly when they attempt to shift the cover from one block to another in response to movements of the suspect. However, no data is available on this phenomenon.

Berkeley patrol officers are convinced that traffic barriers interfere with their ability to respond quickly to emergency calls. But before and after data compiled by the police department indicates that the presence of barriers and other traffic control devices placed in the neighborhood traffic plan did not have any significant impact on overall police response time. Difficulties in using barred streets as detour routes have been experienced in Berkeley. One difficulty in such situations has been the failure of community service officers to take advantage of design features enabling quick disassembly of the barriers for passage of emergency detoured traffic.

Ambulance services and private emergency travel

Strategies in dealing with ambulance services in neighborhood traffic management plans are similar to those for fire apparatus. The placement of barriers on the immediate egress routes of ambulance operating bases and on the immediate access routes to hospital emergency rooms and emergency clinics should either be avoided, or the barriers should have emergency vehicle passageways suitable for ambulances. These provisions plus providing good public information on the location of any barriers not physically traversable by private automobiles and signing of unobstructed hospital access routes are the primary measures which can be taken to facilitate emergency travel in private vehicles.

Refuse collection and deliveries

Regularly routed vehicles for milk deliveries, postal service, refuse collection and the like can have their routes adjusted to operate in an efficient and continuous pattern within the constraints imposed by a system of barriers. Only cul-de-sacs significantly decrease efficiency by forcing vehicles to back-track over previously covered ground. For non-regular unrouted deliveries (such as delivery of a large household appliance), the barrier scheme poses more of a problem by presenting a confusing street pattern to drivers unfamiliar with the arrangement in each neighborhood. A remedy for this situation is for the city or possibly the Chamber of Commerce to distribute maps detailing the barrier pattern to all businesses making frequent deliveries in the city and to provide warning signs in advance of those blocks on which barriers are deployed.

Transit

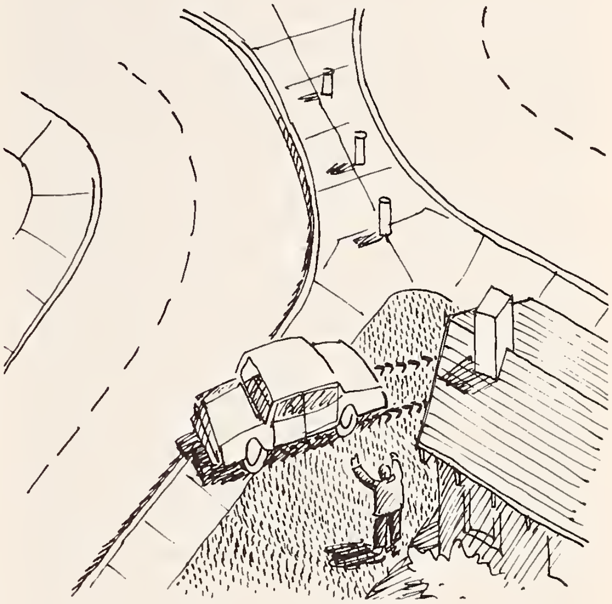
Since public transit service normally operates on arterial and collector streets unobstructed by barriers, minimal interference to these operations is generally inherent. Where signs and other control devices restrict vehicular movements, transit vehicles may be excepted by sign notice. Barrier systems may pose more of a problem to paratransit vehicles, dial-a-ride operations and school bus operations which tend to travel to some extent on the residential street system. Careful design of the barrier system with respect to school bus operations tends to minimize interference although some relocation of pick-up points may be necessary. Dial-a-ride, and other paratransit uses can adjust their operations in much the same manner as regular deliveries and are likely to be minimally impacted by barriers.

Maintenance

Barrier devices' interference with normal maintenance operations is typically minor. Northern cities have reported that diverters, cul-de-sacs and speed bumps complicate removal operations in heavy snow conditions. In Berkeley, where sewage system manholes are typically located in the center of intersections, diagonal diverter barriers must periodically be temporarily disassembled to allow for normal operation of sewage system flushing equipment. Diverse examples of similar kinds of problems have been reported; none are of a particularly serious nature. The essential point is that potential impacts on maintenance be considered in the planning stage so that appropriate adjustments can be designed, or cost impacts of operational changes can be assessed.

Violations of traffic barrier devices

Barrier devices by their very nature frustrate motorists and create a considerable level of driver resentment. Drivers find their favorite neighborhood shortcuts closed off and are forced to use less direct and perhaps congested arterial/collector routes. When they attempt to visit friends in the protected neighborhoods, they may become confused and disoriented by the barriers. They may naturally feel that the residents of the protected neighborhood have created an elitist situation for themselves at the driver's expense. Occasionally residents of the protected neighborhoods, who are personally insensitive to traffic problems and find their accessibility less convenient, react to the barriers from a driver's rather than from a resident's viewpoint.



Naturally, some drivers respond to barriers with behavior that reflects their resentment. A few resort to vandalism, but more prevalent behavior is violation of the device itself. While there is an inherent tendency for some drivers to violate barriers, the actual extent to which this occurs is dependent on how physically easy it is to violate the barrier, the amount of advantage the driver gains by this versus exercising other options, and general expectations regarding enforcement and the consequences of being caught in violation.

These factors all interact with one another so that it is difficult to generalize likely percentages of violation for various forms of devices. However, a few noteworthy points can be made. Barriers with open paved gaps, such as semi-diverters, or diagonal diverters and cul-de-sacs with unprotected emergency vehicle passages are obvious targets for violation.

But in Berkeley, California where some 70 diverters and cul-de-sacs have been deployed as part of the city's areawide neighborhood traffic management plan, barriers with open emergency vehicle passages experienced violation levels on the order of five to seven percent of the traffic formerly using the street.[21] This level of violation is a source of irritation to residents and to the majority of motorists who do obey the devices; but it is clear that even with an emergency vehicle gap easily traversed by normal vehicles, the barrier is highly effective in reducing through traffic volume on the streets where it is employed.

Counts of violations of emergency vehicle passages protected by undercarriage preventers in Berkeley showed no significant differences in the rates of violation than that experienced at barriers with open emergency vehicle passages.[21] However, this observation is somewhat misleading, since the city employed the undercarriage device only at locations where open gaps were initially observed to have high rates of violation. Unfortunately, no recorded data is available to contrast violation experience at individual sites before and after installation of the undercarriage device.

The same violation rate is probably typical for barriers with paved passages guarded by mountable curbs. Where diverters and cul-de-sacs have no paved passage ways but traversal is not physically precluded by strong deterrents (bollards, guard rails, sturdy plant growth, berms and other landscaping details), violation rates tend to be below quantifiable levels. Though infrequent, they still occur often enough to be a concern, particularly because of damage done to landscaping. Occasional violators will even traverse sidewalks and private lawns to avoid a barrier. Metal or wooden bollards should be positioned to preclude these incursions.

Devices or combinations of devices which tend to entrap motorists inside neighborhoods are ones most likely to be violated, particularly by persons encountering them for the first time. For this reason there may be a tendency toward higher violation rates for cul-de-sacs and mid-block closures unless they are designed to be violation proof. For similar reasons, semi-diverters which prohibit exits from a block rather than entries to it are to be avoided. High violation rates can also be expected at sites where the alternative route involves significant out-of-direction travel or passage through heavily congested streets and intersections. Violations of barriers on interior neighborhood streets is more likely than for those on the periphery. At interior locations, drivers have already committed themselves to a neighborhood shortcut and will have to back-track to comply with the barrier device. Furthermore, at interior locations there is a lessened expectation of police surveillance and enforcement. On the other hand, drivers tend to expect a higher probability of surveillance and enforcement and usually can continue their journey on arterial and collector routes without backtracking if the device is at the periphery of the neighborhood. The best way to avoid violation problems is to landscape the device so well that the roadway on the other side is hardly visible and looks as if there never had been any connection between the two street segments separated by the barrier device.

Legal considerations

The basic justification for neighborhood traffic management stems from the fundamental justification for all traffic laws, ordinances and controls — that streets and highways should provide expeditious and reasonably safe service to all legitimate users and uses and that these users and uses should not be killed, injured or frustrated by improper behavior of others. Since local residential streets are intended to serve a broader range of users and uses than other functional classes of streets, it is natural that more specialized controls may be needed to ensure satisfactory performance. More specific legal justification for neighborhood traffic management has been provided by the U.S. Supreme Court (County Board of Arlington County, Va., **Et Al.** v. Rudolph A. Richards, **Et Al**, No. 76-1418, Oct. 11, 1977) in a case involving an Arlington County, Virginia resident-preferential parking program. Beyond specifically upholding resident-preferential parking in the Arlington County case, the court added the broad finding that communities "may decide that restrictions on the flow of outside traffic into particular residential areas would enhance the quality of life thereby reducing noise, traffic hazards and litter." While the Supreme Court ruling appears to affirm basic legal grounds for neighborhood traffic management, a remaining legal issue of concern is that of conformance with the **Manual on Uniform Traffic Control Devices** and the several parallel control and design manuals issued by individual states. The following considerations are relevant to this concern:

- Many of the devices used for neighborhood traffic restraint purposes are standard traffic devices well recognized in the manuals and applied in quite standard ways. Included among these are one-way streets, turn prohibition signs, DO NOT ENTER signs, mandatory turn signs and markings, median barriers and channelization. There are no unusual legal problems with these devices.

- There have been legal challenges to diverters, semi-diverters and retrofit cul-de-sacs on the grounds that they are not recognized traffic control devices. In simple fact, measures loosely called "control devices" in this report are actually not traffic control devices in the strict sense. Some, like circles, semi-diverters, forced-turn islands and median barriers are forms of **channelization**, a recognized and commonly practiced traffic engineering treatment to guide or prevent specific vehicular movements. Others, like diagonal diverters and cul-de-sacs, are geometric features of the road. They are retrofit to be sure, but in this they are not unlike a change in a highway alignment made to take it over a new bridge or different from features which would be routinely accepted in the design of a new residential subdivision. These "geometric features" place certain areas outside the traveled-way and are marked and delineated by standard traffic control devices and traveled-way edge treatment. This is obvious in the case of permanent physical treatments delimited by raised curbs. When physical "devices" are constructed of temporary materials like bollards, planter boxes and the like, this point is less obvious. The area in which they are placed must be clearly marked with the appropriate pavement markings (as well as by appropriate signs, delineators and object markers) for proper driver guidance. The bollards, posts or other materials should be clearly outside the traveled way and placed there to discourage or prevent vehicles from traversing that area — not to delineate the traveled way themselves.*

- Some traffic engineers feel restricted from using any traffic control device not explicitly approved in the **Manual on Uniform Traffic Control Devices** or in parallel "approved" listings of state jurisdictions. Some feel that these manuals define the totality of good traffic engineering practice and anything not in the manuals is de facto, not good practice. Others, while not necessarily believers in the rigid position above, are concerned about exposure to a liability burden if a unique or non-listed device becomes the subject of litigation following an accident to which the device was in some way related. These are misconceptions. The MUTCD and parallel state manuals are intended as standards to ensure nationwide consistency in good traffic engineering practice, not as substitutes for sound engineering analysis and judgment nor as shields behind which officials wishing to avoid problems may hide. Both the way in which the MUTCD is officially managed and evolved and the actual day-to-day practice of traffic engineering belie the rigid application argument. The MUTCD itself and the Federal Highway Administration (FHWA) which oversees it recognize that the manual is not an all encompassing document. Advances in understanding and/or technology lead to new methods of control, new devices and techniques must be added to cover areas not adequately treated or not addressed in the past (controls related to bicycle facilities are a good example of this) and rather unique situations may require special treatment or some deviation from normal practice. For these reasons, the Manual sets forth procedures by which changes in it can be brought about or through which interpretations and approvals for use of devices as an alternative to manual-specified devices or approvals for experimentation may be granted. States, local jurisdictions and even individuals may petition the Federal Highway Administrator. FHWA attempts to be responsive to petitions and has minimal formal application requirements. Requests for using new devices or methods should indicate why a device

---

*Bollards, planters and other landscape materials in the devices under discussion are not intended as or in physical performance similar to guardrails and barriers used as safety devices. That is to say, they are not meant to deflect or constrain out of control vehicles from crossing medians or colliding with roadside obstructions. Rather, they are employed to discourage willful traversal of the area outside the travel way. This parallels the use of fencing and some guardrail on limited access highways to prevent independent-minded drivers from creating their own access at points where interchanges are not provided. Considering that these features outside the traveled way are not intended as and may not perform like safety guardrails, it is imperative that roadway geometrics at these locations be adequately delineated and marked by appropriate centerline, edge and advance warning treatments.

or procedure from MUTCD should not be used, advantages of the proposed procedure or device, any data showing why the proposed device is considered the solution and procedures to be used in any field experiments with the proposed device. Traffic engineers are urged to make application to FHWA or, as appropriate, through similar channels for the various state manuals. This brings experiences and new solutions to the attention of others and thereby broadens, changes and improves the practice of traffic engineering as a whole.

However, in actual practice traffic engineers often find "official" review too time consuming, remote, perhaps even intimidating, and usually out of scale — making a mountain out of a molehill — in relation to the immediate situation they are addressing. In these circumstances many, even some who on other occasions will cite the MUTCD as reason for not taking action on neighborhood traffic problems, will rely upon their own analyses, judgment, ingenuity and application of fundamental traffic engineering principles to develop solutions and will implement them routinely without seeking "official" review.

When traffic engineers deviate from recognized practices or implement new types of controls without seeking official sanction, they should themselves take the steps outlined below which in fact parallel what would be done more formally in making a request for an official request for change, experimentation or interpretation.

1. Carefully measure and document existing conditions and identify a valid traffic control need.
2. Demonstrate the fact that "approved" control devices were considered first and demonstrate substantive rationale for finding the "approved" devices nonresponsive to the problem (or that a "novel device is significantly more responsive).
3. Documents a process in which sensible engineering and design methodology and principles were used to arrive at a reasonable "solution" (i.e., the non-listed or unique device) to the problem.

The words "sensible methodology and principles" and "reasonable solution" are important here. Obviously a solution which directly conflicts with the fundamental principle set out in the control and design manuals and other documents of good engineering practice is neither sensible nor reasonable. On the other hand, a device or measure which is in substantive conformity with the control manuals and design guides, though perhaps not explicitly presented in them, a device which builds upon and extends fundamental engineering principles usually is sensible, reasonable and good traffic engineering.

As an aside to the foregoing, the history of numerous and widespread public complaints of neighborhood traffic problems and demands for action and traffic engineers' frequent inability to provide satisfactory responses are prima facie evidence that the MUTCD and parallel traffic control and design manuals can possibly evolve to define further measures addressing local residential street issues. It is hoped that this "State-of-the-Art Report" will be a step in gaining "official" recognition of devices and measures and in standardization of practices for neighborhood traffic control. Devices like diverters, semi-diverters and retro-fit cul-de-sacs are now pervasive enough that they should be given treatment in traffic control and highway design manuals* whether considered "controls" or "geometric features." The fact is that these and many other devices are now being widely used for neighborhood traffic control. Some devices which appear to be inherently useful, occasionally do not perform properly because traffic engineers, in the absence of authoritative guidance, sometimes use inappropriate materials in their construction, inadequately sign and mark them, make poor geometric design decisions or follow inadequate installation criteria. In other cases, due to the absence of proper guidance, officials have re-

---

*The 9th edition of **Fundamentals of Traffic Engineering**, for one, does treat this subject matter.

sorted to clearly inappropriate and ineffective controls. Traffic engineers are increasingly finding it appropriate if not being **forced** to control and limit residential street traffic. It is time that good practices and appropriate devices for this purpose be given explicit recognition in fundamental traffic engineering manuals and guides.

There are other legal issues of concern other than these related to the MUTCD. In most states, rigid conditions for abandonment of public right-of-way and procedures for doing so are specified by statute. In Berkeley, where the unfortunate term "closure" was used to describe cul-de-sacs, a court suit contended that the cul-de-sacs were an illegal abandonment of public right of way. The City's counter argument is that cul-de-sac streets are not closed or abandoned — anyone can walk on them, ride bicycles on them and drive motor vehicles on them; every property on the cul-de-sac streets is directly accessible by motor vehicle; the streets are in use; they simply are not useful to thru traffic. While this argument seems persuasive, particularly in light of the fact that streets initially built as cul-de-sacs are not considered closed, abandoned or non-public; the case is still under adjudication. Another contention in this Berkeley case is that the City's employment of diverters, semi-diverters, cul-de-sacs and other devices to reduce traffic on some streets while forcing it onto others constitutes a capricious abuse of the City's authority. While the U.S. Supreme Court decision referenced above appears to clearly uphold the authority of local jurisdictions to undertake neighborhood traffic management, this Berkeley suit reinforces the need that traffic management plans be developed, justified and have their impacts assessed in a **well-reasoned planning process.**

References

1. Alexander, Charles E., "Rotating Sign Serves Montgomery School Zone," **Traffic Engineering,** December, 1964.
2. Anonymous, "Windsor Park Gates," unpublished memorandum, Greater London Council, 1976.
3. Appleyard, Donald, et al, **Liveable Urban Streets: Managing Auto Traffic in Neighborhoods,** U.S. Department of Transportation, 1976.
4. Avery, Eugene V., "Effect of Raising Speed Limits on Urban Arterial Streets," Highway Research Board Bulletin 244, 1959.
5. Backus, R.I., "Optical Illusion Improves Safety," **WesternITE,** March-April, 1976.
6. Bandopadhyay, A.K., **Evaluation of Traffic Control Devices at Intersections of Low Volume Roads and Streets,** Purdue University, 1976.
7. Beaubien, Richard, "Stop Sign for Speed Control?" **Traffic Engineering,** November, 1976.
8. Berkeley, California, City of, Department of Public Works, **Closure of Fulton and Ellsworth Streets,** undated.
9. Bevis, Carol and Julia Nutter, "Changing Street Layouts to Reduce Residential Burglary," Annual Meeting of the American Society of Criminology, Atlanta, 1977.
10. Brown, P.J., "Surface Irregularity as a Means of Reducing Speed," **Surveyor,** October, 1972.
11. Buchanan, Colin, **Traffic in Towns,** London, Her Majesty's Stationary Office, 1963.
12. Burney, Georgina M., "Behavior of Drivers on Yellow Bar Patterns — Experiment on Alton By-pass, Hampshire," **Transport and Road Research Laboratory Supplementory Report 263,** 1977.
13. Cataphote Corporation, "Traffic Signs Contest Sparks Museum as Part of Psychology Institute," **Reflections of Cataphote, Vol. 2, No. 1.**
14. Concord, California, City of, Deleuw Cather Summary of Experience, 1977.
15. Conner, Thomas K., "Speed Management Through Rest-in-Red Traffic Signal Operation," **Public Works,** November, 1977.
16. Covina, City of, from unpublished neighborhood traffic control inquiry.
17. Cribbins, Paul D., "Location of Median Openings on Divided Highways," **Traffic Engineering,** April, 1967.
18. Cupertino, California, City of, miscellaneous staff memoranda, 1975.
19. DeJaeger, D.M., "Woonerven (Residential Yards)," **ITE Compendium of Technical Papers,** 47th Annual Meeting, Mexico City, 1977.
20. Deleuw, C.E., "Stop Sign Obedience," unpublished memorandum, 1975.
21. De Leuw, Cather & Company, **Six Months Experience: Berkeley Traffic Management Plan,** 1976.
22. De Leuw, Cather & Company, **Stop Sign Evaluation Study — Prides Crossing Neighborhood,** December, 1975.
23. De Leuw, Cather & Company, Letter to Keith Lockhard, November 1, 1977.
24. Denton, G.G., **The Influence of Visual Pattern on Perceived Speed at Newbridge M8 Midlothian,** Transportation and Road Research Laboratory Report 531, 1973.
25. Elmberg, C.M. and H.L. Michael, "The Effect on Speed of Speed Limit Signs on Suburban Arterial Streets," Joint Highway Research Project, Purdue University, **Report No. 4, 1961.**
26. Elmberg, Curt M., "Gothenburg (Sweden) Uses Barriers to Cut Traffic Congestion," **Civil Engineering,** September, 1972.
27. El Monte, California, City of, De Leuw Cather Summary of Experience, 1977.
28. Fullerton, California, City of, **Report on the Possible Closure of Dorothy Lane in the Vicinity of Longview Drive,** April, 1975.

29. Glendale, California, City of, "Traffic Zone System," unpublished letter, April, 1977.
30. Gothenburg, Town Planning Office, Traffic Planning Department, **Traffic Zone System in Gothenburg**, 1975.
31. Gurnett, George B., "Residential Street Speeds Surveyed: City of La Mirada," **WesternITE**, undated.
32. Hall, Dana L., **Energy, Air Pollution, Delay, and Safety Evaluation of Non-Signalized Control at Low Volume Intersections**, Purdue University, 1977.
33. Hawthorne, California, City of, **Neighborhood Intrusion of Bypass Traffic Through the Holly Glen Tract**, 1977.
34. Heany, John J., "A Highly Effective Safety Device," undated.
35. Herman, Robert and Richard Rothery, "Response to Speed Signs," **Traffic Engineering and Control**, July, 1964.
36. Herms, Bruce F., **Pedestrian Crosswalk Study: Accidents in Painted and Unpainted Crosswalks**, City of San Diego, California Police Department Traffic Bureau, August, 1970.
37. Highway Research Board NCHRP Report 93, **Guidelines for Medial and Marginal Access Control on Major Roadways**, 1970.
38. Highway Research Board NCHRP Report, **Location, Selection and Maintenance of Highway Traffic Barriers**, 1971.
39. Hoyt, Dan W., "In Further Support of Rumble Strips," **Traffic Engineering**, November, 1968.
40. Huberman, S. Arnold, "The Influence of Painted Crosswalks on the Behavior of Pedestrians and Vehicle Operators," University of California Institute of Transportation and Traffic Engineering, May, 1951.
41. Jackman, William T., "Driver Obedience to Stop and Slow Signs," **Highway Research Board Bulletin 161**, 1957.
42. Jacobs, G.D. and D.G. Wilson, "A Study of Pedestrian Risk in Crossing Busy Roads in Four Towns," **Road Research Laboratory Report LR 106**, 1967.
43. Jeffcoate, G.O., "Effect of Speed Limits on Road Safety in Europe," **International Road Federation**, 1969.
44. Kansas City, Missouri, City of, "An Evaluation of the Effects of One Way Traffic Regulations on Traffic Volumes in the Hyde Park Neighborhood," 1977.
45. Kermit, Mark L. and Hein, T.C., **Effect of Rumble Strips on Traffic Control and Driver Behavior**, Highway Research Board, January, 1962.
46. Kermit, Mark L., "Rumble Strips Revisited," **Traffic Engineering**, February, 1968.
47. La Mirada, California, City of, De Leuw Cather Summary of Experience, 1977.
48. Mackie, A.M., **A Comparison of the Accident Rate to Pedestrians on and within 50 Yards of Zebra Crossings**, Road Research Laboratory, Great Britain, October, 1971.
49. Marconi, William, "Speed Control Measures in Residential Areas," **Traffic Engineering, March, 1977.**
50. Marsh, Burton W. and William L. Carson, Engineers' Approach to Speed Limits," **Traffic Engineering and Control**, June, 1960.
51. Millbrae, City of, De Leuw Cather Summary of Experience, 1977.
52. Minnesota Department of Highways, **A Summation of Five Studies in Stop Sign Performance in Urban Areas**, 1945.
53. Mitchell, Richard, memorandum to members of the Concord, California Safety Commission, undated.
54. Mitchell, Richard, **Traffic Control Warrants on Low-Volume Streets**, undated.
55. Nuckles, Nelson B., "Preservation of Neighborhoods by Traffic Diverters," **ITE Compendium of Technical Papers**, 47th Annual Meeting, Mexiço City, 1977.
56. Oppenlander, J.C., "Variables Influencing Spot Speed Characteristics: Review of Literature," **Highway Research Board Special Report 89**, 1966.
57. Ottawa-Carleton, Regional Municipality of, **Glebe Traffic Plan, the Trial Period.**
58. Ottawa-Carleton, Regional Municipality of, **Rumble Strips for the City of Ottawa, 1973.**
59. Ottawa-Carleton, Regional Municipality of, unpublished report.
60. Owens, Robert D., "Effect of Rumble Strips at Rural Stop Locations on Traffic Operations," **Highway Research Record Number**

170, 1967.

61. Palo Alto, California, City of, unpublished staff memoranda, 1972-74.
62. Pleasanton, California, City of, unpublished memorandum, May, 1977.
63. Porter, Victor C., **Report to Planning Commission Regarding Neighborhood Traffic Study from Berkeley Fire Department,** January, 1975.
64. Post, Thomas, and James E. Bernard, **Response of Vehicles to Pavement Undulations,** Highway Research Safety Institute, University of Michigan, March, 1970.
65. Reiss, Martin C. and Allen E. Shinder, "Urban Play Streets: Creating and Operating Part-Time Traffic Free Zones," **Transportation Research Record 605,** 1976.
66. Royal Dutch Touring Club des Pays-Bas ANWB, **Woonerf,** 1977.
67. San Francisco, City of, Department of City Planning, **Report on the Jordan Park Protected Neighborhood Plan,** 1977.
68. Saratoga, California, City of, De Leuw Cather Summary of Experience, 1977.
69. Saratoga, California, City of, De Leuw Cather Summary of Experience, 1977.
70. Seattle Engineering Department, **East Republican Traffic Diverter System,** March, 1977.
71. Seattle Engineering Department, **Stop Sign Evaluation — Fairview Avenue East.** March, 1976.
72. Seattle Engineering Department, **Leschi Traffic Diverter Demonstration,** January, 1976.
73. Seattle Engineering Department, **Traffic Diversion in the Stevens Neighborhood,** 1974.
74. Seddon, P.A., **Traffic Control Measures,** University of Salford, 1971.
75. Sidener, Jack, **Recycling Streets,** 1976.
76. Thompson, J. Michael, **Methods of Traffic Limitation in Urban Areas,** 1972.
77. TJKM Associates, **City of Palo Alto Stop Sign System Evaluation Program,** September, 1976.
78. Toronto, Ontario, Department of Public Works, unpublished memorandum.
79. Transport and Road Research Laboratory, "Speed Control Humps in Cuddesdon Way, Cowley, Oxford," **Leaflet 617,** July, 1976.
80. Transport and Road Research Laboratory, "Speed Control Humps in Motum Road, Norwich," **Leaflet 663,** September, 1977.
81. Transport and Road Research Laboratory, "Speed Control Humps in Palace Road, Haringey, London," **Leaflet 664,** September, 1977.
82. Transport and Road Research Laboratory, "Speed Control Humps in Abbotsbury Road, Kensington, London," **Leaflet 665,** September, 1977.
83. Transportation Research Board NCHRP Report 173, **Highway Noise Generation and Control,** 1976.
84. Transportation Research Board NCHRP Report 174, **Highway Noise: A Design Guide for Prediction and Control,** 1976.
85. United States Census of Housing, 1973.
86. United States Department of Transportation, **Manual on Uniform Traffic Control Devices for Streets and Highways,** 1971.
87. United States Department of Transportation, **Selecting Effective Citizen Participation Techniques,** 1977.
88. Utter, Robert F., **The Influence of Painted Crosswalks on the Behavior of Pedestrians and Automobile Drivers,** University of California Institute of Transportation and Traffic Engineering, 1949.
89. Urban Land Institute, **Residential Streets: Objectives, Principles, and Design Considerations,** 1971.
90. Vikery, Robert L., **Anthropophysical Form,** University of Virginia Press, Charlottesville, 1972.
91. Wallen, Martin A., "Landscaped Structures for Traffic Control," **Traffic Engineering,** 1961.
92. Wallen, Martin A., **Traffic Safety Techniques and Equipment — Residential Neighborhoods,** January, 1964.
93. Walnut Creek, California, City of, De Leuw Cather Summary of Experience, 1977.
94. Walsh, Lawrence B., **A Study of Speed Bumps,** 1975.
95. Watts, G.R., "Road Humps for the Control

of Vehicle Speeds," **Transport and Road Research Laboratory Report 597,** 1973.

96. Welke, Ronald C., "Residential Traffic Controls," **Compendium of Technical Papers, 46th Annual Meeting, Institute of Transportation Engineers,** 1976.
97. Wenger, D.M., "Effect of Change from Two-Way to Four-Way Stop," **Accident Characteristics at Four-Way Stop Control Versus Two-Way Stop Control,** Bureau of Highway Traffic, Pennsylvania State University, 1958.
98. Wiley, C.C., et al, **Effect of Speed Limit Signs on Vehicular Speeds,** Department of Civil Engineering, University of Illinois, 1949.
99. Wilson, D.G. and S.J. Older, **The Effects of Installing New Zebra Crossings in Rugby and Chelmsford,** Road Research Laboratory Report 358, 1970.
100. Witheford, David K., **Speed Enforcement Policies and Practice,** Eno Foundation for Transportation, 1970.
101. Yee, Kimland M., **Traffic Circle Study,** Sacramento Department of Traffic, undated.
102. Yoder, Robert M., "Revolt of the Homeowners," **Saturday Evening Post,** 1956.
103. Zeeger, Charles V., et al, "Speed Reduction in School Zones," **Transportation Research Record 597,** 1976.
104. Perry, Clarence, **The Rebuilding of Blighted Areas: A Study of the Neighborhood Unit in Replanning and Plot Assemblage,** Regional Plan Association, Inc., New York, 1933.
105. Urban Land Institute, **The Community Builder's Handbook,** Washington, D.C., 1968.
106. Simkowitz, H.J., et al, **The Restraint of the Automobile in Residential Neighborhoods,** Organization for Economic Cooperation and Development, April, 1978.
107. Gallion, A.B., & Eisner, S., **The Urban Pattern,** D. Van Nostrand Co. Inc., Princeton, N.J., 1963.
108. Department of the Environment and Department of Transport, **Residential Roads and Footpaths: Layout Considerations,** London, February, 1977.
109. Compton, D.H. & Gilbert, D., **Bath Environmental Capacity Study,** Department of Civil Engineering, Imperial College of Science & Technology, London, August, 1976.
110. Swedish National Board of Urban Planning, **The SCAFT Guidelines 1968, Principles for Urban Planning with Respect to Road Safety,** Stockholm, September, 1968.
111. Marks, Harold, **Traffic Circulation Planning for Communities,** Motor Vehicle Manufacturers Association, 1974.
112. Smith, D.T., "Safety And Location Criteria for Bicycle Facilities, User Manual Volume II," U.S. Department of Transportation, FHWA-RD-75-114, Washington, D.C., 1976.
113. Homburger, W.S., & Kell, J.H., **Fundamentals of Traffic Engineering,** 9th Edition, Institute of Transportation Studies, University of California, 1977.
114. Pegnataro, L.J., **Traffic Engineering, Theory and Practice,** Prentice-Hall, Inc., Inglewood Cliffs, N.J., 1973.
115. Statens Planverk, **Stadens Trafiknat, Trafik Vid Bostaden,** Sweden, 1977.
116. Senate of the Free and Hanseatic City of Hamburg, **Development of Zones Free From Through Traffic in Residential Areas and Measures to Adopt Speed Limits in Residential Areas,** Hamburg State Press Office, Paper 8/2569 17.05.77.

Appendix A

	Technique	Money	Time	Staff	Expertise	Equipment
Information Collection (Continued)	Focused Group Discussion	"Varies in Cost"	Medium-High	Medium	Yes	No
	Delphi	"Can Be Expensive"	High	Low	Yes	No
	Community Sponsored Meetings	"Relatively Minor"	Low	Low	No	No
	Public Hearings	$500-$25,000	High	Medium	Yes	Yes
	Ombudsman (On Agency Staff)	$18,000-$40,000/ Annual Salary	Low-Medium	High	Yes	No
Initiative Planning	Advocacy Planning	$20,000-$100,000/ Year	Low-Medium	Low	Yes	No
	Charrettes	$15,000-$250,000	High	Medium	Yes	Yes (For Overnight Facility)
	Community Planning Centers	$60,000-$200,000/ Year	Medium-High	Low	Yes	No

Scales

Time: Low: Less Than 1 Month
Medium: Between 1 and 2 Months
High: More Than 2 Months

Staff: Low: Single, Short Committment
Medium: Reoccurring Short Committment
High: Committment Longer Than 1 Month

Expertise: No: Requires Only Usual Planning Skills
Yes: Requires Unusual Skills

Equipment: No: Requires Only Usual Agency Equipment
Yes: Requires Unusual Equipment

Appendix A. **Citizen Participation Resoures and Techniques**

Participation Process Support

Technique	Money	Time	Staff	Expertise	Equipment
Citizen Employment	$5,000-$10,000/Employee	Low-Medium	Low	No	No
Citizen Honoraria	For Each Person: at Least $10 per Meeting or $25-$50/ Day or Higher if Repaying at Actual Payscale	Low	Low	No	No
Citizen Training	"Varies Widely"	Low-High	Medium	Yes	Yes
Community Technical Assistance	"Varies"	Medium-High	Low-High	No	No
Coordinator or Coordinator/Catalyst	$20,000-$30,000 Annual Salary	High	Low	No	No
Game Simulation	$100-$500/Day for Existing Game; $10,000-$2 Million To Develop New Game	Medium-High	Medium	Yes	Yes

Scales

Time: Low: Less Than 1 Month
Medium: Between 1 and 2 Months
High: More Than 2 Months

Expertise: No: Requires Only Usual Planning Skills
Yes: Requires Unusual Skills

Staff: Low: Single, Short Committment
Medium: Reoccurring Short Committment
High: Committment Longer Than 1 Month

Equipment: No: Requires Only Usual Agency Equipment
Yes: Requires Unusual Equipment

Decisionmaking

Technique	Money	Time	Staff	Expertise	Equipment
Arbitrative and Mediative Planning	$200-$250/Day Fee for Arbitrator/Mediator	High	Medium	Yes	No
Citizen Referendum (Official) (Unofficial)	 No Cost $5,000-$40,000	 High Medium-High	 Low-Medium Low-Medium	 No No	 No Yes
Citizen Review Board	Depends on Amount Needed for Honoraria and Citizen Training (See Participation Process Support Techniques)	High	High	No	No
Media-Based Issue Balloting	$17,500-$1.5 Million	High	Medium	Yes	Yes

Scales

Time: Low: Less Than 1 Month
Medium: Between 1 and 2 Months
High: More Than 2 Months

Expertise: No: Requires Only Usual Planning Skills
Yes: Requires Unusual Skills

Staff: Low: Single, Short Committment
Medium: Reoccurring Short Committment
High: Committment Longer Than 1 Month

Equipment: No: Requires Only Usual Agency Equipment
Yes: Requires Unusual Equipment

Appendix A. **Citizen Participation Resources and Techniques (continued)**

	Technique	Money	Time	Staff	Expertise	Equipment
Initiative Planning (Continued)	Computer-Based Techniques	"Varies Widely"	Low-High	Low	Yes	Yes
	Design-In and Color Mapping	Under $100-$5,000	Low-Medium	Medium	No	Yes (Models)
	Plural Planning	$50,000-$100,000/ Community Group	High	High	No	No
	Task Force	"Relatively Inexpensive"	Low-Medium	Medium	No	No
	Workshops	$500-$2,000	Low-Medium	Medium	Yes	No
Reactive Planning	Citizens' Advisory Committee	$20,000-$60,000	High	Medium	No	No
	Citizen Representatives on Policy-Making Boards	"Little Expense"	Low	Low	No	No

Scales

Time: Low: Less Than 1 Month
Medium: Between 1 and 2 Months
High: More Than 2 Months

Staff: Low: Single, Short Committment
Medium: Reoccurring Short Committment
High: Committment Longer Than 1 Month

Expertise: No: Requires Only Usual Planning Skills
Yes: Requires Unusual Skills

Equipment: No: Requires Only Usual Agency Equipment
Yes: Requires Unusual Equipment

	Technique	Money	Time	Staff	Expertise	Equipment
Reactive Planning (Continued)	Fishbowl Planning	"Relatively Expensive"	Medium-High	High	No	No
	Interactive Cable TV-Based Participation	"Costly"	(Not Available)	(Not Available)	Yes	Yes
	Meetings—Neighborhood	"Relatively Small"	Medium	Medium	No	No
	Neighborhood Planning Council	(See Advocacy Planning)	Medium	High	No	No
	Policy Capturing	$10-$20 per Computer Regression Analysis; $40,000 for Interactive Computer Graphics Program	Medium-High	Medium	Yes	Yes
	Value Analysis	Many Cost Factors	High	High	Yes	Yes

Scales

Time: Low: Less Than 1 Month
Medium: Between 1 and 2 Months
High: More Than 2 Months

Staff: Low: Single, Short Committment
Medium: Reoccurring Short Committment
High: Committment Longer Than 1 Month

Expertise: No: Requires Only Usual Planning Skills
Yes: Requires Unusual Skills

Equipment: No: Requires Only Usual Agency Equipment
Yes: Requires Unusual Equipment

Appendix A. Citizen Participation Resources and Techniques (continued)

	Technique	Money	Time	Staff	Expertise	Equipment
Information Dissemination	Public Information Program	$5,000–$50,000	Medium-High	Medium-High	No	No
	Drop-In Centers	"Can Be Costly"	Medium	High	No	Yes (Mobile Center)
	Hot Lines	$2,000/Week for Recording Equipment 24 Hours/Day; $40 Installation Fee	Low	Low	No	Yes
	Meeting-Open Information	"Varies Widely"	Low	Medium	No	No
Information Collection	Surveys	$3-$5/Mailed Questionnaire; $10-$15/Telephone Interview; $15-$30/Personal Interview With Basic Analysis of Data	Medium-High	Medium	Yes	Yes

Scales

Time: Low: Less Than 1 Month
Medium: Between 1 and 2 Months
High: More Than 2 Months

Staff: Low: Single, Short Committment
Medium: Reoccurring Short Committment
High: Committment Longer Than 1 Month

Expertise: No: Requires Only Usual Planning Skills
Yes: Requires Unusual Skills

Equipment: No: Requires Only Usual Agency Equipment
Yes: Requires Unusual Equipment

	Technique	Money	Time	Staff	Expertise	Equipment
Participation Process Support (Continued)	Group Dynamics	$150-$1,000/Day for Leaders; $1,600 for Purchase of Video Tape Equipment; $16 for 30 Minutes of Tape	Medium	Low-Medium	Yes	Yes (Video Taping)

Scales

Time: Low: Less Than 1 Month
Medium: Between 1 and 2 Months
High: More Than 2 Months

Staff: Low: Single, Short Committment
Medium: Reoccurring Short Committment
High: Committment Longer Than 1 Month

Expertise: No: Requires Only Usual Planning Skills
Yes: Requires Unusual Skills

Equipment: No: Requires Only Usual Agency Equipment
Yes: Requires Unusual Equipment

Sources:

Ueland and Junker, *A Manual for Achieving Effective Community Participation in Transportation Planning.*

U.S. Federal Highway Administration, *A Manual of Community Involvement Techniques for Designing and Implementing Community Involvement in Highway Planning and Design.*

U.S. Federal Highway Administration, *Effective Citizen Participation in Transportation Planning.*

Yukubousky, *Community Interaction in Transportation Systems and Project Development.*

Appendix A. **Citizen Participation Resources and Techniques (continued)**

Appendix B

Selected references on community participation techniques

1. Judy B. Rosener, "Citizen Participation: Tying Strategy to Function" in **Citizen Participation Certification for Community Development: A Reader on the Citizen Participation Process,** ed. Patricia Marshall. Washington, D.C.: National Association of Housing and Redevelopment Officials, February 1977.
2. James J. Schuster, John N. Balog and Anthony F. Dreisbach, **Optimization of Citizen Participation in the Transportation Planning Process,** Report No. DOT-TST-76-96. Springfield, Virginia: National Technical Information Center, 1976.
3. Transportation Research Board, **Citizen's Role in Transportation Planning;** Transportation Research Record No. 555. Washington, D.C.: National Research Council, 1975.
4. Ueland and Junker Architects and Planners and Portfolio Associates, Inc., **A Manual for Achieving Effective Community Participation in Transportation Planning.** Harrisburg, Pennsylvania: Pennsylvania Department of Transportation, April 1974.
5. U.S. Federal Highway Administration, Office of Environmental Policy, **A Manual of Community Involvement Techniques for Designing and Implementing Community Involvement in Highway Planning and Design.** Washington, D.C.: Federal Highway Administration, January 1977.
6. U.S. Federal Highway Administration, Socio-Economic Studies Division, **Effective Citizen Participation in Transportation Planning,** Volume I, Community Involvement Processes. Washington, D.C.: Government Printing Office, 1976.
7. Richard Yukubousky, **Community Interaction in Transportation Systems and Project Development: A Framework for Application: Planning and Research Report 50.** Albany, New York: New York State Department of Transportation, September 1973. Reprints Marvin L. Manheim and John H. Suhrbier, **A Catalogue of Community Interaction Techniques,** Massachusetts Institute of Technology Transportation and Community Values Report No. 72-10, unpublished report submitted as part of the National Cooperative Highway Research Project 8-8(3).

Appendix C

Techniques and measurements for neighborhood traffic management planning

Introduction

This appendix outlines operational measurements to assess traffic issues in a neighborhood and, if a protection device has been installed, to determine its effects and effectiveness. A summary of the measures is presented in Table 10.

Some types of measures are appropriate both in the planning stages and for evaluation of performance after implementation. Others not particularly useful in planning are taken simply to record important impacts which become evident after implementation. Also, different types of measures are taken to assess the direct impacts of traffic control on the "protected" area and those used to assess the impacts on others affected.

Operational measurements which indicate the presence of a problem

Traffic Volume

A limited number of attempts have been made to establish threshold levels at which traffic volumes on residential streets become a perceived problem. The publication **Residential Streets** suggests that local streets should carry less than 1,000 vehicles per day.[89] The City of Dallas has extrapolated this value and uses 1,000 per day or 100 in the peak hour in both directions.[55] Montgomery County, Maryland has ascertained

Table 10
Technical measurements for neighborhood traffic management

Measure	Used In Needs Assessment	 Alternative Evaluation	 Follow-up Evaluation	Special Considerations
Total Traffic	●	●	●	ADT, peak hour and nighttime counts in response to particular problem
Through Traffic	●		●	Estimation by use of trip generation rates or license survey of car following
Speed	●	●	●	Radar or other automatic procedure, car following does not work
Traffic Composition	●	●	●	Standard classification counts when trucks or motorcycles are problems
Traffic Safety	●	●	●	Low numbers of accidents usually make statistics meaningless; must respond to incidents and perceived safety problems
Traffic Noise	●	●	●	See NCHRP report #174 for estimation technique
Air Quality	●		●	Minimal impact by NTM
Capacity of Adjacent Arterials		●	●	SeeHRB Highway Capacity Manual
Number of People Effected	●	●	●	Manual count of affected households
Effect on Resident Accessibility	●	●	●	Qualitative evaluation
Effect on Emergency Services	●	●	●	See Chapter 5
Impact on Pedestrians, Bicycles, Handicapped	●	●	●	Qualitative evaluation of design features — See Chapter 3 for individual devices
Level of Driver Obedience		●	●	See Chapter 3 for individual devices
Construction Costs		●		See Chapter 3 for individual devices

that 200 vehicles in one direction per hour "appears to coincide with an approximate point when local residents experience a visual and mental disturbance, causing them to initiate complaints of excessive traffic."[96] Finally, Appleyard in his study of streets in San Francisco, where residences tend to border sidewalks and are quite close to the streets, found that 33 percent of the people on streets of less than 2,000 vehicles per day felt traffic to be fairly or very heavy on their streets; 90 percent felt this way on streets with 10,000 vpd.[3]

These few studies only touch upon the nature of the problem. There is a wide range of environmental conditions — including residential density, building setback line, other non-traffic related problems such as crime, appearance and general neighborhood character — which can influence the vulnerability of residents and hence, the level of traffic which residents perceive as a problem. Thus additional research is needed to determine a set of threshold traffic volumes (and associated environmental conditions) which can be used as a basis for determining if a problem exists. However, it should be amply clear that the "capacity" of local residential streets is not governed by "volumetric capability" but by environmental considerations.[111]

In Britain, researchers have defined the "environmental capacity" (acceptable traffic volume) of various types of streets on the basis of noise, effects on pedestrians and visual intrusion.[109] Volume levels based on noise criteria are computed using methodology similar to that described in this report. Pedestrian based criteria relate to conflicts and delays experienced in crossing streets. Visual intrusion criteria are subjective. This work presents a promising methodology for determining what traffic levels are appropriate on individual streets. But the specific results reported in the referenced Bath study are not reproduced here as useful rules of thumb as they are subjective to the particular streets studied in Bath, an area of especially unique character. The Bath researchers also warn that the level of effort involved in estimating environmental capacities on a street-by-street basis may make their approach extremely costly in practical application. Despite this, the Bath work is a useful step in the attempt to specifically quantify how much traffic is acceptable and those interested are urged to consult the referenced report.

As a more pragmatic guide, the analyst can use the standards developed by the agencies listed at the start of this section or the functional classification volume ranges listed in Chapter 4. However, there are two important distinctions in the measuring of traffic volumes. First, a problem may exist only during specific periods of the day (peak hours, nighttime), or it may be a day-long problem. Measurements should therefore be made on an hourly basis to determine this factor. In addition, traffic on neighborhood streets may be "local" or "through" traffic. The distinction between these two types of traffic becomes somewhat clouded as the size of the neighborhood increases.

Three techniques can be suggested for determining the percentage of through traffic. One method would be to define a neighborhood boundary, or define the limits of a specific street to be protected, and conduct a license plate survey of entering and exiting vehicles. This technique becomes quite costly as the number of entrances increase. A more cost-effective technique would be to determine the volume of local traffic which **should** occur on the street using standard trip generation rates. An average value of 10 trips per household can be used for most typical low to medium density areas. By comparing the theoretical traffic generation to the observed volume, a reasonable estimate of the percentage of through traffic can be obtained. Finally, a limited sample of cars could be followed as they enter a neighborhood to determine if their destination is local or beyond the neighborhood.

A final note on the collection of traffic volume data is the importance of covering both streets from which complaints are received and streets where traffic might be diverted by a management project. By anticipating complaints related to implementation of a plan, the planner will have sufficient data before and after implementation to either confirm or refute complaints received external to the protected neighborhood.

Traffic Speed

Traffic speed is one of the most frequent complaints registered regarding traffic on residential streets. Yet very little research has been done to quantify a threshold level or levels where speed becomes a perceived problem. Studies to date have focused on speed in relation to accidents, for the most part on non-residential streets; and speed in relation to posted or prima facie speed limits. These studies are clearly more driver-oriented than neighborhood-oriented.

Perhaps the best guideline to "officially" acceptable speed in neighborhoods are the speed limits established for non-arterial streets by various state and local jurisdictions. A summary of some of these limits on two lane urban and suburban locations was presented in Chapter 3 in Tables 5 and 6. In general, limits of 15-25 mph have been established around school zones, while limits of 25-30 mph have been established for other parts of local streets. These limits have been established on the basis of being judged reasonable and safe for the conditions to which they apply. By contrast, in the Dutch Woonerf or "residential yards," the design objective is to limit traffic speed to 7 to 14 mph[19] and Swedish guidelines call for speed limits of 19 mph (30 kmph).[110]

A review of cases where speeding is considered to be a problem and speed checks are subsequently conducted has shown that speeds above the 25-30 mph range have appeared to produce complaints. However, such a statement is not based on a solid program of research which might establish the various contributing factors which lead to the perception that speed is a problem.

A special problem related to speed on residential streets is that while traditional traffic engineering procedures attempt to base speed limits on the 85th percentile of observed speed, the residents may be most concerned about the aberrant few who exceed resonable speeds. Since speed is viewed correctly as a contributor to accidents, it is the excessive speed of the few that can appear to create unsafe conditions on local streets. Thus in measuring speed on a street in an attempt to evaluate the existence of a problem, it would appear reasonable to give consideration not only to the average and 85th percentile speeds, but also to the degree to which the highest 15% depart from safe practices.

In this regard, the simple geometric design of the street may contribute to the potential for speeding to occur, and the evaluation must include recognition of the potential as well as the actual occurrence; for example, wide, straight streets with few intersections have a greater potential for speeding than do streets that may be either narrow, curved or broken by numerous cross streets. In addition, certain types of drivers, notably the teenage hot-rodder, have a reputation for excessive speeds. Noting the types of drivers who are at the high end of the speed range may be a useful key to determining the type of solution needed.

In summary, based on the limited data available on speeds on local streets, it would appear that measurements indicating 85th percentile speeds above 25-30 mph would be a reasonable basis for acknowledging the existence of a problem. In addition, special attention should be given to the highest 15% of auto speeds to determine the frequency and degree of speeding, as well as general nature of the aberrant speeding drivers themselves. But considering the trends in European residential street planning and the prevalence of resident concerns in this country, it seems apparent that what is not "speeding" by our official standards may still be "too fast" for residential neighborhoods and further research on residential street speed limits is needed.

Traffic Composition

Traffic composition relates to the mixture of automobiles, buses, trucks, motorcycles and bicycles in the traffic stream. This characteristic is in fact a secondary variable related to traffic noise and traffic safety. Traffic composition can be simply measured by a standard classification count. However, count categories should specifically focus on vehicle types which tend to be most irritating to residents. Counts by hour may be useful to ascertain whether the problem exists all day, during the peak hour, or at night.

Traffic Direction

The only known study on residential preference related to direction was conducted by Appleyard in San Francisco.[3] It indicated that people living on streets with more than 5000 vehicles/day were relatively indifferent to whether traffic was one- or two-way whereas people on streets with less than 2000 vpd, an overwhelming majority (74%) preferred their street to remain two-way. This can be attributed to the presence of high volumes on most one-way streets in San Francisco and the anticipation that such a condition would occur if these respondents' streets were converted to one-way. Were a one-way pattern to be created in a way such as to remove through and/or high speed traffic, it is probable that traffic direction would not be a significant factor. Traffic direction should thus be considered in terms of whether the street pattern promotes or discourages through traffic. On two-way streets, directional dominance of intruding traffic flows either on an all-day or peak period basis can also be an important consideration in traffic management planning.

Traffic Safety

Traffic safety in neighborhoods is a sensitive issue which is quite hard to quantify. While the number of accidents or the accident rate can be computed, residents tend to be sensitive to more than actual accidents in their neighborhoods. Safety in neighborhoods tends to be related to intuitive perceptions about streets as safe places to walk along, to cross, and for children to play in. Clearly these factors are related to speed and volume, but statistical correlation with perception of safety has not been made, if indeed it is possible. Furthermore, in their perceptions of safety, residents tend to be aware of **incidents** such as near-collisions or vehicles striking pets, events unrecorded in the normal traffic accident records traffic engineers use. There is also a problem in the area of accident rate measurements, since on low volume streets, accidents are quite rare; thus measurements in a small area may be highly unrepresentative of actual safety problems. A possible technique for agencies contemplating a statistical evaluation is to compile accident rates for various classification of streets (freeways, arterials, collectors, and local streets) on a city or regionwide basis. Comparison of rates in a small neighborhood can then be used, with due respect to the size of the local sample, to compare the local condition to the areawide average. Neighborhoods with accident rates above the norm may be considered as potential problem areas, though statistical significance is not always possible. Another technique used in Seattle is to ask residents by survey to spot-locate near-misses, pet accidents and other unrecorded safety incidents and then compile and analyze these in much the same way as normal accident data.

Traffic Noise

Traffic noise is a variable that can either be measured directly or computed on the basis of traffic volume, speed, composition and distance from the noise source. The analysis of traffic noise is a rather new science and as a result there are several ways of both measurement and computation. The three basic methods of computation are:

- L_{10} — the sound level of the loudest 10% of the vehicles passing a point in a specified period of time;
- L_{eq} — the average noise level as measured over a 24-hour day;
- L_{dn} — the average noise level as measured over a 24-hour day with a 10 db penalty for nighttime observations to account for perceived higher sensitivity to nighttime noise.

L_{10} and L_{eq} are used by FHWA in their design policies; L_{dn} is used by EPA in their environmental impact evaluation policies. L_{eq} and L_{dn} both respond to the average condition, which may be of concern where steady streams of traffic occur. L_{10} responds to the less frequent peaks, which may be the most bothersome in a residential environment.

A number of standards have been developed as reasonable or acceptable levels of noise. The FHWA has established 70 db at L_{10} in the peak hour and 75 db at L_{eq} for the total day as their design guidelines for noise in residential areas. EPA has established an L_{dn} level of 65 as their criterion for acceptable noise. However, further study is needed to determine threshold levels of acceptable noise for various levels of noise.

In lieu of actual measurements of noise, the reader is directed to NCHRP Reports 173[83] and 174,[84] for the most current analysis of the problem; the latter volume presents techniques for estimating noise levels based on traffic volume, traffic composition and distance from the roadway. These techniques are useful for determining if the above standards are exceeded, or if a particular local condition exceeds noise levels that would normally be encountered.

Acceleration/Braking

Acceleration and braking add an increment of noise above that encountered when vehicles are moving at steady speed. They also add to driving and energy costs, driving time and air pollution. Measurement of this characteristic is not specifically needed as an evaluation tool, except that locations where it occurs should be noted, such as at stop signs or at road curves. Studies in the neighborhood should also determine if the noise created by acceleration and braking is perceived as a problem. Likewise, the installation of any control devices should consider whether acceleration and braking will occur as a result of the installation.

Systemwide measurements

The previous measurements relate to problems that occur on the residential streets themselves. However, prior to installation of neighborhood protective devices, consideration should be given to several systemwide characteristics which will be affected by these devices.

Capacity Utilization of Relevant Major Intersection

Any successful program of neighborhood protection will inevitably divert some traffic to adjacent arterial streets. Part of the analysis prior to determination of the elements of a neighborhood protection plan should therefore determine the ability of the adjacent arterial street system to accommodate added traffic.

Clearly this is a classic trade-off condition. If the analysis shows that adjacent streets do not have sufficient capacity, decisions will be needed to balance the desires of the residents for quiet streets, the desire of the motorists for efficient travel, and the resources of the local jurisdiction to provide for efficient traffic movement without the use of local streets.

As one example of a technique for dealing with this issue, Montgomery County, Maryland will not implement a neighborhood protection program "where the service level of an adjacent intersection will deteriorate beyond Level 'D' or where an existing service Level 'E' or 'F' will be extended."[96] Parallel to such a criterion is of course the possible decision to improve the adjacent intersection to the point where an acceptable service level can be obtained. In many cases it may be possible to "solve" the neighborhood's traffic intrusion problem through measures on the arterial street system, either correcting specific deficiencies which caused the neighborhood incursions in the first place or simply providing good enough arterial service that drivers do not perceive local street shortcuts as an advantage.

Number of People Affected

It is valuable in assessing the need for a neighborhood protection program to determine how many people will be affected positively, how many will be affected negatively, and to what extent each will be affected.

Operational measures of effectiveness to be applied to residential protective devices

This section deals with additional measures which can be used to evaluate alternatives and effectiveness of neighborhood protection devices on the streets where they have been installed. The measures are intended to determine if the devices are achieving their goal and how well.

Control Effectiveness

The first question which must be asked is: Is the device performing the function it was intended to perform? If the device was installed to reduce speed, are speeds in fact lower? If a barrier was installed, is it effective or is it being violated? In some cases this basic question can be answered by inspection; in other cases, use will be made of the previous and following measures of effectiveness. The first step in the evaluation process, however, is the proper selection of those measures which specifically apply to the device, since all of the measures will not apply to all devices.

Traffic Safety

Evaluation of the effectiveness of neighborhood protection devices from a safety viewpoint has three elements:

- Safety of the devices themselves
- Safety on the protected streets
- Safety on the surrounding streets

All newly installed neighborhood protection devices should be closely monitored in the months following installation to assure that the devices themselves are not the causes of new accidents. Poorly visible and poorly marked devices, cul-de-sacs with insufficient turning radii, forced turn channelization with poor sight distance, and other poorly conceived installations are certain to bring legal difficulties if accidents occur, and may lead to the complete undoing of a comprehensive protection program. Proper design is of course indispensable to avoiding such a situation, but monitoring after installation is equally vital to detect any unforseen problems.

Safety on the protected streets is a sensitive problem as noted in the prior section. Before and after measurements can be made, but if the sample size or area is small, the comparison may not be statistically significant. In addition, this type of analysis may not reflect the change in perceptions of safety in the neighborhood.

Finally, evaluation should be made of the streets surrounding the protected neighborhood. Accident decreases in the neighborhood may be offset by increases on surrounding streets. Ultimately this may result in a net reduction of accidents if the shift concentrates the accidents where traffic engineering countermeasures can be employed effectively. However at the initial evaluation stage, the important point is that of searching broadly enough to detect shifts in accident locations which may occur. Tables 11 and 12 show examples of this type of evaluation for the comprehensive program implemented in Berkeley, California.[21]

Table 11

Accident comparison — West Berkeley neighborhood area

	Neighborhood Local Streets		Bounding Arterials	
Type of Accident	Before*	After**	Before*	After**
Broadside	9	1	11	16
Sideswipe	4	1	12	9
Pedestrian-Auto	1	0	6	3
Bicycle-Auto	1	0	0	0
Head-On	0	1	2	1
Rear-End	5	5	17	13
Hit Fixed Object	1	2	1	2
Overturned	0	0	0	1
Other	0	1	0	2
Totals	21	11	49	47

Table 12

Accident comparison — Le Conte neighborhood area

	Neighborhood Local Streets		Bounding Arterials	
Type of Accident	Before*	After**	Before*	After**
Broadside	11	0	16	14
Sideswipe	6	3	15	8
Pedestrian-Auto	0	0	3	2
Bicycle-Auto	0	1	2	4
Head-On	1	0	1	3
Rear-End	1	2	12	17
Hit Fixed Object	1	1	1	0
Overturned	0	0	0	0
Other	0	0	0	1
Totals	20	7	50	58

---

*Pre-traffic Management Plan implementation, October, November, December, 1973.

**Post-Traffic Management Plan implementation, October, November, December, 1975.

Source: **De Leuw, Cather & Company; Six Months Experience, Berkely Traffic Management Plan, 1976.**

Table 13

Typical construction costs for neighborhood protection devices (1976 costs)

Traffic Signals	$30,00 - $40,000
Temporary Diverters	$500 - $2,000
Landscaped Diverters	$1,000 - $12,000
Additional Fire Hydrant	$1,500 - $2,500
Rumble Strips	$400/approach
Trafficy Circle (temporary)	$1,000 - $2,000
Concrete & Asphalt Islands	\$2.50/ft^2
Signs	$30 - $50
Paint and Bar Islands	\$.45/ft^2
Chokers	$400 - $500
Pavement Markings	$10 - $40 units

Driver Obedience

Measurements of driver obedience are a direct measure of whether a device is performing its function. It can indicate the need for a more effective device or for more enforcement.

It should not be assumed that because a device causes an apparent barrier to traffic, that it will not be violated. Studies in Berkeley showed that in some locations, sidewalks and vacant lots were used to bypass clear barriers. Monitoring of obedience can thus aid in decisions on proper types of devices for the concerned driver population, and on the specific design of the devices. A sympathetic driver population with feasible alternative routes may allow use of a less restrictive type of device or alternatively, less enforcement. Only by monitoring of obedience can this factor be determined for the local condition.

Construction Costs

Construction costs for the various types of devices can vary greatly, depending on whether they are permanent or temporary; the amount of landscaping, if any; and special considerations such as the need to install added fire hydrants and connections. While cost estimates should be made specifically for each project, Table 13 presents a range of typical costs for various devices as gleaned from recent experiences.

In addition to these costs for construction, communities should expect some expenses for community interaction and plan development, as well as for any necessary environmental impact report efforts.

Vandalism and Maintenance Costs

Vandalism is a highly localized item which can be influenced by the degree of animosity towards the devices, the type of neighborhood where the device is installed, and the design of the device itself. The vandalism may be inherent to the neighborhood and thus not directly related to feelings about the protection program itself. While little data is available to specify expected costs due to vandalism, the City of Berkeley experienced costs due to vandalism in the range of 5% of the construction costs during the 6 months following installation of its citywide program. Two-thirds of this cost was associated with repeated vandalism at specific locations, providing a small measure of the degree of acceptance of these few devices.

Typical **annual** maintenance costs following the initial period might be on the order of $150-200 per diverter, $0.10 per foot of curbline and centerline markings to be repainted, $20 per pavement marking to be repainted, and $2-5 per sign to be replaced.

Costs of Added Time and Expense to Drivers

A thorough evaluation of protection devices should indicate these driver related costs. It should be noted that they apply both to the through drivers diverted to other streets, as well as to local neighborhood drivers whose access distance to their homes is increased. These costs are somewhat speculative, and it is extremely difficult to estimate the real value of tiny delays or time savings to individual drivers or accurately guage the effect on operating costs of the small changes in operational characteristics imposed by most traffic management actions.

Surveys

Throughout Chapter 4, applications of survey research techniques as appropriate to the various stages of planning and evaluating neighborhood traffic schemes have been indicated. Illustrations of surveys actually used by communities at various stages of the planning process have been presented. This State-of-the-Art report is not intended as a manual on how to do surveys. There are many existing publications dealing with survey methods, including material for the layperson as well as the survey specialist which are referenced at the conclusion of this appendix. However, a few key points about applications of survey research techniques to neighborhood traffic issues merit specific note here.

Organization

Before any survey is launched, there must be a clear understanding of the specific objectives it is supposed to accomplish since objectives have a strong effect on overall survey design, sampling methods and design of the survey instrument. Surveys connected with neighborhood traffic management are unusual because, unlike most surveys, data gathered thereby may be only a secondary objective. In this case, publicizing a plan or the existence of the planning process and the fact of having given everyone the opportunity to identify needs or express opinions is as important as the direct response data. By contrast, at the evaluation stage, the data return has dominant importance.

Selecting a Survey Design

The essential need here is to reach the desired target population group. Thus it is mandatory to define who is in this group — it may be residents on a particular street or it may be the entire community. The design or strategy should involve selecting an approach which will reach the target group as effectively as possible within budget. This means, for example, that a random telephone survey would be an unlikely choice for reaching drivers who shortcut through a particular street or neighborhood, since most calls would be to unqualified households.

A number of factors affect choice of survey strategy. Cost, desired response rate, desired control over who responds, wording, format, length, subject and population surveyed are all considerations and no simple rule of thumb should normally be applied. However, self-administered mailback surveys usually are most common and most suitable for neighborhood traffic management applications. However, procedures to assure adequate response rate and against response bias are important.

Survey work can be very expensive. Great care must be taken to recognize all costs before beginning. Often surveys take far more time to produce results than expected. This is because of questionnaire approvals, weather, slow (mailback) or low rates (in other methods) of response, and delays in processing and analyzing data (particularly if computer analyses are used). Avoid study designs which leave too little slack in the time schedule for delays; an extra 50 percent is not too much.

Sampling

In normal survey research, full enumerations (100 percent samples) are very seldom used. They are extremely expensive and usually add little if anything to the useful accuracy of the results. The typical exception is in the case of a very small population (i.e, up to perhaps 200) in which samples would be too small for reliable inferences to be drawn. However, in dealing with neighborhood traffic issues, because of the importance of giving everyone an opportunity to comment, 100 percent samples are the norm rather than the exception.

The major concern in survey sampling is to avoid bias, or non-representative results. Much of this requires only thoughtful common sense; for example, to learn about the desires of silent citizens one should not survey just people who turn up for community meetings. A household-oriented approach would be more appropriate to reach this group. Even where 100 percent samples are utilized, control of returns is needed to assure that adequate numbers of responses are received from each critical resident category.

There are many clever statistical designs for sampling, including simple random, stratified, cluster, systematic, and various composite sampling techniques. The application of these principles in any reasonably large survey should be guided or at least advised by a competent statistical technician, to avoid embarrassing (or worse) errors. Properly used, statistical survey principles can save much effort and money. Statistical inference, the power to draw from a sample reliable conclusions about the whole population, is mainly controlled by absolute sample size — not the proportion of the population sampled. Ignore any advice to use "a straight ten percent" or other proportion. Get a statistician if in doubt. While the above noted use of 100 percent samples in neighborhood traffic management related survey applications may downgrade the importance of sophisticated statistical approaches, presence of a competent statistician is always a reassuring asset.

Instrument Design

The instrument must be clear and of interest to the respondent. Otherwise unsuspected and even undetected response biases as well as refusals will occur. The instrument should **always** be pretested, along with the procedure for administering it. Pretesting invariably uncovers points of misunderstanding, difficulty, or delay. Questions can all too easily be poorly worded, resulting in useless or no responses. This is especially true of items concerning future behavior of the respondent or his/her household to a hypothetical situation. Great care must be taken in design of such items, particularly in depicting the details of what a traffic management plan might be like, if this is the subject of the question.

The temptation to include extra "interesting" questions should be resisted. They make the survey more expensive and less reliable, annoy the respondent, and usually never get analyzed anyway. This is a vice of many inexperienced survey designers.

General References in Survey Research

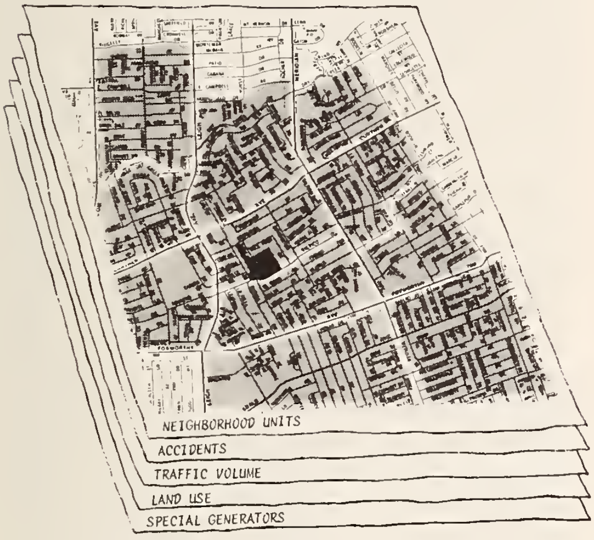
Urban Transportation Systems Associates, Inc. **Urban Mass Transportation Travel Surveys**, for U.S. Department of Transportation, August, 1972.

Raj, Des, **The Design of Sample Surveys**, McGraw-Hill Book Company, Inc., 1972.

Cochran, William G., **Sampling Techniques**, John Wiley and Sons, Inc., 1963.

Appendix D

Organization of needed technical data



This appendix describes in detail a technique for arraying data for planning traffic management schemes on a series of overlays as a convenient organizational technique. The system was used in Berkeley, California in developing that city's traffic management plan.

Base Map

A street base map at a scale of one inch = 200 feet to one inch = 500 feet should be utilized. For large planning areas, a series of maps of this scale in reasonable desktop size sheets should be used. For smaller planning areas, such as when single neighborhoods are considered, a much finer scale (say one inch = 100 feet) can provide area coverage on a desktop size sheet and will also permit plotting of specific geometric details rather than just general schematics as on the larger scale maps. Base map coverage should extend to areas outside the primary planning zone potentially impacted by traffic management actions (this can include extending the map beyond jurisdictional boundaries).

The street system designations should be encoded on the base map (i.e, locals, collector, arterials, limited access highways). Also shown should be any significant bicycle or pedestrian ways separate from the street system, directions of any one-way streets, as well as any existing physical barriers to travel. Right-of-way and travel way dimensions may be shown on the base map or on a separate overlay.

Overlay 1: Perceived Problems

On this overlay, problems identified through various forms of community input, as well as those possibly identified by staff, should be displayed. Problems should be encoded at the approximate locations where they are perceived to occur on the street system using simple graphic representations for the common generic types of complaints (speed, noise, too much traffic volume, too much truck traffic, accidents, child safety problems, general pedestrian problems, etc.). Where problems of a rather unique nature are identified, specific details may be briefly notated on the overlay. In cases where considerable unique descriptive detail is associated with many of the identified problem points, it is useful to correlate symbolic representations on the overlay to a separate descriptive text by means of number codes.

Overlay 2: Traffic Data

Information displayed on this overlay would include several types of objective data measures: traffic volume counts, speed studies, noise measurements, vehicle classification data, results of through traffic surveys, results of traffic obedience studies and any other relevant data. Traffic volumes would be shown directly on the overlay. The other types of studies which require some form of tabular presentation would be indicated by a code and a key which would reference the planner to the specific relevant tabulation or file. The object of this overlay is to let the planner see immediately what specific objective traffic data is available in the vicinity of any particular site within the planning area and to aid in the evaluation process.

Overlay 3: Congestion Data

On this overlay, capacity deficient locations on arterial streets bordering the neighborhood would be listed and notations would be included relative to specific causes and possible solutions. If turning counts and detailed capacity computations exist, numerical reference keys to them should be included on the overlay. Using this display, the planner can determine whether traffic intrusion problems on local residential streets are being caused by specific deficiencies on the arterials and collectors. If such is the case, the planner can look to solutions which cure the problem at its source — improvements at the bottleneck condition — as well as ones which merely shield the neighborhood from the problem's effects. The planner may also use the overlay to draw inferences as to whether a control device proposal on the local residential streets will further complicate operation problems on arterial and collector roads in the vicinity.

Overlay 4: Accident Location Map

This overlay would consist of the accident spot map which most city traffic or police departments compile as a matter of routine. Ideally individual overlays for several recent years of accidents would be available. The object in having the accident overlay is not simply to confirm or disprove the community's perception of safety problems and high accident incidents. Bona fide safety problems may indeed exist at locations where no prior accidents are reported; the community is often intensely aware of such indications of safety problems as frequent near misses and vehicles striking pet animals — incidents which do not show up in normal accident reports. The object in having the accident spot maps available is to use them for specific analytic detail. If there are recorded accidents on the complaint sites, the planner can obtain the case numbers, look at the detailed police accident reports and collision diagrams, and determine what specific pattern of accidents may be occurring and what countermeasures may be suggested by the sites' accident histories. Thus, the planner uses the accident information not so much to verify or deny the perceived problem as to obtain more detailed information from available records which may point to employment of specific solution measures.

Overlay 5: Traffic Control Device Inventory

Ideally this overlay would display all existing traffic control devices on the streets. Frequently such an inventory already is available in plotted form in city files, but nearly as frequently is either not available or incomplete. At a minimum, the graphic should display traffic signals, stop signs and yield controls. It is also desirable to plot locations of crosswalks, various types of warning signs, speed limits, and other significant pavement markings. This is a basic reference graphic since it is essential that any new proposed device fit within the context of existing control devices in its vicinity.

Overlay 6: Neighborhood Boundaries

On this overlay, the boundaries of integral neighborhoods would be outlined. Neighborhood units should be defined from the sense of the planner's definition of neighborhood and as community residents perceive their neighborhood, not according to artificial demarkation lines such as voting districts or census tracts. The object in defining these boundaries is to assist the planner in developing schemes which enhance the quality of neighborhoods as integral units, to avoid schemes which conflict with the community's sense of neighborhood identity, and to pinpoint situations where existing traffic conditions create problems by posing conflicts with neighborhood integrity and identity. The neighborhood boundary delineation may be presented as a separate overlay or in combination with the land use map overlay (see below). A separate overlay showing census boundaries and other data compilation related units (i.e., regional traffic analysis zones,) should also be prepared.

Overlay 7: Traffic Management Units

The purpose of this overlay is to identify physical areas which through traffic should not penetrate and conversely, those streets which must remain open to through traffic. This identification requires somewhat subjective judgement, and these areas may change during the course of the study. The main purpose is to ensure that a local residential street on the boundary of a neighborhood is not undesirably subjected to added through traffic from some protection device, and that all residential streets in a unit are bounded by streets needed for through traffic. This map may or may not coincide with Overlay 6, the neighborhood boundary map. One objective in preparing this overlay is to attempt to reconcile differences between the two.

Overlay 8: Land Use Maps

This overlay would be a very simple land use map intended to show locations of single family residential, multiple family residential, mixed residential, office-commercial, and industrial activities. The basic purpose of this overlay is to delineate points of change in basic land use activities and mixes of activities which may generate problems. The more elaborate land use maps which provide multiple distinctions in densities and types of activities are undesirable for this use as they provide an unnecessary and misleading amount of detail. The object in having this display available is to be able to define lines where traffic generated by office, commercial and industrial activities may be prevented from spilling over into residence areas, to help identify streets which may be more or less sensitive to the effects of traffic, to identify areas where land use mixes may demand special consideration, and to confirm the land use basis for neighborhood boundary definition.

Overlay 9: Special Activity Generators

This overlay would spot the location and identify categorically those community activity centers which by their nature generate significant traffic activity or pose specialized accessibility considerations. Facilities which should be located on this overlay include schools, hospitals, rapid transit stations, large employment sites located on internal streets of a generally residential area, and special nuisance traffic generators like drive-in fast food outlets and high turnover all night convenience shops when located within or on the fringes of residential areas. The intent of this graphic is to make the planner aware of the locations of these special sites so that the plan can be specifically tailored to respond to their special needs (i.e, extra traffic protection around a school or community park; good emergency accessibility to hospitals from the surrounding arterial collector routes, but buffering the neighborhood from the impacts of hospital visitor/employee traffic; and buffering the residential areas from the impacts of special nuisance generators).

Overlay 10: Fire and Other Emergency Vehicle Considerations

On this overlay, the locations of all fire stations would be plotted, along with those of police stations, and ambulance service operating quarters if different from the hospitals. Primary routes of egress from the fire stations, police stations and ambulance staging areas and routes of response to all areas of the community should be plotted. Locations of all fire plugs should also be plotted. Normally, information on the fire routes can be found in fire department training manuals, and fire plug locations if not plotted in such manuals are available from utility maps. Police and ambulance egress routes can be determined either by simple inspection or by conversations with operating personnel.

In using this overlay the planner should be concerned with three things. First, traffic management actions should not block or unduly delay critical fire routes, particularly in the blocks in the immediate vicinity of the station area. Specific suggestions for such situations are discussed in Chapter 5.

The second major consideration for the planner relative to emergency vehicles is one of considering the implications to emergency vehicle routes of actions taken on streets other than those designated as the emergency vehicle routes (i.e., shifts of traffic from another street which might cause serious congestion on an emergency vehicle route). Thirdly, the planner should inspect the overall pattern of emergency vehicle response in the context of each traffic control proposal so that no portion of a neighborhood becomes particularly isolated relative to service by emergency vehicles. Finally, location of fire plugs relative to the individual devices should be considered so that fire plugs are conveniently accessible on both sides of any barrier included in the plan. Where necessary, installation of additional fire plugs should be included as an element of barrier design.

Overlay 11: Public Transit Operations

Routes of public transit services would be plotted on this overlay. Also noted would be those stops and terminal stations where significant park-ride and kiss-ride activities take place. In using this overlay in an alternative development process, the following considerations should be taken into account:

- Control devices should not block or significantly impede transit routes.

- Where neighborhood traffic control devices must be employed on transit routes, devices selected should be ones which make it possible to continue transit operations with minimum interference. Devices to which specific exemptions for transit operations can be appended should be favorably considered, for example a left-turn prohibition from which transit vehicles are exempted by a supplementary message plate. Also, when control devices are placed on routes used by transit, care should be taken that the facilities meet specific transit functional needs — such as allowing reasonable space for bus stops and passenger waiting areas, providing required turning radius for transit vehicles and so forth.

- Transit routes should not be shifted capriciously in an attempt to eliminate conflicts between their operations and a neighborhood traffic control proposal. In most cases the transit route is located on a particular street for good reasons even if that reason does not seem particularly obvious to the planner. And even if the original choice in locating the transit route on the street of concern versus an available parallel route seems to have been made rather arbitrarily and shifting does not pose any significant operational concerns, route shifts are still to be discouraged. Such shifts can negatively impact rider habits developed around the existing route structure.

- The planner should also be conscious of secondary impacts of devices located off the transit route streets which may cause congestion or peculiar operations difficulties on streets on which transit does operate.

- Attempts should be made to maintain good accessibility to those stops where significant park-ride and kiss-ride activity is noted as taking place.

Overlay 12: School Transit

Use of a plot of school bus routes in the planning process should parallel that of the public transit overlay. However, because school transportation services are transporting a captive ridership, minor changes in routes which shift pickup locations or cause slightly circuitous routings or delays are not as serious an adverse effect as is the case with public transit. On the other hand, since it is often a policy to locate pickup points for school children on the neighborhood residential streets rather than on the arterials and collectors (to protect them from exposure to traffic), it is likely that there will be a far greater frequency of conflicts between traffic control device proposals and school bus routes than there are with normal public transit operations. Another consideration in planning neighborhood traffic control devices is the need to allow for reasonable bus circulating loops for passenger pickup and dropoff around the school site.

Overlay 13: Trucks

This overlay would detail existing truck routes and spot locations of trucking yards and other facilities likely to generate high levels of truck traffic. This graphic will enable the planner to identify deficiencies in the existing truck route system, areas which reasonably demand accessibility by truck and areas where certain types of truck limits might reasonably be imposed.

Overlay 14: Bikeways

All bikeways, including both on-street and off-street facilities, should be delineated. This graphic will enable planners to include specific provisions so that neighborhood traffic control device proposals do not block or pose hazardous obstacles to bikeways. Streets heavily used by bicyclists should also be noted on the graphic even if they are not formally designated as bike routes.

Overlay 15: Neighborhood Proposed Plans and Citizen Solutions

Specific proposals to remedy problems identified by the community should be plotted and screened against all of the information available on the overlays above in much the same fashion as the planner goes through the process of developing a plan of his own. Assessment of community proposed plans as a first step of analysis will assist the planner in formulating further concepts and, more importantly, give people who have taken the trouble to propose a solution a rational assessment of their proposals.

Overlay 16: Site Inspection Field Notes

To prepare an effective neighborhood traffic management plan for an area, it is essential that the planner have a detailed familiarity with it. This familiarity can only be gained in the field. Prior to generation of alternatives, the planner should undertake a tour of the entire planning area, stopping as necessary to take photographs at significant points and to experience conditions from the viewpoint of the motorist, pedestrian, bicyclist and area resident. Field notes and photos taken on the site tour should be compiled in a log, and comments and photos should be number keyed to an overlay for easy reference so that they may be retrieved for consideration during the alternative generation process.

Appendix E

TABLE 14: SUMMARY OF CITIES AND DEVICES REVIEWED STATE OF THE ART SEARCH

Jurisdiction	Diagonal Diverters	Semi-Diverters	Cul-de-Sac/Street Closures	One-way Streets/Do Not Enter	Improve Major Streets	Rumble Strips	Bumps, Undulations	Stop Signs	Chokers/Narrowing	Traffic Circles	Traffic Signals	Turn Prohibitions	Forced Turns	Special Parking Restrictions	Median Barriers	Enforce Speed Laws	Truck Prohibitions	Special Signs/Speed Limit Signs
Fort Worth, Texas								●								●		
St. Joseph, Michigan								●										
Boston, Massachusetts							●		●								●	
Pittsburgh, PA								●			●							●
Inglewood, CA	●							●										
Traverse City, Michigan								●										
Claremont, CA																	●	●
Campbell, CA			●													●		●
Dartmouth, Canada							●	●										●
Omaha, Nebraska			●															
Davis, CA	●		●					●										
Akron, Ohio								●										
Torrance, CA			●	●			●					●			●			●
Beverly Hills, CA								●										
Detroit, Michigan												●						
Oklahoma City, OK				●			●											●
Simi Valley, CA			●															
Santa Cruz, CA								●										
Buena Park, CA								●							●			
Redondo Beach, CA			●															
Alexandria, VA			●															
Halifax, Nova Scotia			●					●				●	●					●
Oakville, Canada								●										
Littleton, Colorado			●												●			●
Tampa, Florida			●															
Jacksonville, Florida								●										●
Dallas, Texas			●					●										●
Dayton, Ohio	●		●	●					●									
Cambridge, MA				●				●						●			●	
San Luis Obispo, CA								●										
Sacramento, CA	●																	
New Haven, CT					●			●										
New Orleans, LA				●								●		●				●
Philadelphia, PA				●				●									●	
Rochester, NY				●				●										
Toledo, OH	●																	
St. Petersburg, Florida								●										
Washington, D.C.	●			●			●	●				●		●				●

Jurisdictions reporting neighborhood traffic control devices

TABLE 14: Summary of Cities and Devices Reviewed — State of the Art Search (continued)

Jurisdiction	Diagonal Diverters	Semi-Diverters	Cul-de-Sac/Street Closures	One-way Streets/Do Not Enter	Improve Major Streets	Rumble Strips	Bumps, Undulations	Stop Signs	Chokers/Narrowing	Traffic Circles	Traffic Signals	Turn Prohibitions	Forced Turns	Special Parking Restrictions	Median Barriers	Enforce Speed Laws	Truck Prohibitions	Special Signs/Speed Limit Signs
San Jose, CA							●											
Sacramento Co., CA										●								
Cupertino, CA								●	●									
Saratoga, CA								●		●		●	●					●
Carson, CA															●			
Covina, CA								●										
Cyprus, CA			●															
Downey, CA			●												●			
Glendale, CA								●										
Hawthorne, CA												●						
Huntington Beach, CA													●					
Irvine, CA															●			
Los Angeles, CA			●					●										
Norwalk, CA			●															
Pasadena, CA	●																	
Placentia, CA															●			
Rancho-Palos Verdes, CA															●			
South Pasadena, CA			●															
Whittier, CA			●															
Oakland, CA	●								●									
San Diego, CA									●									
Belmont, CA			●															
San Mateo, CA		●	●		●					●								
Menlo Park, CA	●		●															
Lafayette, CA								●	●			●				●		
Richmond, CA	●		●										●					
Albany, CA															●			
Redwood City, CA															●			
Walnut Creek, CA		●	●															●
Pleasant Hill, CA		●																
Skokie, Illinois																		●
Columbus, Ohio								●										
Louisville, KY	●			●														
Hartford, CT			●															
Chicago, Illinois	●		●	●				●										
Minneapolis, Minnesota	●												●					
Grand Rapids, Michigan	●		●															
Metuchen, NJ			●															

Jurisdictions reporting neighborhood traffic control devices (continued)

TABLE 14: Summary of Cities and Devices Reviewed — State of the Art Search (continued)

Jurisdiction	Diagonal Diverters	Semi-Diverters	Cul-de-Sac/Street Closures	One-way Streets/Do Not Enter	Improve Major Streets	Rumble Strips	Bumps, Undulations	Stop Signs	Chokers/Narrowing	Traffic Circles	Traffic Signals	Turn Prohibitions	Forced Turns	Special Parking Restrictions	Median Barriers	Enforce Speed Laws	Truck Prohibitions	Special Signs/Speed Limit Signs
Buffalo, NY				●								●						
Concord, MA								●									●	
Flint, Michigan								●										●
Houston, Texas			●									●						
Keane, NH								●										
Memphis, Tennessee				●														●
Miami, Florida					●					●		●						
Nashville, Tennessee	●														●			●
Isla Vista, CA			●															
Aurora, CA	●		●					●			●	●						●
Charlotte, NC						●						●			●			
Cleveland, Ohio			●	●								●	●					
Berkeley, CA	●	●	●					●	●	●	●	●	●		●			●
Decatur, Illinois	●			●				●	●				●	●	●			●
El Paso, Texas			●															
Farmington, Utah			●				●	●						●	●			●
Hampton, VA	●			●					●				●					
Kalamazoo, Michigan				●				●				●	●	●				
Kansas City, MO				●														
Lake Oswego, OR	●			●														
Madison, Wisconsin	●		●	●				●	●	●	●		●	●				●
Norfolk, VA												●					●	
Palo Alto, CA	●		●					●			●				●			
Rocky Mount, NC			●	●				●			●	●	●	●	●			●
St. Louis, MO	●		●	●			●	●	●									
St. Paul, Minnesota	●		●					●						●				
Salt Lake, Utah				●														
San Francisco, CA		●			●		●		●			●	●	●			●	
Santa Ana, CA	●		●									●	●					
Seattle, WA	●	●	●				●	●		●			●	●				●
Shaker Heights, Ohio	●	●	●	●					●				●	●				●
Springfield, MA									●									
Vancouver, BC	●		●				●			●			●					
Visalia, CA									●									
Wichita, Kansas	●	●	●										●					
Toronto, Ontario							●											
Concord, CA								●							●			

Jurisdictions reporting neighborhood traffic control devices (continued)

TABLE 14: Summary of Cities and Devices Reviewed — State of the Art Search (continued)

Jurisdiction	Diagonal Diverters	Semi-Diverters	Cul-de-Sac/Street Closures	One-way Streets/Do Not Enter	Improve Major Streets	Rumble Strips	Bumps, Undulations	Stop Signs	Chokers/Narrowing	Traffic Circles	Traffic Signals	Turn Prohibitions	Forced Turns	Special Parking Restrictions	Median Barriers	Enforce Speed Laws	Truck Prohibitions	Special Signs/Speed Limit Signs
Eugene, OR	●	●	●	●					●	●					●			
Joliet, Illinois	●										●							
Portland, OR	●	●	●						●									
Baltimore, MD																		
Tucson, AZ																		

Jurisdictions reporting neighborhood traffic control devices (continued)

Note: Table 14 is by no means a complete summary of all jurisdictions believed to be using various devices cited. It is simply a notation of those neighborhood traffic control devices observed or reported in the above North American communities which comprise the data base for this State-of-the-Art report. Many more North American jurisdictions are believed using some of these devices for neighborhood traffic control purposes. Jurisdictions cited above may also use other devices not indicated on the table. Some devices indicated above are test installations subsequently removed.

☆U.S. GOVERNMENT PRINTING OFFICE: 1981 — 725-802/1215 REGION 3-1

State of the

[redacted]

~~[illegible]~~

L Kin

Form DOT F 1720

FORMERLY FORM DO

FEDERALLY COORDINATED PROGRAM (FCP) OF HIGHWAY RESEARCH AND DEVELOPMENT

The Offices of Research and Development (R&D) of the Federal Highway Administration (FHWA) are responsible for a broad program of staff and contract research and development and a Federal-aid program, conducted by or through the State highway transportation agencies, that includes the Highway Planning and Research (HP&R) program and the National Cooperative Highway Research Program (NCHRP) managed by the Transportation Research Board. The FCP is a carefully selected group of projects that uses research and development resources to obtain timely solutions to urgent national highway engineering problems.*

The diagonal double stripe on the cover of this report represents a highway and is color-coded to identify the FCP category that the report falls under. A red stripe is used for category 1, dark blue for category 2, light blue for category 3, brown for category 4, gray for category 5, green for categories 6 and 7, and an orange stripe identifies category 0.

FCP Category Descriptions

1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems associated with the responsibilities of the FHWA under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware, signing, and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion, and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology, by improving designs for existing as well as new facilities, and by balancing the demand-capacity relationship through traffic management techniques such as bus and carpool preferential treatment, motorist information, and rerouting of traffic.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements that affect the quality of the human environment. The goals are reduction of adverse highway and traffic impacts, and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge and technology of materials properties, using available natural materials, improving structural foundation materials, recycling highway materials, converting industrial wastes into useful highway products, developing extender or substitute materials for those in short supply, and developing more rapid and reliable testing procedures. The goals are lower highway construction costs and extended maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural and hydraulic designs, fabrication processes, and construction techniques to provide safe, efficient highways at reasonable costs.

6. Improved Technology for Highway Construction

This category is concerned with the research, development, and implementation of highway construction technology to increase productivity, reduce energy consumption, conserve dwindling resources, and reduce costs while improving the quality and methods of construction.

7. Improved Technology for Highway Maintenance

This category addresses problems in preserving the Nation's highways and includes activities in physical maintenance, traffic services, management, and equipment. The goal is to maximize operational efficiency and safety to the traveling public while conserving resources.

0. Other New Studies

This category, not included in the seven-volume official statement of the FCP, is concerned with HP&R and NCHRP studies not specifically related to FCP projects. These studies involve R&D support of other FHWA program office research.

---

* The complete seven-volume official statement of the FCP is available from the National Technical Information Service, Springfield, Va. 22161. Single copies of the introductory volume are available without charge from Program Analysis (HRD-3), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.